FINAL REPORT

EVALUATION OF WATER TREATMENT PLANTS IN INDIA

SPONSOR

CPHEEO, MINISTRY OF URBAN DEVELOPMENT, GOVERNMENT OF INDIA

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE

NEHRU MARG, NAGPUR – 440 020

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FOREWORD

In the context of India's commitment to the goals of International Drinking Water Supply and Sanitation Decade (IWSSD) and "Health for All by 2000 A.D.", investments in water supply sector have been stepped up significantly. Effective operation and maintenance of the assets already created and the new facilities that would come up is a sine qua non to ensure a commensurate return in the form of safe, wholesome water to the public at minimum cost. The CPHEEO, Ministry of Urban Development, Govt. of India, sponsored a nation-wide survey of water treatment plants to bring out the 'state of the art' of operation and maintenance, focus attention of the concerned agencies on deficiencies, if any, and suggest practical measures for overall improvement.

This report is presented in two parts. Part I presents the strategy adopted for the study, the salient findings and an objective analysis of the current status of planning, implementation and management of water works and practical recommendations for improvement. Part II of the report is addressed to the detailed appraisal of each of the water works selected for evaluation. The study involved review and analysis of engineering designs, in-depth assessment of the performance of each unit process and the present status with respect to O & M, plant personnel, laboratory facilities, finance and management. Practical recommendations for effecting improvement in operation and maintenance have been suggested, wherever relevant.

The cooperation and assistance extended by the Chief Engineers of State PHEDs/Water Supply Boards, senior engineers and the plant staff as also the suggestions and guidance of Mr. V. Venugopalan, Adviser (PHEE), CPHEEO, Ministry of Urban Development, in the successful completion of the project are gratefully acknowledged.

Nagpur
June, 1989.

(R. PARAMASIVAM)
Project Leader

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PART I

STATUS REPORT

1. INTRODUCTION

India, a signatory to the U.N. Resolution on International Water Supply and Sanitation Decade, (1981-1990), is committed to the goal of providing safe drinking water and adequate sanitation to all its citizens. The Mid-Decade review of the programme has shown that as of March 31, 1985, the actual coverage of water supply has been 72.88 per cent and 56.20 per cent in the urban and rural sectors respectively(1). The review also revealed that the single most important constraint to achieving the goal has been inadequate financial resources. In the light of the progress achieved so far in this sector and the various constraints experienced, the 'Decade' target for water supply has been scaled down to 90 per cent for urban coverage and 85 per cent for rural coverage as against the original target of 100 per cent for both urban and rural. The allocation for VII Plan for water supply and sanitation has been Rs. 6522.47 crores as against the proposed outlay of Rs. 19883 crores.

The problem of supplying adequate quantity of safe water to the public does not end with the construction of water works. It is imperative that the assets created are operated and maintained properly. Any deficiencies in operation and maintenance of facilities would lead to the deterioration of the system, unproductive use of investment and scarce resources and expose the public at large to the risk of water-borne diseases due to supply of water not conforming to prescribed standards. Therefore, the aspect of operation and maintenance of water treatment systems

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(1) International Drinking Water Supply and Sanitation Decade (1981-90) : India - status Paper, V.Venugopalan, J. IWWA, Vol.XX, No. 4, P-337 (1988)

2. OBJECTIVE AND SCOPE OF STUDY

In the context of the Decade goal, a large number of new water treatment plants will have to be built and the existing ones augmented. Creation of such capital intensive utilities calls for not only sound planning but also development of systems to ensure commensurate return in the form of a quality product i.e. safe, potable water to the public. Instances of poor operation and maintenance practices have, on many occasions, resulted in decreased utility or even early failure of newly constructed facilities. It is against this backdrop that the Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development, Government of India, retained NEERI to undertake an organised nation-wide survey and appraisal of urban water treatment plants.

The study addressed to an in-depth evaluation of the present status of operation and maintenance of water treatment plants from different parts of the country, so as to bring into focus the gaps and deficiencies, if any, and to suggest practical measures for improvements in planning and design, as well as operation and maintenance of the systems.

The scope of work comprised the following :

* Consultation with CPHEEO and the respective state Chief Engineer of Public Health Engineering Department/ water supply agency for identification and selection of treatment plants keeping in view such criteria as the size of the plant, source of raw water and treatment flow-sheet

* Reconnaisance visit(s) to the selected plants for collection of design and engineering data including construction drawings

* Field visits for evaluation of raw water quality and plant performance at various stages of treatment and discussions with senior engineers and plant staff

* A detailed study of the chemical dosing facilities and assessment of operation and upkeep of mechanical equipment

* A critical appraisal of the laboratory facilities, equipment and staff deployed for operation, maintenance and management of water works

* An objective assessment of the above so as to bring out gaps in design, operation and maintenance and practical suggestions for overall improvement

3. METHODOLOGY

Extensive preparatory and desk work was undertaken to delineate the plan of work and the logistics for field survey and evaluation as depicted in Figs. 1 and 2. Proformae were designed for selection of water treatment plants (Annexure I) and for collection of detailed information on plant design and engineering data, water quality and other relevant aspects such as laboratory facilities, plant personnel, cost of operation and maintenance, etc. (Annexure II).

The selection of plants has been made keeping in view the plant size, source of raw water, the treatment flow sheet and the agency responsible for operation and maintenance so as to provide a representative sample of water works from different parts of the country as shown in Fig. 3 and listed in Table 1. In many cities, a cluster of water treatment plants receiving raw water from one or more sources are located at one place. These have been constructed at different points of time. In such cases, the plant selected for evaluation has been specifically indicated.The design data and engineering details for the plants selected were obtained from the plant authorities by the study teams. This information formed the basis for review of designs and evaluation of the plant performance. In order to ensure uniformity in methodology for field study, a checklist (Annexure III) along with a note (Annexure IV) on plant appraisal was prepared and finalised after detailed discussions with the project teams. The checklist highlighted those aspects which need to be looked into in detail to facilitate an objective evaluation. The frequency of field visits was decided keeping in view the size of the plant, and available logistic support and to cover, as far as possible, different seasons of the year so as to adequately reflect the plant performance due to changes in water quality.

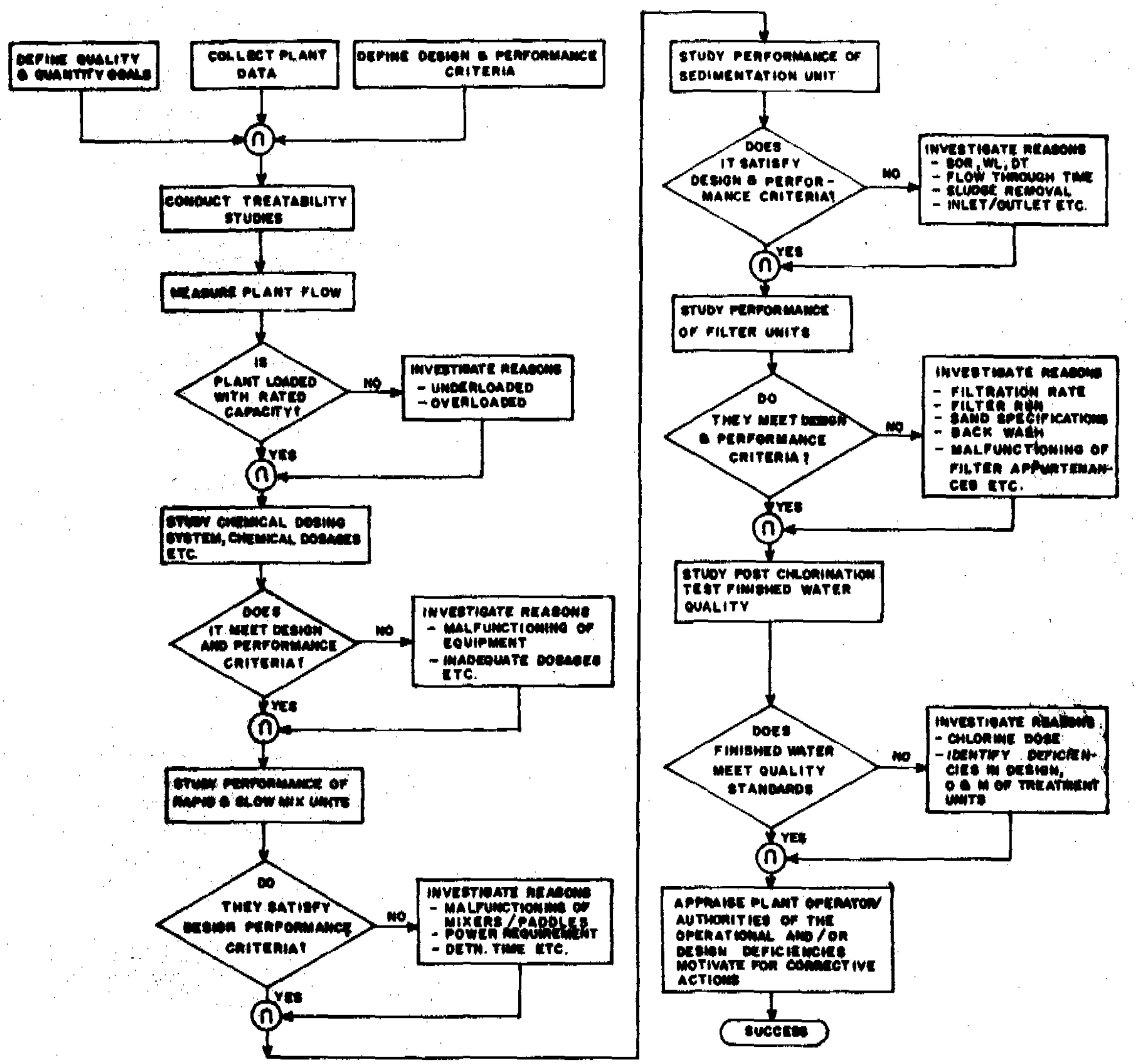

FIG. 1 EVALUATION PLANNING DIAGRAM

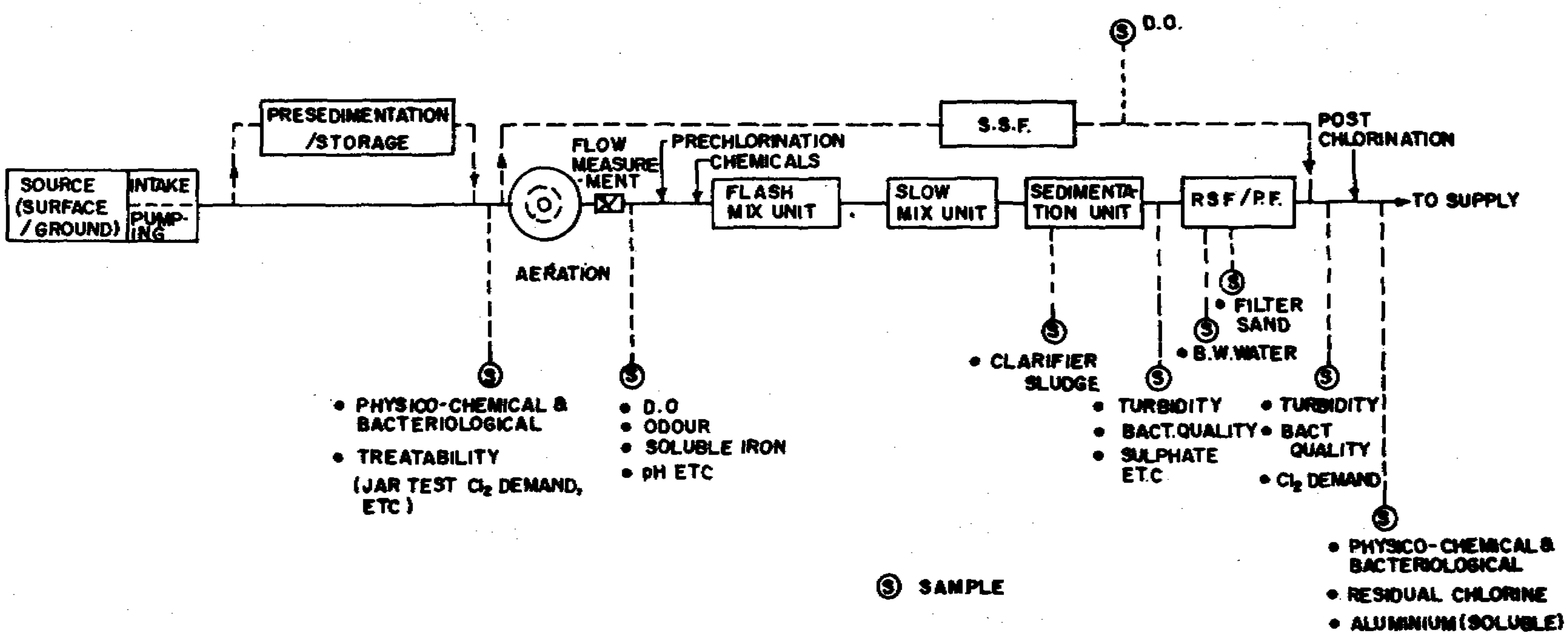

FIG. 2 EVALUATION OPERATIONAL DIAGRAM

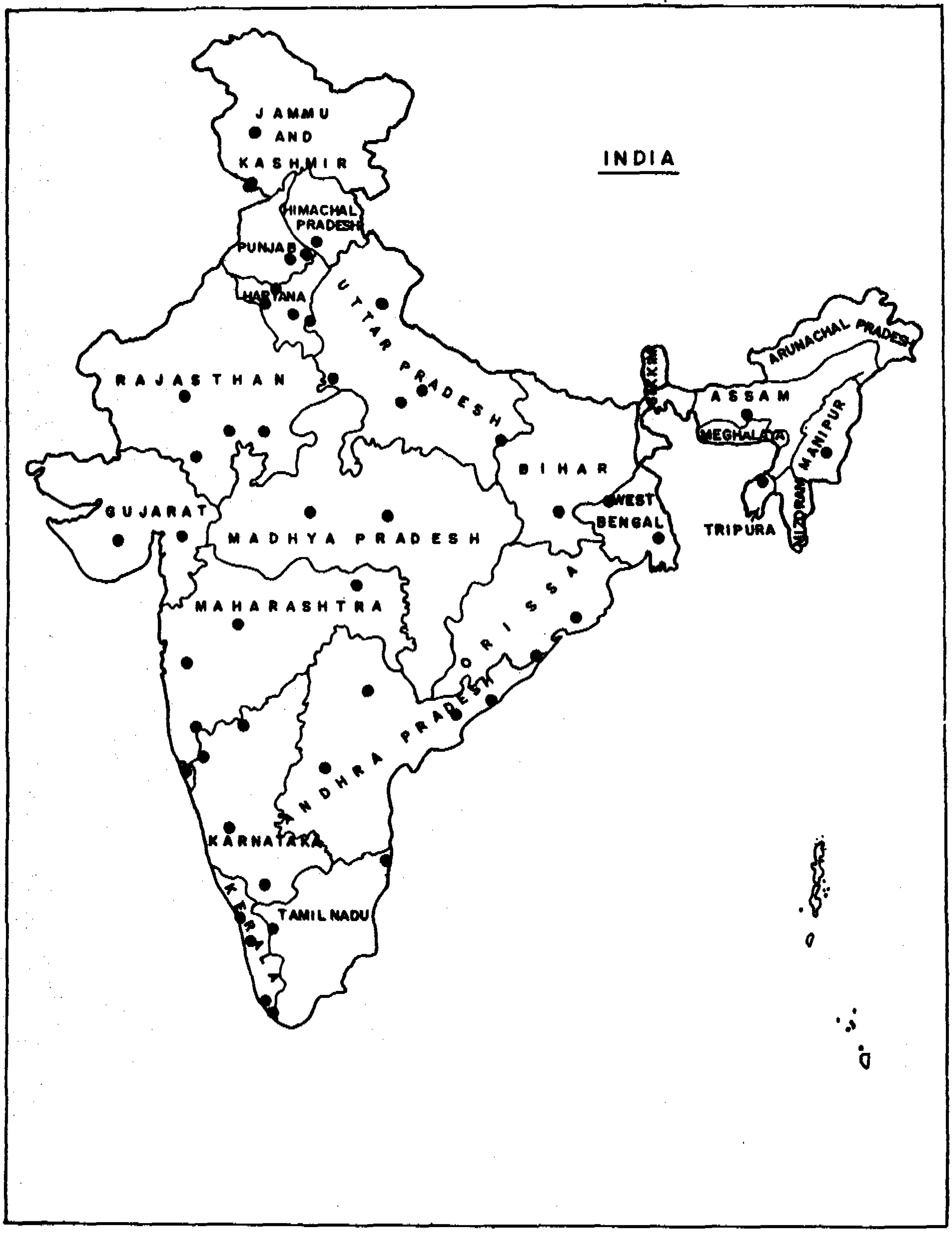

FIG. 3 LOCATIONS OF WATER TREATMENT PLANTS EVALUATED

TABLE 1

LIST OF WATER WORKS SELECTED FOR EVALUATION

ANDHRA PRADESH

Kurnool

Rajahmundry

Visakhapatnam

Warangal

ASSAM

Gauhati

BIHAR

Ranchi

CHANDIGARH (UT)

Chandigarh

DELHI (UT)

Delhi

GUJARAT

Baroda

Bhavnagar

GOA

Goa

HARYANA

Hansi

Hissar

Rohtak

HIMACHAL PRADESH

Shimla

JAMMU & KASHMIR

Jammu

Srinagar

KARNATAKA

Belgaum

Bijapur

Mysore

Shimoga

KERALA

Calicut

Thiruvalla

Trichur

Trivandrum

MADHYA PRADESH

Bhopal

Jabalpur

MAHARASHTRA

Aurangabad

Kolhapur

Nagpur

Pune

MANIPUR

Imphal

ORISSA

Berhampur

Bhubaneshwar

PUNJAB

Rajpura

RAJASTHAN

Bhilwara

Jodhpur

Kota

Udaipur

TAMIL NADU

Coimbatore

Madras

TRIPURA

Agartala

UTTAR PRADESH

Agra

Kanpur

Lucknow

Nainital

Varanasi

WEST BENGAL

Asansol

Calcutta

4. FINDINGS - AN OVERVIEW

While detailed information on each one of the plants evaluated is furnished in Part II of the report the salient findings of the survey are presented hereunder.

The classification of water works evaluated based on the design capacity, the raw water source and the O & M agency is presented in Fig.4 through Fig.6 respectively. Plants of less than 10 mld capacity constituted 18% ; 74% of the plants had a capacity less than 50 mld and 16% of the plants were of capacity larger than 100 mld. While all the plants were based on surface sources, the predominant source of raw water was rivers followed by lakes and canals. The distribution of plants with respect to O & M agency showed that 45% of the plants were operated and maintained by the State Public Health Engineering Departments, 37% by autonomous agencies like Water Supply Boards and Jal Sansthans and 18% by local bodies such as Municipal Corporations, Municipalities etc. In a few instances, there was dual control - one agency responsible for production and treatment while another was incharge of distribution.

Summary data on the physico-chemical and bacteriological quality of raw water for all the plants evaluated is presented in Table 2. As regards the availability and the functionality of raw water flow measuring devices it was found that in seven plants there was no provision for flow measurement and in the case of twenty plants the devices installed were not in working order. In the rest of the plants the devices were functional.

As regards the treatment flow sheet, with the exception of one, all the plants had provision for coagulation - flocculation with alum. Lime addition was practised in eleven plants to aid in coagulation. All the plants had rapid sand filters while in some of the older plants both slow sand filters and rapid sand filters were in use. In most of the plants, especially the larger ones, chlorine gas was used for disinfection. Bleaching powder was used in smaller plants as also in large ones, when chlorine gas was in short supply (Fig. 7).

Summary data on the performance of plants at different stages of treatment as judged by the yardsticks of turbidity and coliform group of organisms is presented in Table 3. Forty seven per cent of the plants surveyed were meeting the CPHEEO standards (Annexure V) with respect to turbidity (< 2.5 NTU); seventy three per cent of plants were satisfying the prescribed bacteriological quality (coliform absent) and only thirty nine per cent of the plants were consistently producing (during all the visits) a finished water meeting in the CPHEEO standards for both turbidity and bacteriological quality (Table 4).

The status regarding laboratory facilities for routine plant control and monitoring is presented in Fig. 8. Most of the plants did not fully meet the CPHEEO norms. A noteworthy observation has been that, in quite a good number of plants, the laboratory facilities provided have not been put to use for want of competent staff.

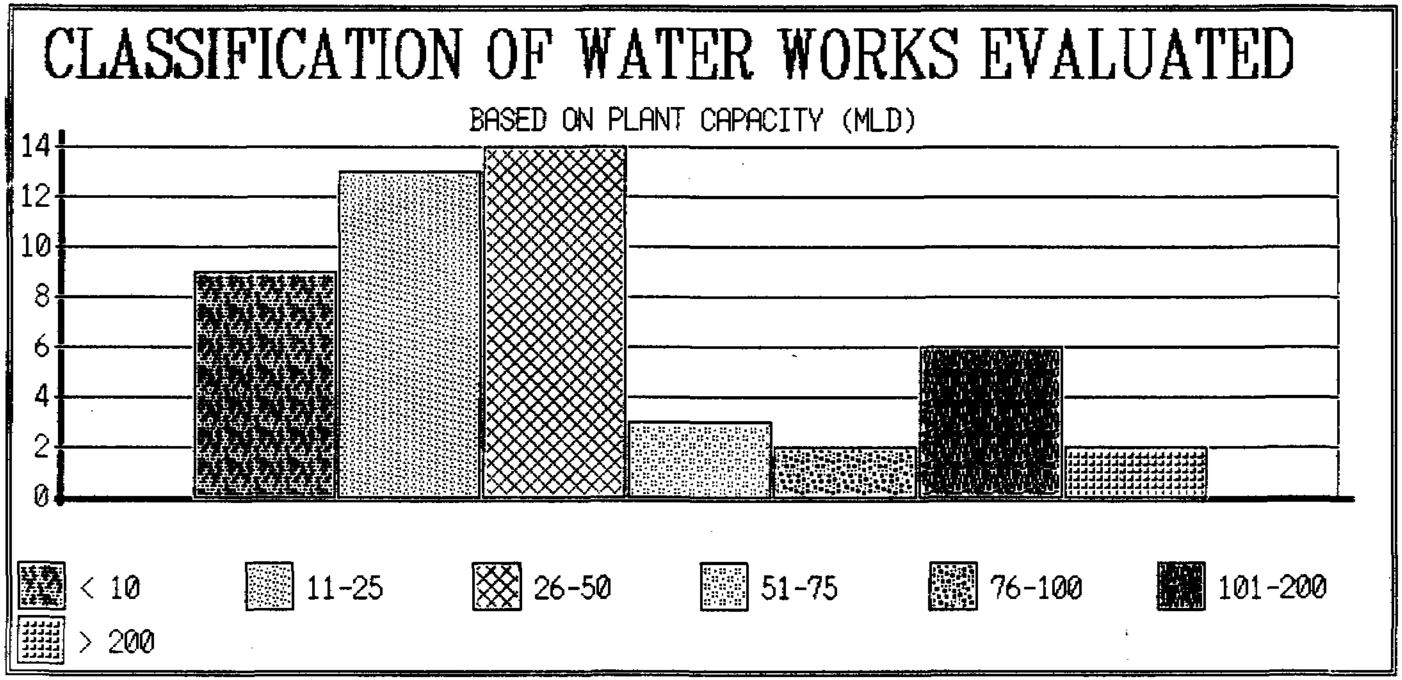
CLASSIFICATION OF WATER WORKS EVALUATED
BASED ON PLANT CAPACITY (MLD)
14
12
10
8
6
4
2
0
< 10
11-25
26-50
51-75
76-100
101-200
> 200

FIG. 4

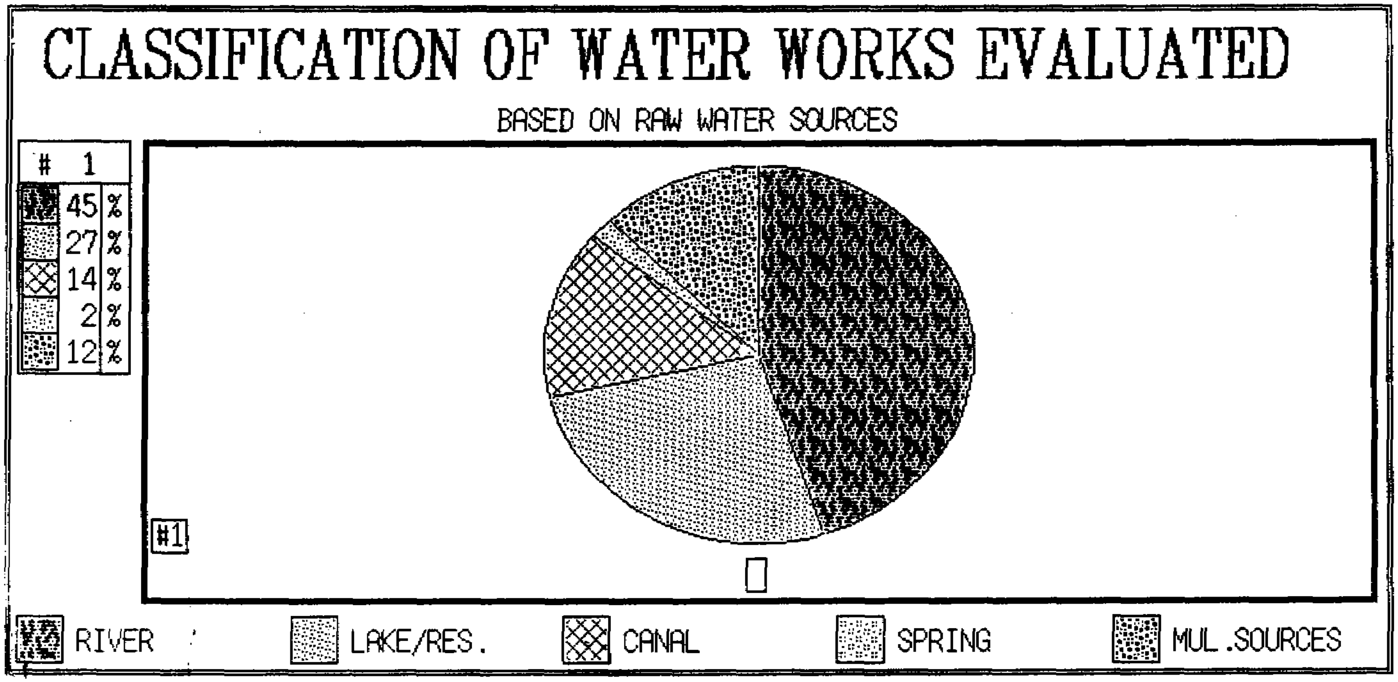
CLASSIFICATION OF WATER WORKS EVALUATED
BASED ON RAW WATER SOURCES
1
45 %
27 %
14 %
2 %
12 %
#1
RIVER
LAKE/RES.
CANAL
SPRING
MUL.SOURCES

FIG. 5

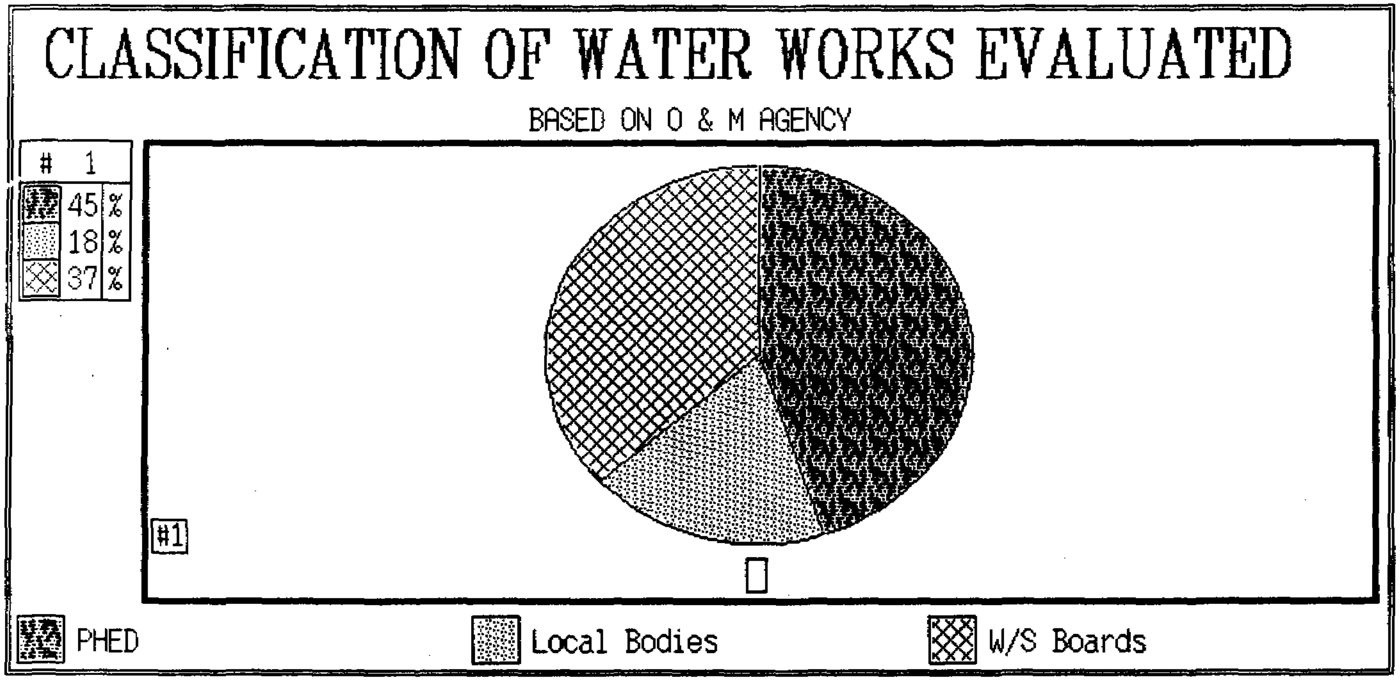
CLASSIFICATION OF WATER WORKS EVALUATED
BASED ON O & M AGENCY
1
45 %
18 %
37 %
#1
PHED
Local Bodies
W/S Boards

FIG. 6

TABLE 2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF RAW WATER QUALITY FOR PLANTS EVALUATED

NAME OF PLANT	PHYSICO-CHEMICAL PARAMETERS											BACTERIOLOGICAL PARAMETERS	
	Turbidity (NTU)	pH	T.Alk. ($CaCO_3$)	T.Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Chlorides (Cl)	Sulphates (SO_4)	Iron (Fe)	Fluoride (F)	Nitrates (NO_3)	Total coliform (MPN per 100 ml)	E.coli (MPN per 100 ml)
ANDHRA PRADESH													
Kurnool	1-60	7.5-8.7	140-188	124-206	32-39	11-26	61-133	22-74	0.1	0.6-1.5	-	75-9300	43-2400
Rajahmundry	2.5-110	7.9-8.1	92-94	86-106	18-20	9-13	11-17	6-13	0.1	0.4-0.5	-	4600-46000	4600-24
Visakhapatnam	0.1-150	7.8-8.2	64-94	68-86	13-18	8-12	9-11	9	0.7	0.2-0.8	-	9-240	4 -43
Warangal	1.5-3.5	8.2-8.9	96-124	60-110	14-24	6-13	16-20	20-35	0.2	0.5-0.8	-	460-2400	93-2400
ASSAM													
Gauhati	27-48	7.6	44-56	76-80	15-16	9-10	3-4	10-14	1.3-1..6	Tr.-0.2	Tr.	790-7900	110-790
BIHAR													
Ranchi	7.0-21	7.0	36-46	28-38	10-12	1-2	4-22	7-14	0.6-1.8	0.4	Tr.	490-680	110-680
CHANDIGARH (UT)													
Chandigarh	3.1-8.0	7.7-7.8	71-74	91-110	26-30	6-10	3-17	26	0.15	0.2-0.5	1.6-2	540-1600	300
DELHI (UT)													
Delhi	5.0-600	7.8-8.5	86-144	86-248	22-42	6-35	7-58	10-45	Tr	0.2 -0.4	Tr.	170 -5400	-
GUJARAT													
Baroda	4.5-80	7.7-8.2	100-160	70-140	16-22	7-20	40-60	18-40	-	-	1-4	240-2400	93-230
Bhavnagar	6.8-40	7.7-8.6	110-180	90-190	16-27	12-29	50-130	24-40	-	--	<1.5	93-460	23-240
GOA													
Goa-Opa	5.0-9.0	7.3-7.4	24-48	30-48	6-17	1-4	5-20	Tr.-3	Tr.-0.2	-	Tr.	1100-2400	Nil-150

Contd...

Table 2 Contd ...

NAME OF PLANT	PHYSICO-CHEMICAL PARAMETERS											BACTERIOLOGICAL PARAMETERS	
	Turbidity (NTU)	pH	T.Alk. ($CaCO_3$)	T.Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Chlorides (Cl)	Sulphates (SO_4)	Iron (Fe)	Fluoride (F)	Nitrates (NO_3)	Total coliform (MPN per 100 ml)	E.coli (MPN per 100 ml)
HARYANA													
Hansi	3.0-13	7.8-9.0	40-88	56-118	14 -28	5 -12	7 -16	23 -28	Tr.-0.1	-	-	8 - 94	-
Hissar	4.0-12	7.6-8.5	64-80	80-102	32-36	4- 17	7-9	12-14	-	-	-	8-540	-
Rohtak	0.8-1.5	7.8-9.0	60-74	80-102	22 -28	5 -8	5 -10	28 -64	Tr	-	-	23 -50	-
HIMACHAL PRADESH													
Shimla	3.0	7.5	68	80	24	5	7	16	Tr	0.54	1.7	140	-
JAMMU & KASHMIR													
Jammu	18	8.2	76	76	26	3	6	6	Tr	0.45	2.9	840	-
Srinagar	7.3	7.9	48	42	14	1	2	2	0.45	0.3	Tr.	14	-
KARNATAKA													
Belgaum	3.4-7.8	6.5-7.8	22-30	14-28	3-9	2	4-9	2-23	Tr.-0.1	0.5-0.8	-	23-1100	7-9
Bijapur	4.5-12.5	7.5-7.8	86-116	112-124	18-34	9-19	13-34	19-33	Tr.	0.2	-	43-210	15-23
Mysore	0.5-1.7	7.2-7.6	80-122	47-66	11-14	3-9	6-20	Tr.-2	Tr.-0.3	Tr.-0.3	-	150-930	15-93
Shimoga	3.5-20	7.0-7.1	26-64	16-36	5-9	1-3	9-22	4-8	0.5-0.8	Tr.-0.1	-	240-2400	4-430
KERALA													
Calicut	2.0	7.3	36	16	6	0	720	2	1.4	-	-	130	-
Thiruvalla	5.0-12	6.6-6.8	8-30	12-20	8	0	8-10	2-3	0.2-0.4	-	-	0	-
Trichur	3.0-12.0	6.5-6.8	12-28	12-16	-	-	3-5	1-2	1.2-1.3	-	-	79-920	22
Trivandrum	8.0	6.8	20	10	4	0	3	2	0.4	-	-	5400	-

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Table 2 Contd ...

NAME OF PLANT	PHYSICO-CHEMICAL PARAMETERS											BACTERIOLOGICAL PARAMETERS	
	Turbidity (NTU)	pH	T.Alk. ($CaCO_3$)	T.Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Chlorides (Cl)	Sulphates (SO_4)	Iron (Fe)	Fluoride (F)	Nitrates (NO_3)	Total coliform (MPN per 100 ml)	E.coli (MPN per 100 ml)
MADHYA PRADESH													
Bhopal	5.0-19.0	7.9-8.1	66-89	55-95	14-34	2-4	3-6	<1	0.2-0.8	<0.1	5-7	93-1600	23-1600
Jabalpur	15	7.8-8.4	105-142	86-130	23-32	7-12	3-4	0-1	0.3-2.2	0.17	0.7-1.9	500	8-27
MAHARASHTRA													
Aurangabad	6.0-27	7.7-8.5	110-130	126-152	20-27	16-22	60-80	9-22	0.1-0.5	-	Tr.	240-1500	9-93
Kolhapur	12-1500	7.4-8.2	28-40	50-52	11-17	2-6	16-28	Tr.-10	0.2-0.7	-	1-11	46000-1100000	11-23
Nagpur	17-22	8.4	163-164	148-153	37-39	12-15	17-35	13-24	0.2-1.9	0.4-0.8	Tr.-2	9-240	4-80
Pune	2.0-70	7.3-7.6	32-40	30-42	9-10	1-5	18-22	Tr.-8	0.2-0.4	-	Tr.	2400-7240000	Nil
MANIPUR													
Imphal	17-95	7-8.5	30-44	30-80	12-14	4-12	3-8	12-13	0.4-2.8	Tr.-0.1	0.3-0.8	4300-13000	2300-9200
ORISSA													
Berhampur	10	7.9	84	76	18	7	7	1	0.3	0.2	0.35	13	4
Bhubaneshwar	24	7.7	61	55	17	3	5	4	2.7	0.14	0.4	>1600	1600
PUNJAB													
Rajpura	5.5	8.2	154	103	32	6	5	27	Tr	0.6	2.6	240	-
RAJASTHAN													
Bhilwara	6.0	7.8	84	156	29	21	28	2	0.6	Nil	-	93	0
Jodhpur	8.5-41	7.4-7.8	104-108	184-196	35-41	22-23	28-64	3-7	-	Nil	Nil	93->2400	43-1100
Kota	2.8-3.4	7.5-8.1	80-92	108-240	29	9-41	12-15	2	0.1-0.4	Nil	-	28-75	0-23
Udaipur	7.4-9.4	7.4-7.9	154-198	148-176	34-38	16-20	62-80	3-15	0.3-0.4	0.1-0.3	-	93	4

Contd...

Table 2 Contd ...

NAME OF PLANT	PHYSICO-CHEMICAL PARAMETERS											BACTERIOLOGICAL PARAMETERS	
	Turbidity (NTU)	pH	T.Alk. ($CaCO_3$)	T.Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Chlorides (Cl)	Sulphates (SO_4)	Iron (Fe)	Fluoride (F)	Nitrates (NO_3)	Total coliform (MPN per 100 ml)	E.coli (MPN per 100 ml)
TAMIL NADU													
Coimbatore	3.0-4.0	6.8-7.7	12-21	8.0-12	2-3	0-2	5-7	2-3	0.2-0.3	0.1	-	70-11000	4-230
Madras	5.5-8.8	7.8-8.2	34-206	78-240	14-90	3-10	41-125	13-62	Tr.	<0.1	-	2400-4600	9-23
TRIPURA													
Agartala	36-37	7.0	64-81	54-100	14-20	5-12	3-5	12-14	-	Tr.	0.4-0.7	3500-24000	2800-24000
UTTAR PRADESH													
Agra	5.0-10	8.1-8.5	200-280	262-360	38-71	41-47	114-274	74-138	0.4-2	0.5-0.6	0.3-10	13000-24000	900-2300
Kanpur	6.0-30	7.8-8.4	35-240	76-174	31-47	9-18	3-38	14-36	0.1-1.4	0.2-0.5	Tr.	11000-35000	5000-7000
Lucknow	12-29	8.4-8.8	230-255	160-196	29 -38	21 -24	6 -8	5 -12	0.7 -1.9	0.4 -0.5	Tr.	1700-9000	50 -1600
Nainital	2.5-6.0	7.7-7.9	260-300	360-414	50-63	48 -63	7-13	44-112	Tr.	0.1-0.12	1.0-2.1	540-1600	94-130
Varanasi	5.0-8.5	8.1-8.2	180-200	142-172	33-34	14-21	20-29	18-32	Tr.	0.3-0.4	Tr.	1700-3500	90-170
WEST BENGAL													
Asansol	10-820	6.9-8.1	29-70	84-92	18-19	10-11	2-6	0-5	Tr.-5.7	0.4-0.8	-	21-2400	91
Calcutta	32-120	7.5	189	140-150	33-48	5-15	11	12-21	1.3	0.06	-	13000-24000	1700-2300

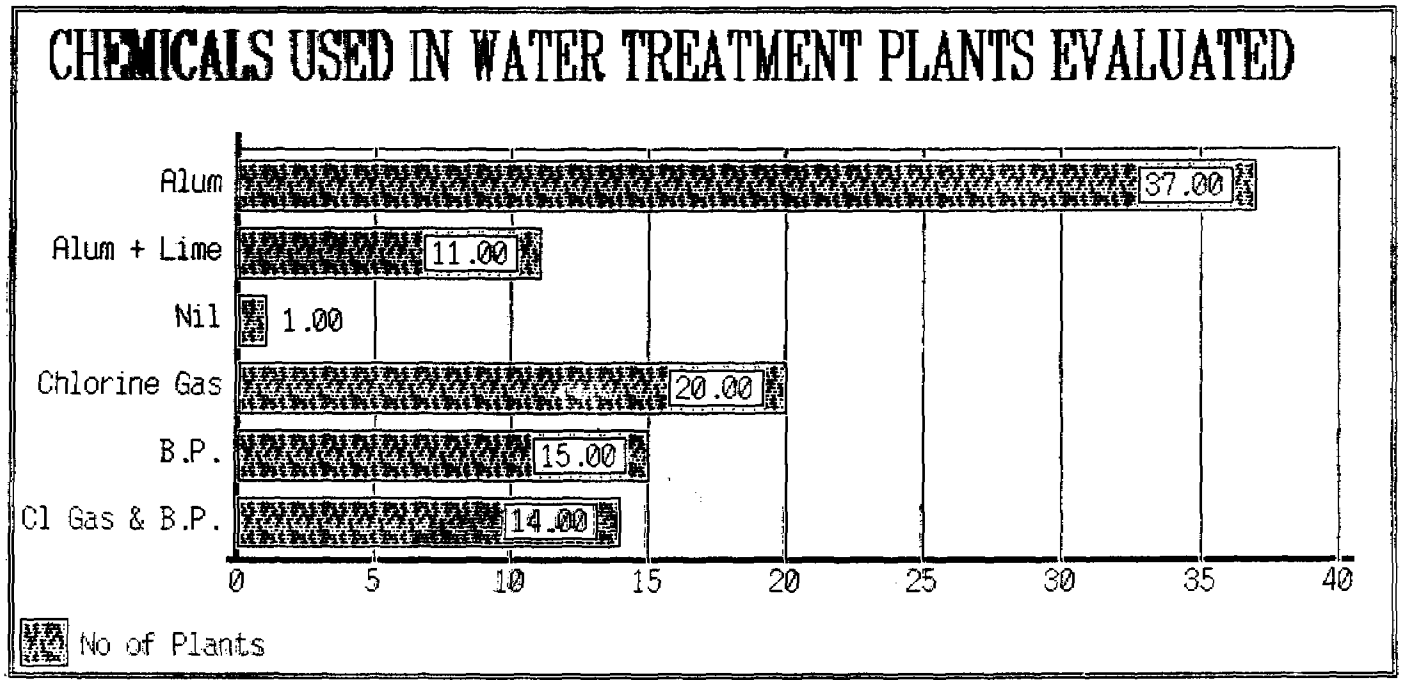

CHEMICALS USED IN WATER TREATMENT PLANTS EVALUATED
Alum
Alum + Lime
Nil
Chlorine Gas
B.P.
Cl Gas & B.P.
37.00
11.00
1.00
20.00
15.00
14.00
0
5
10
15
20
25
30
35
40
No of Plants

FIG. 7

TABLE 3

PERFORMANCE OF PLANTS AT VARIOUS STAGES OF TREATMENT

Name of the Plant	Raw water source	Turbidity (NTU)				Total Coliform (MPN/100 ml)			
		Raw	Set.	Fil.	Fin.	Raw	Set.	Fil.	Fin.
ANDHRA PRADESH									
Kurnool	Canal	10-60	1-10	1-2.5	0.8-4.5	75-9300	460-2400	9-150	0-460
Rajahmundry	River	2.5-110	0.8-26	0.5-3	0.5-1.0	4600-46000	9300-15000	4600-9300	Nil
Visakhapatnam	River/ Impoundment	0.1-150	0.1-8.5	0.1-0.5	0.1-3.0	0-240	0-930	23-930	0-15
Warangal	Canal	1.5-3.5	1-3	0.2-2.5	0.2-1.0	460-2400	460-1500	0-93	Nil
ASSAM									
Gauhati	River	27-48	5.2-9.0	-	1.2-5.0	790-7900	70-220	0-26	Nil
BIHAR									
Ranchi	Dam	7-21	3.7-14	-	1-3.5	490-680	49-68	0-45	Nil
CHANDIGARH (UT)									
Chandigarh	Canal	3.1-8.0	2.6-6.6	0.8-1.1	0.8-1.0	540-1600	60-280	20-130	Nil
DELHI (UT)									
Delhi	River	30	1.5-5.0	0.3-1.7	0.4	170	2.0	5.0	Nil

Contd...

Table 3 Contd...

Name of the Plant	Raw water source	Turbidity (NTU)				Total Coliform (MPN/100 ml)			
		Raw	Set.	Fil.	Fin.	Raw	Set.	Fil.	Fin.
GUJARAT									
Baroda	Reservoir	4.5-80	6-10	3-6.0	-	240-2400	-	24-240	-
Bhavnagar	Reservoir/ lake	6.8-40	4-18	3.5-13	-	93-460	-	-	0-23
GOA									
Goa-Opa	River	5-9.3	5-5.5	0.8-2.5	-	1100-2400	140-460	4-93	Nil
HARYANA									
Hansi	Canal	3-13	2-12	1.7-95	2-4	8-94	5-41	2-13	Nil
Hissar	Canal	4-12	1.5-2.5	1.4-4.0	1.8-2.0	8-540	0-170	0-7	
Rothak	Canal	0.8-1.5	1-1.5	1-1.5	0.8-1.0	23-50	4-30	2.0	Nil
HIMACHAL PRADESH									
Shimla	Stream	3	2.5	1.5	-	140	75	95	-
JAMMU & KASHMIR									
Jammu	River	18	9.2	1.1	1.4	840	145	60	26
Srinagar	Lake,canal Reservoir, Stream	7.3	4.3	2.8	5.6	14	8	2	0

Contd ...

Table 3 Contd...

Name of the Plant	Raw water source	Turbidity (NTU)				Total Coliform (MPN/100 ml)			
		Raw	Set.	Fil.	Fin.	Raw	Set.	Fil.	Fin.
KARNATAKA									
Belgaum	Lake	3.4-7.8	2-4.5	0.3-1.0	0.4-1.5	23-1100	7-43	0-4	Nil
Bijapur	Tank	4.5-12.5	6.5-8.0	1.7-4.2	7.4-8.0	43-210	4-240	0-93	0-4
Mysore	Dam	0.5-1.7	0.3-1.2	0.2-0.5	0.2-1.5	150-230	23-240	4-93	0-4
Shimoga	River	3.5-20	2-8	1.5-2.0	2.2-5.2	240-2400	43-460	0-43	Nil
KERALA									
Calicut	River	2-5	5-6	1-4	1-2	130-460	47	33	Nil
Thiruvalla	Impoundment	5-50	5-25	3-6	3-5	170-1600	540	170	Nil
Trichur	Impoundment	3-10	4-10	1-5	2-3	240-920	350	130	Nil
Trivandrum	River	8-50	6-50	3-20	3-10	350-5400	2400	330	Nil
MADHYA PRADESH									
Bhopal	Lake	5-19	2.3-4.0	1.5	1.5-2.0	93-1600	0-240	0-21	Nil
Jabalpur	River	15	3.5	1.0	0.9-1.0	500	27-80	18-50	Nil

Contd...

Table 3 Contd...

Name of the Plant	Raw water source	Turbidity (NTU)				Total Coliform (MPN/100 ml)			
		Raw	Set.	Fil.	Fin.	Raw	Set.	Fil.	Fin.
MAHARASHTRA									
Aurangabad	River	6-27	4.5-16	0.5-0.8	-	240-15000	43-2400	9-240	Nil
Kolhapur	River	12-1500	9-60	1.1-7.5	-	$46000-11x10^5$	93-150	0-21	Nil
Nagpur	River	17-22	8-10	0.6-1.1	0.5-1.0	9-240	27	30-170	0-27
Pune	River	2.5-70	1.5-38	1.2-4.6	-	-	$2400-724x10^4$	$240-11x10^5$	Nil
MANIPUR									
Imphal	River	17-95	12-60	40	7.2-9.0	4300-13000	93-1300	2-49	Nil
ORISSA									
Berhampur	Lake	10	7.0	8.5-9.0	-	13	50	23	2.0
Bhubaneshwar	River	24	8.5	0.5-10	14	>1600	240	4.0	Nil
PUNJAB									
Rajpura	Canal	5.5	5.4	1.5	1.5	240	85	35	8
RAJASTHAN									
Bhilwara	River	6.0	7.5	2.5	2.0	93	Nil	Nil	Nil
Jodhpur	Canal/lake	8.5-58	8-12	2.6-6.2	4-5.0	93->2400	0-43	0-43	Nil
Kota	River	2.8-3.4	1.2-2.0	0.9-1.2	1.3-2.6	28-75	43-75	23-43	Nil
Udaipur	Lake	6.4-10	3.8-7.0	2.1-3.8	1.5-4.0	93	4.0	15	23

Contd...

Table 3 Contd...

Name of the Plant	Raw water source	Turbidity (NTU)				Total Coliform (MPN/100 ml)			
		Raw	Set.	Fil.	Fin.	Raw	Set.	Fil.	Fin.
TAMIL NADU									
Coimbatore	Lake	3-4	0.2-1.8	0.3-0.7	0.2-1.3	70-11000	0-7	4-15	Nil
Madras	Lake	5.5-8.8	3.5-13.6	1.5-6.7	2-6.4	2400-4600	0-9	0-460	Nil
TRIPURA									
Agartala	River	36-37	11-12	4.6	4.0	3500-24000	540-920	23-330	Nil
UTTAR PRADESH									
Agra	River	5-10	2-5	1.5-4.5	2-3.5	13000-24000	230-3500	11-2400	0-33
Kanpur	River	14-30	7.5-12	1.2-9.0	1.507.0	11000-35000	920-1400	220->2400	Nil
Lucknow	River	9.5-29	5-11	1.3-5.6	2.5-6.5	230-9000	33-16000	0-2200	Nil
Nainital	Lake/spring	5.0	-	2.5	2.5	540-1600	-	-	Nil
Varanasi	River	5-8.5	2-8.0	0.6-3.5	2.5-3.0	1700-3500	350-940	8-1100	0-23
WEST BENGAL									
Asansol	Dam	10-820	20.8-25	2.5-14	4.5-15	21-2400	9.0	Nil	0-33
Calcutta	River	32-120	1.5-15	0.5-7.5	-	13000-24000	400-2700	11-1300	0-11

TABLE 4

PERFORMANCE OF PLANTS VIS-A-VIS CPHEEO STANDARDS

Name of the plant	MEETING CPHEEO STANDARDS	
	Turbidity (NTU) <2.5	Total coliform - ve
ANDHRA PRADESH		
Kurnool	No	Yes
Rajahmundry	Yes	Yes
Visakhapatnam	No	Yes
Warangal	Yes	Yes
ASSAM		
Gauhati	No	Yes
BIHAR		
Ranchi	No	Yes
CHANDIGARH (UT)		
Chandigarh	Yes	Yes
DELHI (UT)		
Delhi	Yes	Yes
GUJARAT		
Baroda	No	No
Bhavnagar	No	No
GOA		
Goa	Yes	Yes
HARYANA		
Hansi	No	Yes
Hissar	Yes	Yes
Rohtak	Yes	Yes

Contd...

Table 4 Contd ...

Name of the plant	MEETING CPHEEO STANDARDS	
	Turbidity (NTU) <2.5	Total coliform - ve
HIMACHAL PRADESH		
Shimla	Yes	No
JAMMU & KASHMIR		
Jammu	Yes	No
Srinagar	No	Yes
KARNATAKA		
Belgaum	Yes	Yes
Bijapur	No	No
Mysore	Yes	No
Shimoga	Yes	Yes
KERALA		
Calicut	Yes	Yes
Thiruvalla	No	Yes
Trichur	Yes	Yes
Trivandrum	No	Yes
MADHYA PRADESH		
Bhopal	Yes	Yes
Jabalpur	Yes	Yes

Contd...

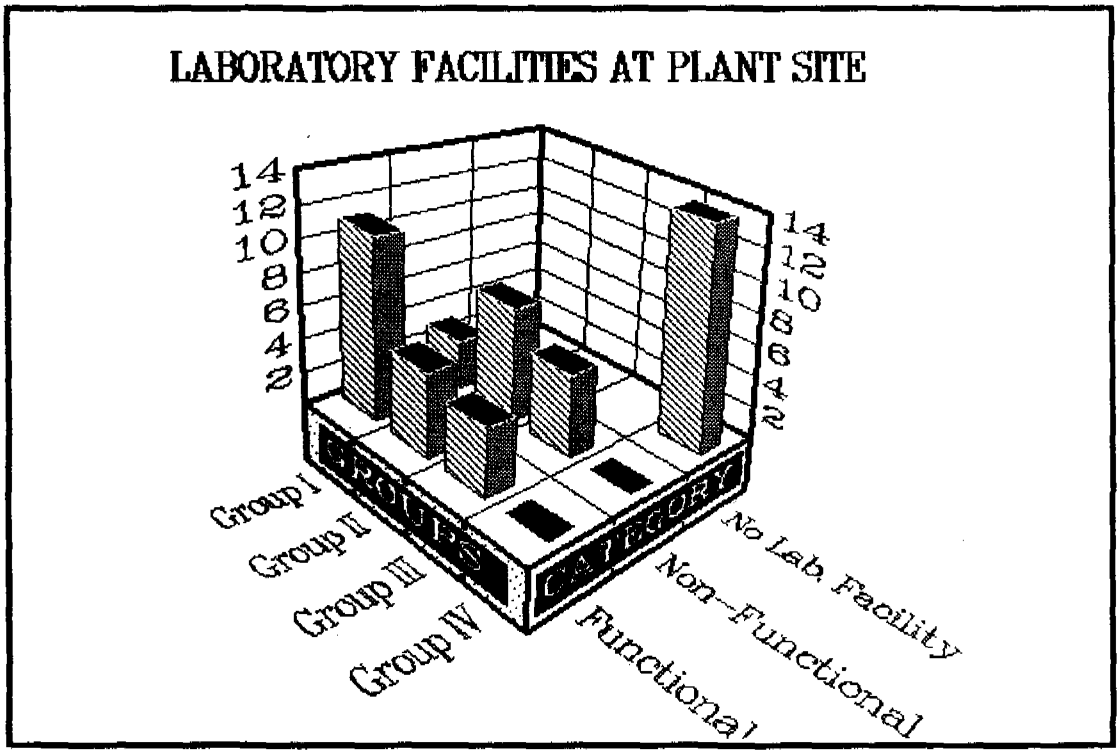
Table 4 Contd ...

Name of the plant	MEETING CPHEEO STANDARDS Turbidity (NTU) <2.5	Total coliform - ve
MAHARASHTRA		
Aurangabad	Yes	Yes
Kolhapur	No	Yes
Nagpur	Yes	Yes
Pune	No	Yes
MANIPUR		
Imphal	No	Yes
ORISSA		
Berhampur	No	No
Bhubaneshwar	No	Yes
PUNJAB		
Rajpura	Yes	No
RAJASTHAN		
Bhilwara	Yes	Yes
Jodhpur	No	Yes
Kota	Yes	Yes
Udaipur	No	Yes
TAMIL NADU		
Coimbatore	Yes	Yes
Madras	No	Yes
TRIPURA		
Agartala	No	Yes

Contd...

Table 4 Contd...

Name of the plant	MEETING CPHEEO STANDARDS	
	Turbidity (NTU) <2.5	Total coliform - ve
UTTAR PRADESH		
Agra	No	No
Kanpur	No	Yes
Lucknow	No	No
Nainital	Yes	Yes
Varanasi	No	No
WEST BENGAL		
Asansol	No	No
Calcutta	No	No



Group I - Physico-Chemical and Bacteriological Analysis

Group II - Only Physico-Chemical Analysis

Group III - Only pH, Turbidity and Residual Chlorine

Group IV - No Facilities

FIG. : 8

5. SITUATION ANALYSIS

5.1 General

The rapid growth in urban population inevitably exerts pressures on the civic services, especially water supply. Because of several constraints coverage of water supply has not been keeping pace with the population growth. The production and supply of adequate quantity of water still continues to be the major concern and pre-occupation of many a water supply agency. Hence, priority is accorded to the development of new works and operation and maintenance of already created facilities is given a low priority even to the extent of neglecting them. Paradoxically, while the rate of urban growth has been increasing, the Plan outlay for water supply as a percentage of total outlay has shown a decline during the VII Plan as could be seen from Table 5.

A fact that emerges from the study is that long term planning for water supply to meet the legitimate demands of both the present and the future has been lacking in general. The growth in facilities has often been haphazard and bordering on "fire-fighting" approach. In this context a sound, holological approach to the resolution of the problem of drinking water supply based on the concept of regional carrying capacity as depicted in Fig. 9 and elaborated in Fig. 10 is imperative. The supportive capacity of the regional environment will determine the quantity of the water resources available and the assimilative capacity of the water body would determine its quality to qualify for the intended use.

5.2 Source Protection and Water Quality Monitoring

All the treatment plants evaluated draw raw water from surface sources although in a few cases the treated water supply is supplemented with tubewell waters. The chemical quality of raw water (Table 2) in general is within the limits prescribed by CPHEEO. However, there are very few, if at all, water works which have a regular programme of raw water quality monitoring and surveillance.

The very first step in assuring a safe and acceptable public water supply is protecting the source from pollution so as to minimise the future liability to the health and well-being of the water consumer and the economic burden to the water supply agency. With shrinking fresh water resources, the quality of raw water supplies may be expected to deteriorate as a result of industrial and domestic waste discharges. This could be mitigated by judicious management and oversight of land use and human activities within the watershed involved. The principles to be followed in a water supply source protection programme and the areas of concern to be incorporated into a monitoring and inspection programme are illustrated in Annexure VI.

Table 5

PLAN OUTLAY ON WATER SUPPLY AND SANITATION

Plan	Total outlay	Outlay on water supply and sanitation	% Total outlay
	(Rupees in Crores)		
3rd plan	8,576.5	105.7	1.23
4th plan	15,782.5	458.9	2.91
5th plan	39,426.2	1091.6	2.77
6th plan	97,500.0	3907.80	4.00
7th plan	180,000.0	5547.64	3.08

Source : "Institutional and financial issues relating to urban water supply and sanitation sector during the Eighth five year plan (1990-1995). Report of the Sub-Group on Financial and Institutional Issues. Ministry of Urban Development, Govt. of India,April 1989.

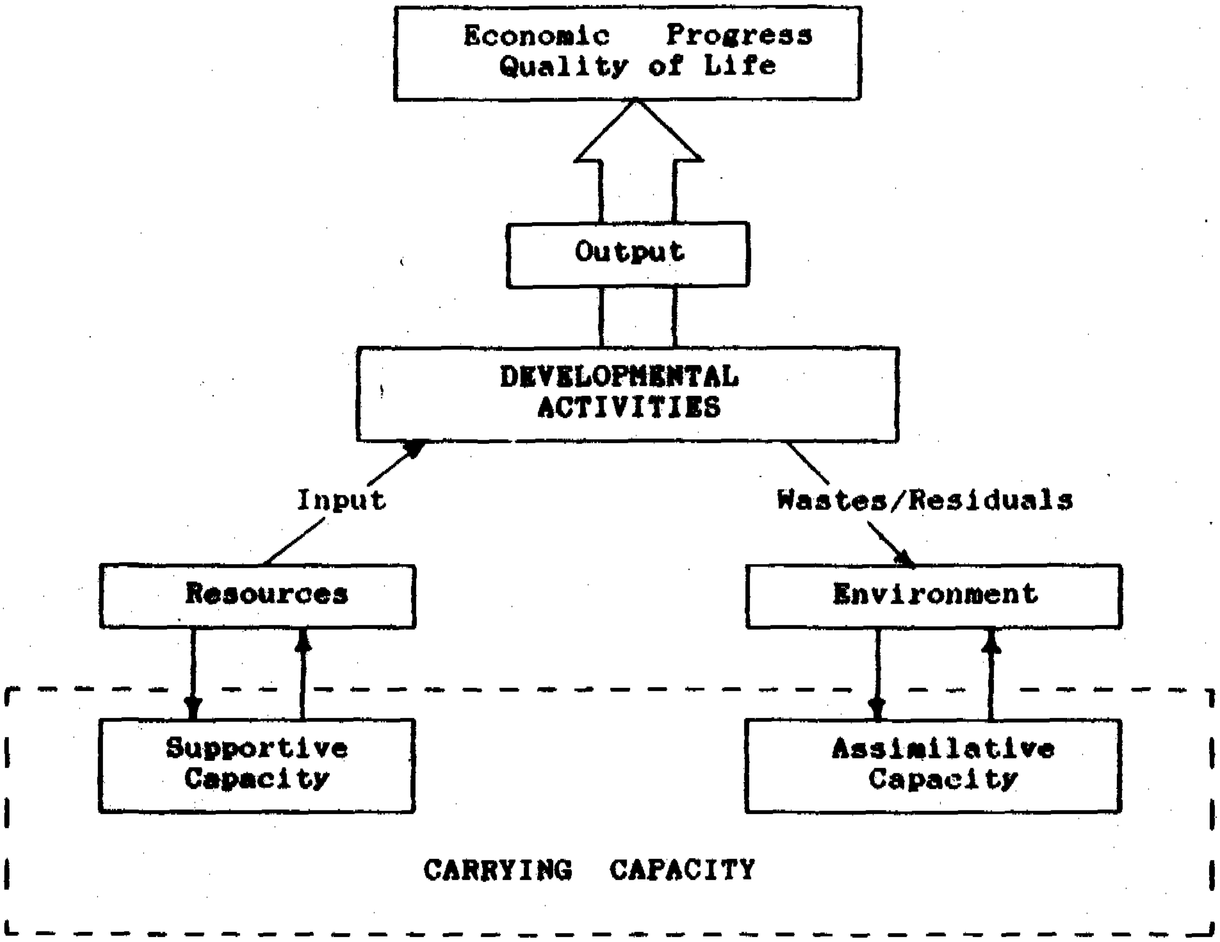


FIG. 9 ELEMENTS OF REGIONAL CARRYING CAPACITY

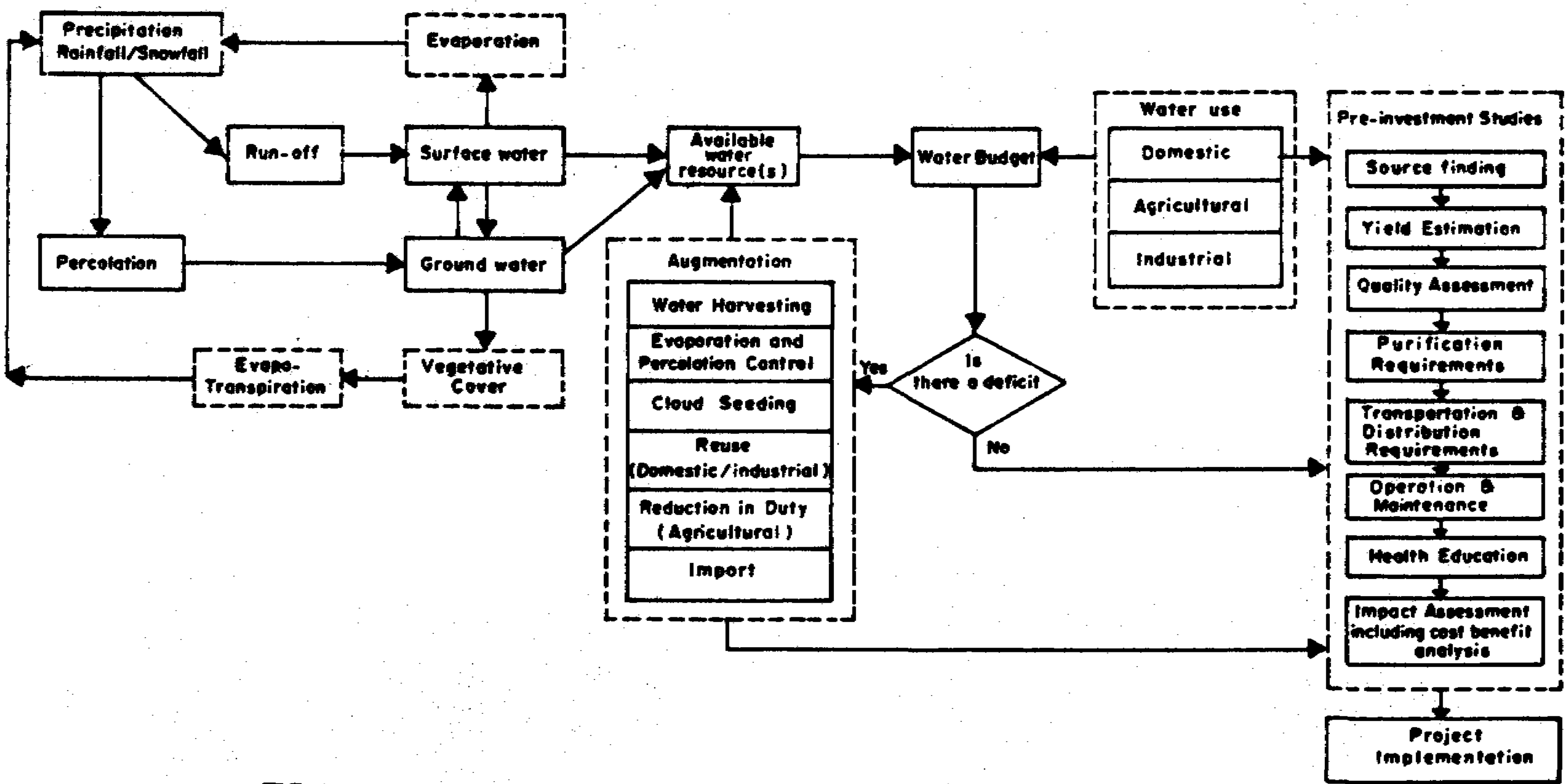


FIG. 10 MACRO AND MICRO ANALYSIS FOR WATER SUPPLY PLANNING

5.3 Raw Water Intake

A serious difficulty often experienced in river based water supplies is the shifting of the river flow away from the intake works during lean months, especially in summer. Construction of bunds/channels to divert the flow to the intake involves considerable expenditure of a recurring nature. On the other hand, there exists the problem of silting of intakes during floods in monsoon causing difficulties in pumping and quick wear and tear of the pumps. There have been instances of flocculators and settling tanks being rendered inoperative due to deposition of silt carried over from the raw water. These point to the need for a careful study of the river regime prior to the selection of site for location of intake and appropriate provision in the design to mitigate the problem.

5.4 Treatment Flowsheet and Process Design

Analysis and review of design norms for the plants evaluated indicate that the design criteria followed are,in general, within the range recommended by CPHEEO (Annexure VII). However, a decision on treatment flow sheet is often made as a matter of routine and not based on assessment of raw water quality and treatability studies to meet the specified quality standards. There have been several instances where aeration has been provided for raw waters drawn from flowing streams and rivers though the decision is not dictated by water quality considerations. The high cost of such units does not justify the seemingly enhanced aesthetics of the plant. Further, the treatment plants are designed unit by unit without considering the interactive nature of the constituent unit operations influencing the functionality and cost of the system as a whole.

5.5 Flow Measurement and control

A knowledge of the plant inflow is of vital importance for effective operation and control of the various units, be it chemical dosing or division of flow between the operating units. The evaluation study has revealed that in a majority (57 %) of the plants, a reliable system of measuring the plant inflow is absent or where installed is defunct for one reason or another. Often, the plant inflow is reckoned with the rated capacity of the pumps, which can be significantly different from the true value. Lack of reliable information on plant flow also leads to wasteful use of chemicals and other resources. Use of even a small excess of chemical(s), especially in large plants, can mean a significant drain on the resources in the long run. Further, any effort at augmentation of treatment capacity should be preceded by a critical appraisal of the existing facilities for their potential to handle larger flows for which a sound system of flow measurement is a pre-requisite.

It has been observed in a few instances that when a sub system of a treatment plant is designed as multiple units to operate in parallel, division of plant inflow equally between the units is not achieved due to defective construction resulting in unequal hydraulic grade line.Corrective measures for such deficiencies are neither simple nor practical. A sure remedy is to ensure extra care and attention right at the time of construction to eliminate such contingencies.

5.6 Chemical dosing and control

Provision for pre-chlorination and lime addition has been made in a number of plants. Pre-chlorination while improving the quality of raw water, also aids in coagulation and in the control of biological growth in settling tanks and filters. Lime addition is practised to improve coagulation. The evaluation study has revealed that the addition of these chemicals is often indiscriminate and not supported by laboratory testing of water quality and treatability studies. Dosing of these chemicals, when not required, would only add to the cost of O & M without commensurate improvement in water quality.

Filter alum has been invariably used for coagulation of turbid waters. In order to facilitate gravity flow of the chemical solution to the point of application, the alum solutionizing tanks are usually located in the first floor of the chemical house. The preparation of alum solution involves lifting of weighed quantities of the chemical manually to the solutionizing tanks, admitting a measured stream of water and keeping the contents stirred by mechanical or other means to maintain a uniform concentration of the solution. This operation is labour intensive and often not adequately supervised. A cost effective alternative, which will be free from most of these problems, is to construct the alum solutionizing tanks at ground level and to lift the prepared solution to the dosing tank by means of chemical pumps.

Also,the maintenance of alum solutionizing facilities and dosing equipment invariably leaves much to be desired. The constant head alum dosing gear is often in a state of disrepair due to corrosion and lack of proper maintenance. In many plants surveyed, adequate stock of chemicals (Alum, lime and chlorine gas / bleaching powder) to last for even a few days was not maintained.

5.7 Coagulation and Flocculation

The manner of addition of alum solution to the incoming flow of raw water is often not conducive for achieving good results. Point addition of alum in the raw water channel is most common. The crude method of dumping alum blocks into the raw water channel, especially during high turbidity season, is also a common observation. Such practices not only lead to wastage of costly chemicals but also result in poor quality of product water. A simple, effective method of ensuring uniform dispersion of the coagulant is to add the solution through a perforated pipe placed across the entire width of the raw water channel just upstream of the measuring weir. The turbulence generated at the weir would facilitate mixing of the chemical.

Initial mixing of chemicals and subsequent flocculation are usually achieved by electrically driven mechanical devices. While these devices function effectively when operated and maintained properly, a tendency is evident among design engineers to overlook,if not ignore, consideration of simpler alternatives especially for small plants (upto 10 mld) where skilled operation and maintenance and adequate supervision can not always be ensured. In such cases, hydraulic mixing devices could provide a simple alternative consistent with functional efficiency. Similarly, hydraulic and pebble-bed flocculators could be equally effective as conventional mechanical flocculators.

In a number of plants addition of alum is totally dispensed with during periods of low turbidity (less than 20 NTU) on grounds of effecting economy. However, this is achieved at the cost of product water quality. It is well established that a nominal dose of alum is a must for ensuring satisfactory bacteriological quality of filtered water. The nominal dose of alum also helps in better removal of other suspended impurities during filtration. In contrast with the above practice, there have been instances when alum is added to the incoming raw water but provision made for rapid mixing and flocculation is not used for effective pre-treatment.

It has also been observed in a few plants treating impounded waters of low turbidity, that recycling a part of the clarifier sludge or retaining it in the clarifier for a longer period without desludging, aids in flocculation. The extent of recirculation and the season when this could be practised with advantage will be site specific and therefore, have to be decided after adequate field trials only.

5.8 Sedimentation

In large plants circular clariflocculators with provision for mechanical sludge collection are most commonly used while horizontal-flow rectangular settling tanks or upflow sludge blanket clarifiers have been used in plants of smaller capacities.

Overloading of the clarifiers beyond the design limits has been a common observation in a number of plants. On the other hand,there have been instances when, because of continued drought conditions, some of the plants are very much underloaded.

Clariflocculators, with rotating bridge and sludge scraper arms are rendered non-functional during times of heavy silt accumulation. This contingency arises especially with plants treating highly turbid waters carrying considerable silt, for effective removal of which provision is lacking in the design. Failure of flocculation and sludge removal mechanism during such critical periods results in forced shut down and reduced plant output. Lack of preventive maintenance of clarifier equipment is also found to result in their failure and pre-mature replacement.

In smaller plants which can not readily command technical resources, support services and competent personnel for operation and maintenance, horizontal-flow rectangular settling tanks without mechanical sludge removal are much to be preferred as space is generally not restricted and labour for cleaning the tanks is readily available. Furthermore, a properly designed horizontal-flow rectangular settling tank, because of its better hydraulic efficiency, when overloaded, can still produce a satisfactory effluent as observed in the present study.

5.9 Filtration

With the exception of a few plants which have both slow and rapid sand filters, all the plants evaluated had conventional rapid sand filters. By and large, the condition of the filters and their maintenance have been far from satisfactory. Most of the filter appurtenances such as filter rate setter, rate indicator, the rate control equipment and the loss of head indicators were defunct for one reason or another. Rapid sand filters in general are backwashed once in 24 hours as a matter of routine with no regard to filtrate turbidity or the head loss development. Maintenance of the filter beds in general has been poor as evidenced by the presence of mud balls, filter cracks, mounds and craters due to improper and inadequate backwashing, and defective/ damaged underdrains resulting in unequal distribution of compressed air and backwash water. While provision for backwashing in itself has been inadequate in many cases, absence of air scour due to non-functioning of air blowers/compressors results in inadequately cleaned filters with attendant problems. Many of the filters were in such a bad shape as to warrant complete overhauling. Only in 47 % of the water works surveyed,the filters produced a filtrate with a turbidity less than 2.5 NTU, the standard prescribed by CPHEEO (Table 4).

In the light of the most common observation that the rate setters, the filter rate controllers, and the rate indicators installed at the outlet of rapid sand filters are defunct and do not serve the intended purpose, there is a need for a simpler and rugged system of rate control. This can be achieved by "influent flow-splitting" with the help of weirs which divide the incoming water equally among the filters. As the filtration proceeds, the water level in the filter rises to compensate for the headloss buildup. This method of filter control eliminates the need for expensive rate controllers and loss of head indicators. However, the filter box must be slightly deeper as the sill of the outlet weir will be in level with the top of the sand bed. In view of the many advantages, this system of rate control has much to commend for adoption, especially in smaller plants.

In traditional water works practice, the rapid filters and the pipe gallery are usually housed in a permanent building. This facilitates all weather operation of the filters, especially in places with extreme weather conditions. Housing the filters has also been a matter of individual preference of the design engineer. However, of late, due to steep escalation in cost of water works construction, there have been welcome departures, in that the filters are 'open to sky' for effecting economy consistent with functional efficiency. Only the filter gallery is housed under a roof to enable all weather operation. The evaluation study has shown that not providing a roof over the filters does not in any way affect their routine operation and maintenance but can lead to considerable economy (upto 30%) in construction cost.

5.10 Disinfection

Disinfection using chlorine gas/bleaching powder has been provided in all the plants without exception. However, the practice leaves much to be desired both in metropolitan plants and small works alike. Often, the chlorine dose is fixed arbitrarily and not based on laboratory tests for chlorine demand. In many cases, the bleaching powder used has been of sub-standard quality and the problem is further aggravated due to poor storage conditions. The chlorinators are characterised by leaky joints and corroded parts, with the result chlorine gas from cylinders/tonne containers conveyed through pipes is directly bubbled into the raw/filtered water channels. The chlorination rooms do not often satisfy the minimum safety requirements recommended by CPHEEO.

The survey has shown that only in 73 % of the plants evaluated, disinfection has been effective as confirmed by the absence of coliform group of organisms in the finished water. In many plants facility for testing residual chlorine was lacking.

5.11 Laboratory for Plant control

The general observation that the quality of final product water meets with the CPHEEO recommendations does not necessarily imply that all the treatment units are operated properly and function at their optimal level. For example, inspite of a poor quality of settled water, the filtrate turbidity could be within the acceptable limit but achieved at the expense of shorter filter runs than otherwise possible.

The need for routine laboratory tests for plant control needs no emphasis. At the minimum, these should include tests for turbidity and pH of water at various stages of treatment and residual chlorine in finished water so as to ensure effective control on chemical dosing and plant operation. Further, for plants treating waters of fluctuating quality, especially turbidity, a jar testing machine is essential to determine the optimum chemical dose(s). In many a plant evaluated, facilities for these tests were not available at the plant site. While most of the plants were underequipped, there were also instances where the facilities available were not fully utilised. Lack of supervision, non-availability of competent staff, meagre allocation of funds and lack of interest and motivation among the staff were the major constraints for this not-so-happy situation.

5.12 Plant Maintenance and Records

Proper planning and scheduling of routine operation and maintenance activities are vital in ensuring the functionality of water works. Presently, such an organised system with effective supervision and managerial control is absent in most of the plants surveyed. The maintenance, is by and large breakdown oriented and the concept of preventive maintenance is rarely in vogue. The essential elements of an organised maintenance programme are outlined in Annexure VIII and a detailed list of maintenance activities which can serve as a guide are presented in Annexure IX.

Another common observation, especially in the case of older plants, is the non-availability of relevant information and records pertaining to the plant. These include detailed plans and drawings of each one of the components of the water works, O & M manuals, schedule of daily operation, schedule of inspection of machinery, records of equipment, records of water quality, records of key activities of O & M, staff position and inventory of stores. Knowledge of and ready access to this information is vital for proper operation and maintenance of the plant, its performance appraisal and for planning facility expansion.

5.13 Plant Personnel, Training and Manpower Development

The performance of a plant will only be as good as the designer, the builder and more importantly the operator allow it to be. Even the best designed and constructed plant cannot perform well in the hands of a poor operator. Therefore, competent plant personnel is a sine quo non to produce, at all times, a consistently good quality, safe water meeting the prescribed standards. A critical appraisal of this issue has brought forth a few significant observations.

In most of the plants maintained by local bodies, there are too many plant personnel, especially at the lower level and their productivity is far from satisfactory. With the result, they constitute a major source of drain on the revenue receipts of the waterworks. Excepting in a few states there are no well-defined norms prescribed for the number of personnel at various levels vis-a-vis the size of the plant and treatment flow sheet. Neither are their job descriptions clearly laid down. The other side of the coin is that a definite policy for career and man-power development of plant personnel is lacking. Also, proper motivation and incentives aimed at development of technical skill and knowledge in plant operation with commensurate salaries appears to be missing. In the light of a critical review and appraisal of the norms currently in vogue, the recommended staffing pattern for water works is indicated in Annexure X.

Plant operators seem to be the weakest link in water supply sector due to lack of training and training facilities. Only a few states have established their own training centres, mostly located in metropolitan cities but also catering to the needs of local bodies. While a number of training courses are organised by several agencies under the sponsorship of CPHEEO for middle and higher level personnel, adequate programmes are not available for sub-professionals like filter operators and attendants. Necessarily,these courses have to be designed by the state agencies in the local language keeping in view the educational level of such personnel.

It is also observed that some of the training courses are essentially classroom oriented without adequate practical or "hands-on" training. This imbalance in the course contents needs to be removed through a proper blend of theory and practice. Also a system of certification of plant operators would seem very necessary in the light of large investments made on sophisticated plants to ensure their satisfactory performance. Necessary legal provision to this effect should be made by all the states. A system of gradation of the operators should be devised through a National or State Board.

Another important observation regarding training programmes is the absence of a follow-up by the funding agency and feed-back from the user departments. An in-built mechanism by which the funding agency has ready access to information regarding the post-deployment and performance of the trained manpower is lacking. Periodic review leading to measures for upgradation of technical and managerial skills through a continuing programme of career and manpower development of plant staff at all levels should be undertaken.

5.14 Organisational and Financial

The institutional structure for management of water supply in different states takes different forms such as Public Health Engineering Departments (PHEDs), Water Supply and Sewerage/Drainage Boards, Municipal Corporations, Municipalities etc. While uniformity in structure may not be feasible because of diverse local factors, there should be only one organisation in one urban area which will be fully responsible for water supply and accountable to the public.

Very few local bodies have adequate qualified and competent engineering and technical personnel for planning, designing and implementing water supply projects on their own. Works of capital nature are, therefore, invariably assigned to the PHED or Water Supply and Sewerage/Drainage Boards. While local bodies should take on the full responsibility for operation and maintenance of water supply systems, experience has shown that most of them are reluctant to do so because of their weak resource base.

Limited experience has shown that privatisation or allowing commercial organisations to manage operation and maintenance of water services could be effective and prevent valuable assets from deterioration. It is worth testing out this experience further by incorporating, if necessary, appropriate statutory changes in the charter of local governing institutions.

A major constraint in effective operation and maintenance of water supply systems has been inadequate financial resources. Because of several contributing factors, the revenue receipts from water supply rarely meet the expenditure incurred in the production and distribution of potable water. The shortfall is usually madeup, if at all, through other sources of revenue.

The problem could be tackled with recourse to the following :

(i) Effective management of existing production and distribution facilities and good-house keeping. Pilot studies conducted by NEERI in a number on Indian cities have shown that 17-44 % of the total water supplied is lost through leakages and wastage from the distribution system. This is not only a loss of precious resource but also a drain on the revenue income of the water agency. Through an organised system of waste assessment, leak detection and control and preventive maintenance of water distribution system, the leakage could be reduced to less than 10 per cent. This means postponing the need for capacity augmentation or saving in the capital cost required for facility expansion, and

(ii) Application of the principle of cost recovery with recourse to metering of supplies, cross-subsidisation and progressive tariff structure with due consideration to serve the economically weaker sections of the population.

It is imperative that the water supply system must generate necessary funds to meet the annual cost of operation and maintenance and to provide for a reserve for meeting the capital expenses for future improvement to the system. This will require suitable restructuring of water rates and tariff based on the cost of production, operation and maintenance and effective collection of the same. It would be difficult to collect the entire cost from the beneficiaries. But the systems have to be maintained properly to utilise the investment already made and infrastructural facilities created and to provide the basic need of water supply to the people. It might, therefore, be desirable to subsidise the operation and maintenance for some period, say for (the next) 5 years. It is expected that during this period the concerned local bodies will take appropriate action to meter the supply and levy appropriate charges to recover fully the cost of operation and maintenance and any other charges of the water supply system. The Government may decide on the quantum of subsidy to be provided for operation and maintenance to each individual local body based on the actual financial position and performance record of the local body.

5.15 Management Information System

An organised management information system (MIS) for collection, storage, retrieval and dissemination of information on urban water supply has been lacking in most of the states. Such information is crucial and a vital input for effective planning, monitoring and policy formulation. A typical format for MIS data base for urban water supply is given in Annexure XI.

5.16 Public Relations

Perhaps, one of the most neglected aspects of water works management has been public relations. The local elite and the common public in general are ignorant about the source of their water supply, the various steps the water goes through before it is turned into a potable product, the complexities and cost involved in the process of treatment and distribution. A general awareness and appreciation of this information could enlist the goodwill and cooperation of the consumers and pave the way for better relations between the two. This could be achieved through the media, handouts, popular lectures and brochures and through 'open days' when the public are allowed free access to the waterworks.

Voluntary agencies can play a useful role in improving the quality of service to community from local bodies, facilitate community level dialogue in planning, motivation and monitoring of water supply.

5.17 Epilogue

Summing up, the present scenario of water works management in general is less than satisfactory, if not gloomy. Planning for urban water supply is characterised by a never ending race to catch up with the growing needs of the galloping population and the depleting fresh water resources. There have been design and construction deficiencies leading to poor functionality of treatment plants. The weak resource base of water supply agencies and the consequent meagre allocation of funds for O & M compounded by the apathy and negligence of the plant staff on one hand and the laxity and complacency among the supervisory staff on the other, have resulted in the poor operation and maintenance of the valuable assets and decreased quality of service to the public. There is an imbalance in the staffing pattern reflecting in the sub-optimal performance of plants and erosion of revenues. The overall situation points to the need for innovation, dynamism and professionalism in this vital sector so as to guarantee to the urbanites, adequate supply of safe water on a sustainable basis, a pre-requisite to attain the goal of "Health for All by 2000 A.D."

6. RECOMMENDATIONS

The following recommendations emerge from the field observations of the survey teams, a critical appraisal of the performance and current status of operation and maintenance of water works and detailed discussions with senior engineers of State PHEDs/Water Supply Boards, supervisory staff and plant personnel. Specific recommendations for the individual plants evaluated are incorporated in Part II of the report.

* A holological approach to the resolution of the problem of urban water supply based on the concept of environmental carrying capacity is essential for a sustainable, long term solution.

* In keeping with the National Water Policy, highest priority should be accorded to the drinking water needs while planning water resources development projects. Interaction and co-ordination between the various agencies dealing with water should be ensured to minimise conflict of views and interests. As part of long term planning, assured sources of water supply including conjunctive use of surface and ground water to meet the needs of cities should be identified and their linkages established with irrigation and multipurpose projects.

* In order to achieve the U.N. goal of 'Health for All by 2000 A.D.' and keeping in view the backlog in coverage of urban water supply on one hand and the growing needs on the other, there is an imperative need for increase in Plan allocation to the sector.

* There is equally a need for a more realistic estimate of water needs through accurate projection of future population based on past growth trends, per capita water demand and the requirements of other sectors of development. Augmentation of supply should be so planned and implemented that by the time the existing capacity reaches its saturation, the facility expansion goes on stream.

* For effective administration and management of urban water supply there should be only one organisation in one .urban area fully responsible and accountable to the public and vested with total autonomy, both financial and functional.

* A regular, organised programme of raw water quality monitoring and surveillance need be undertaken by water supply agencies in order to implement appropriate preventive and corrective measures for preservation and protection of water quality and to obviate, in the long run, the need for complex water treatment facilities or alternative sources to meet the quality standards.

* The design of treatment flow sheet should not be decided as a matter of routine but based on a long term assessment of water quality and scientifically carried out treatability studies to meet the prescribed standards of finished water quality.

* In the light of the recurring problem of silting of intakes experienced by water works based on river sources, a detailed study of the river regime should precede the decision on siting of the intake. In order to mitigate the problem, a stilling chamber between the intake and the sump well should be provided together with appropriate means for continuous/periodic removal of silt.

* It should be made mandatory for all water works to install mastermeters (Venturi/Orifice type) at the raw water pumping station(s) or a measuring flume/weir in the raw water inlet channel with appropriate indicating, recording and integrating system to provide accurate information on raw water inflow which is vital for plant operation and control. The mastermeters should also be installed in the clear water pumping stations to facilitate maintaining a record of the quantity of finished water put into the distribution system.

* In large plants handling considerable quantity of alum, the traditional practice of carrying manually alum blocks to elevated alum solutionising tanks, which is beset with problems could be dispensed with in favour of ground level alum solutionising tanks and dosing by chemical metering pumps.

* In small plants which cannot afford technical resources, support services and competent personnel for operation and maintenance, simple, proven systems such as horizontal- flow rectangular settling tanks (without mechanical sludge removal mechanism) should be preferred. Similarly, baffled hydraulic mixing devices and pebble-bed flocculators, when properly designed could provide simple alternatives to conventional systems without compromising on the functional efficiency.

* In the light of the most common observation that in conventional rapid sand filters, the filter rate control system is invariably defunct, the simple system of influent flow splitting could be adopted with advantage, especially for small plants (upto 20 mld).

* A well equipped laboratory with adequate and competent staff should form an integral part of all urban water works to ensure effective plant control and production of safe water at all times with minimum cost.

* Meagre allocation of funds and lack of management supervision have been the major contributing factors to the present unsatisfactory status of O & M of

water works. Measures to improve the financial resource base, especially of local bodies could include : i) systematic and regular waste and leakage survey and detection followed by prompt corrective measures to bring about a reduction of the shortfalls in water production and improve the financial returns from water tariff, ii) levy of realistic water tariff for domestic, commercial and industrial uses and full realization thereof, iii) concessional power tariff for water works similar to that for agricultural purposes, iv) grant-in-aid from the State/Centre to the deserving cases based on their performance and v) infusion of professionalism in water supply management including selective privatisation, if necessary.

* The most commonly prevalent 'the squeaking wheel gets the grease' approach to the maintenance of water works should be discarded forthwith in favour of an organised system of preventive maintenance with effective higher level supervision to improve functional reliability and productivity of water works as a whole.

* In large plants such as those serving metropolitan cities, introduction of automation should be considered as a time and labour saving measure and to ensure quick response to changes in water quality and operational control.

* There is an urgent need for rationalisation of water works staffing pattern that would ensure effective operation and maintenance of costly assets, improve productivity and reduce O & M costs.

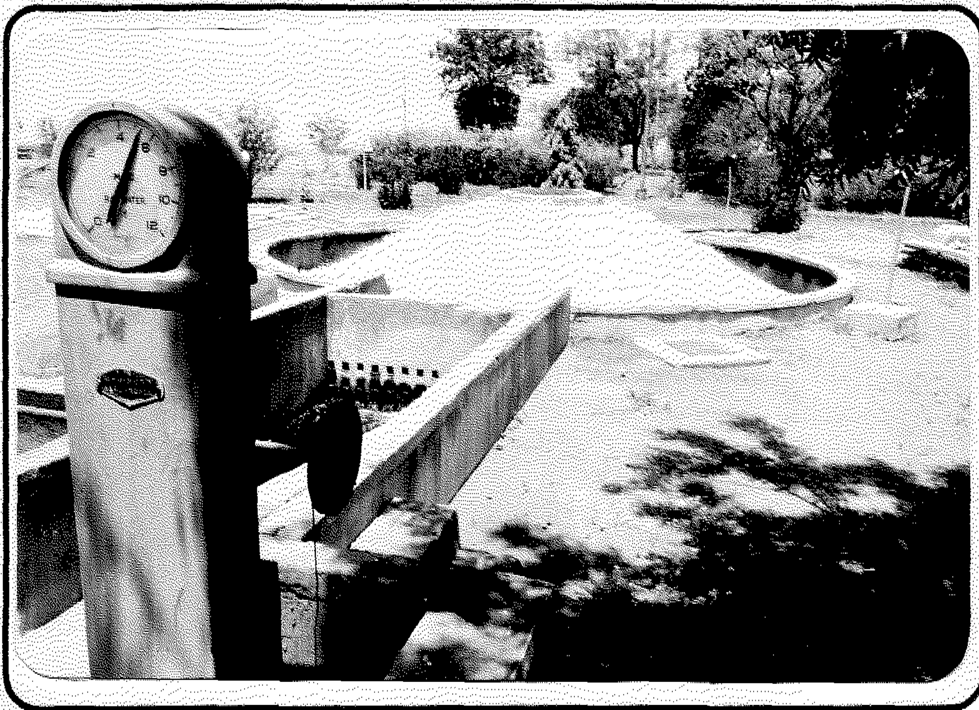
* A system of certification of sub-professionals such as filter operators should be evolved at the state level based on guidelines to be formulated at the national level to ensure effective operation and maintenance of treatment plants.

* A continuing programme of training and manpower development aimed at upgradation of technical and managerial skills of water works personnel at all levels should be implemented by the water supply agencies. State level training centres with adequate infrastructural facilities should be established for training of sub-professionals. Necessary allocation of funds in the budget for the purpose should be made mandatory.

* For effective planning, monitoring and policy formulation, an organised Management Information System (MIS) should be established at each state level for collection, storage, retrieval and dissemination of information on water supply with appropriate linkages at the national level.

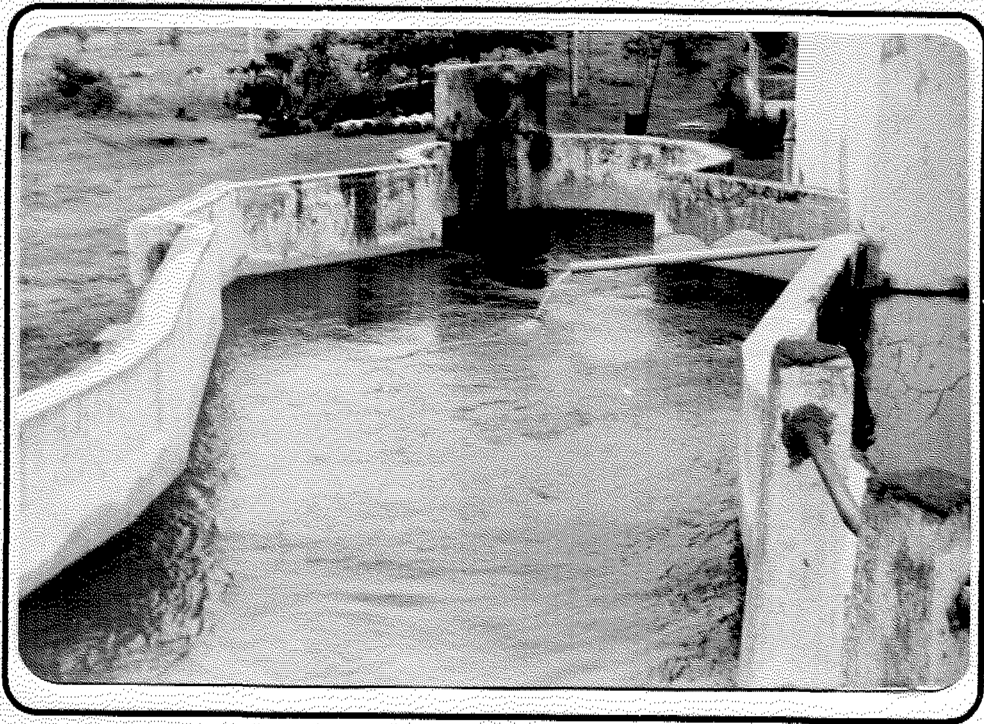
* There is an urgent need for enhanced support to R & D aimed at development of innovative and cost effective systems for water supply and treatment with recourse to Operations Research tools.

* * * * *

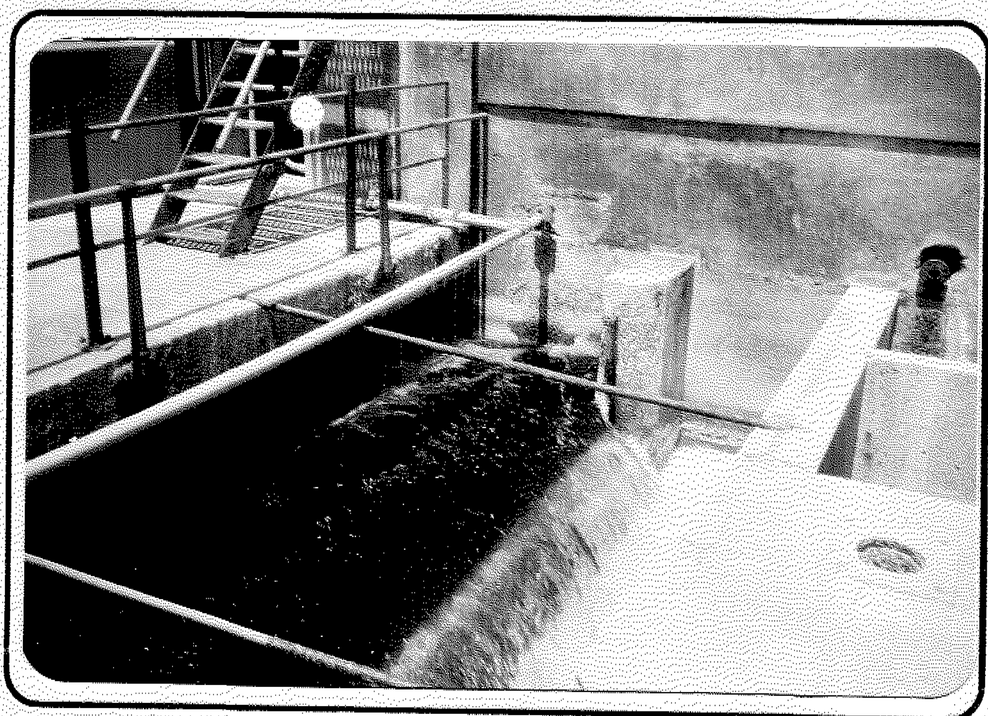


RELIABLE FLOW MEASURING SYSTEM
- A PREREQUISITE FOR PLANT CONTROL

WELL MAINTAINED CHEMICAL DOSING SYSTEM
- A RARE SIGHT



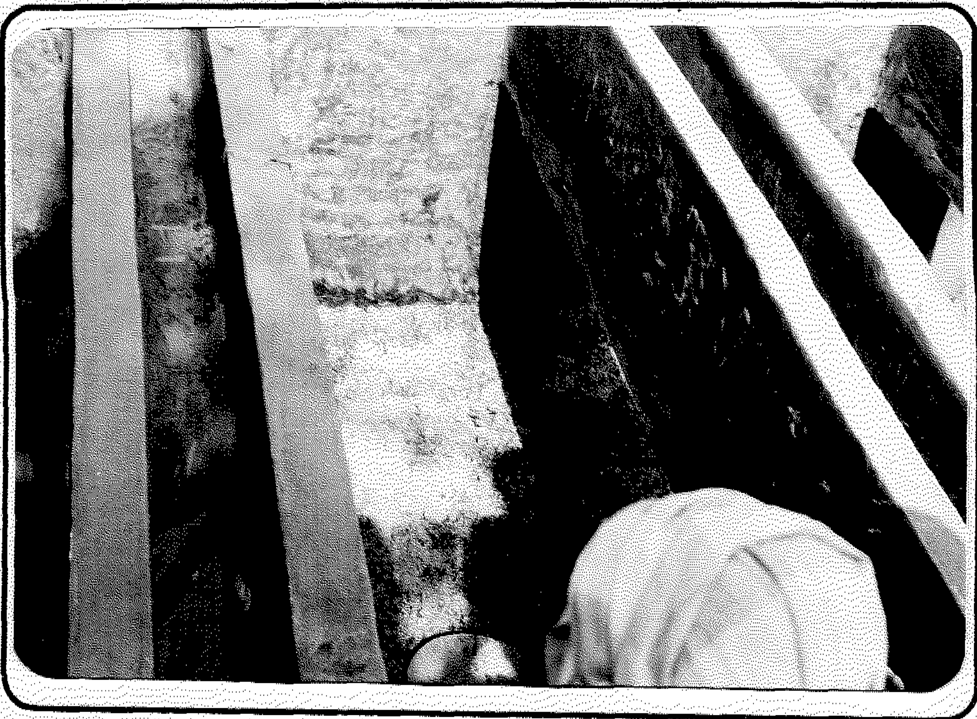
SINGLE POINT ADDITION OF COAGULANT CHEMICAL
- NOT CONDUCIVE FOR EFFECTIVE MIXING



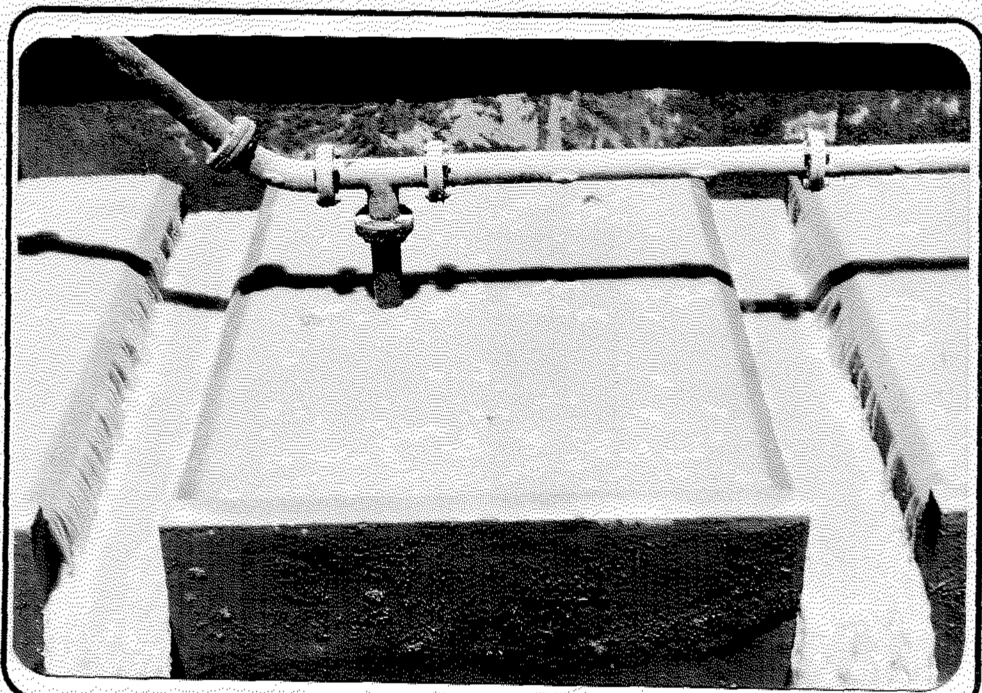
CHEMICAL DOSING THROUGH A PERFORATED PIPE
- SIMPLE BUT EFFECTIVE

SILTED SEDIMENTATION TANKS AND AQUATIC WEED GROWTH
RESULT OF NEGLECTED MAINTENANCE

CLARIFIER FLOODED DUE TO OVERLOADING
- NOT AN UNCOMMON SCENE



A SAND FILTER WITHOUT FILTER SAND !



UNIFORM DISTRIBUTION OF BACKWASH WATER
PROOF OF GOOD DESIGN AND OPERATION

A WELL EQUIPPED LABORATORY
- VITAL FOR EFFECTIVE PLANT CONTROL

GOOD HOUSEKEEPING
- AN EXAMPLE TO FOLLOW

ANNEXURES

Annexure I

PROFORMA FOR SELECTION OF WATER TREATMENT PLANTS

1.	Name of Waterworks	:
2.	Location	:
3.	Year of construction	:
4.	Design capacity of the plant	:
5.	Design population	:
6.	Augmentation/ Modification, if any with details	:
7.	Present yield	:
8.	Population (1981 census) of the city/town served by the plant	
9.	Plant ownership	:
10.	Agency in-charge of operation & maintenance	:
11.	Source of raw water	:
12.	Treatment flow sheet	:

SIGNATURE OF THE AUTHORITY

Annexure II

PROFORMA FOR COLLECTION OF ENGINEERING AND TECHNICAL DATA FOR WATER TREATMENT PLANTS

Name/Location of Plant

1. **Source of Raw Water**
   River
   Lake
   Canal
   Impounded reservoir
   Any other
   Low Water Level (LWL)
   High Water Level (HWL)
   Expected yield
   Maximum
   Average
   Minimum

2. **Raw Water Intake**
   Distance from the treatment works (furnish details of intake with drawings)
   Screens
   Type (removable, fixed)
   Size of openings
   Area of openings
   Method of cleaning
   Source(s) of Pollution, if any, in the vicinity (within 1 km) of intake
   Location and distance from intake
   Quantity of waste discharge
   Characteristics (Physical, Chemical and Bacteriological) of the waste

3. **Raw Water Pumping**
   No. of pumps
   Type (Furnish detailed specifications)
   Capacity of each pump
   Standby
   Diameter of rising main/gravity main

4. **Raw Water Flow Measurement and Control**
   Type of flow measuring device
   Detailed dimensions
   Capacity : Design
   Maximum
   Provisions for Flow rate indicator

Integrator (Total Flow Meter)
Flow Recorder
Arrangement for raw water flow control with details

5. **Pre-treatment**

Coagulation
Chemicals used for coagulation
Point(s) of application
Design dose
Type of feed
a) Wet feed
b) Dry feed

If wet feed, strength of solution used
No. of tanks
Size and capacity of each tank

If dry feed, give details
Dosing equipment
Type
Design capacity
Method of dose control
Pipes carrying the chemicals
Material
Size

Chemical Mixing
i) Mechanical
Size of flash mixer chamber
Detention time
Type of mixer (furnish details with drawings)
Speed................ rpm
H.P.
ii) Hydraulic
a) Hydraulic Jump sketch with all dimensions
b) Channel type
Length of channel
Velocity in channel for average flow
No., size and spacing baffles/fins
If fins, angle at which placed
Detention time

Flocculation

i) **Mechanical**
No. of units
Dimensions
Detention time
No. and size of paddles
Speed : rpm
H.P.

ii) **Hydraulic**
Type : end to end over and under
No. of tanks
Dimensions
No.,size and spacing of baffles
Velocity at reduced Section
Detention time

6. **Sedimentation**

Type of unit
Horizontal flow
Vertical flow
Mixed flow
Radial flow

Geometry of unit
Square
Circular
Rectangular
No. of units and dimensions of each unit
(Furnish detailed drawings)
Detention time
Design surface overflow rate
Inlet arrangement
- i) Weir
- ii) Single pipe
- iii) Multiple pipe
- iv) With baffle boards
- v) Baffles with multiple openings

Outlet arrangement
- i) End weir
- ii) Circumferencial weir
- iii) Troughs
- iv) Orifices

Method of sludge collection and removal
Details of mechanical scraper (if any)
In case of sludge blanket type
Side water depth
Slope (hopper bottom)
Bottom dimensions
Inlet pipe diameter
Maximum design depth of sludge blanket
No. and dimensions of clear water troughs
Method of sludge withdrawal
i) Hydrostatic removal
ii) Manual cleaning
iii) Pumping
Method of sludge disposal
Lagoon
Water course
Treatment

7. Filtration

Filter type
Rapid gravity
Pressure filter
Slow sand
Dual media
Principle of operation
i) Constant rate
ii) Declining rate

Rapid Gravity Filters
Nos. and size of filters
Design rate of filtration
Average
Maximum
Free board
Normal depth of water above sand bed
Maximum permissible headloss
Normal filter run
Filter media details
Sand a) Effective size
b) Uniformity coefficient
c) Depth

Supporting gravel, if any

a) No. of layers

b) Depth of each layer

c) Size of each layer

Underdrainage system

a) Type

b) Size laterals

c) Spacing of laterals

d) Diameter and spacing of openings

e) Size of manifold

If any other type-give details

Wash water troughs

Shape and size

Numbers

Spacing

Lip elevation above unexpanded sand bed

Size of wash water gullet

If syphon discharge system

No. of syphons

Size

Spacing

Piping : Influent pipe size Velocity

Effluent pipe size Velocity

Backwash arrangements

Method of filter backwash Water/air

Source of washwater

Backwash water tank capacity

Elevation with respect to filter bottom

Backwash header pipe size

Washwater outlet pipe diameter

Backwashpipe diameter (of delivery) for each filter

Surface wash details (if provided)

Design backwash water rate

Control loss of head while backwashing

Design per cent wastage in backwashing

Auxiliary scour with compressed air (if used)

Design rate of air supply

Delivery pressure - Duration of air supply

H.P of compressor motor

Compressor capacity

Storage tank capacity

Flow measuring devices for backwash rate and compressed air

Filter controls
Type of rate controller (Furnish details)
Rate of flow indicator (capacity range)
Loss of head indicator (range)

Slow sand filters
Shape No. and size of units
Design rate of filtration
    Average
    Maximum
Hours of filter operation
Free board
Normal depth of water
Maximum permissible headloss
Normal filter run
Filter media details
Sand : a) Effective size
    b) Uniformity coefficient
    c) Depth
Supporting gravel, if any :
a) No. of layers
b) Depth of each layer
c) Size of each layer
Underdrainage system (give details)
Depth of sand scraping
Method of sand washing
Quantity of water required for sand washing
Percent loss of sand in washing
Average time required to put the filter back into service after scraping
Minimum sand depth permitted
Any extra filter bed area/unit provided
Frequency of resanding overhauling
Provision for backfilling and draining of supernatant
Ventilation provided, if any

8. **Chlorination**
Chlorine used as
a) Chlorine gas
b) Bleaching powder
Direct feed or solution feed
Chlorinator type (vacuum, pressure)
Capacity
Make
Number of chlorinators

Average chlorine dose
If bleaching powder is used
Method of dosing
Design capacity
Dose control
Point(s) of application
Contact period provided

9. **Clear or Treated Water Reservoir**
Material of construction

Capacity : Compartments, if any and their capacities
MWL of reservoir
LWL of reservoir
Bottom reservoir
Free board
Provision for :
Ventilation
Overflow
Mosquito and other aquatic insects
Proof arrangement
Access and cleaning

10. **Clear Water Pumping**
Size of pump house
Type of building
Type and no. of pumps H.P. - Standby
Standby power
Flow, measuring and recording devices

11. **General Plant and Building Data**
Plant site
Distance from the city
Access roads
Rail siding
Ground elevation
Protection against flooding
Size of property
Fencing
Landscaping
Outdoor lighting
Provision for future expansion
Plant layout

Building
Type of structure
Size

Facilities
Drinking water
Toilet
Locker room
Washroom and shower
Lunch room
Tool room
Workshop

Chemical Storage
Location
Lime
Alum
Bleaching powder/chlorine
Other
Unloading and Handling methods and facilities

12. **Laboratory Facilities**

Chemical
Distilled water still
Fuming cupboard and hood
Jar testing machine
pH meter
Colorimeter
Turbidimeter
Residual chlorine kit
Reagents
Balance

Bacteriological
Refrigerator
Incubator
Oven
Autoclave
Microscope

General
Glassware
Sinks
Gas
Air
Water

Electricity
Lighting
Fire protection

13. Staff and Personnel Data

Designation	No.	Grade	Qualification	Years of service	Special Training if any

14. Financial Aspects

Capital cost of treatment plant
Annual Expenditure
    Interest
    Depreciation
    Chemicals, power etc.
    Maintenance and repairs
Staff salary
Cost of water treatment (per mld)
Water Rates
Annual revenue from sale of water

15. Proforma for recording water quality parameters

Name / Location of Plant

General

Nature and source of sample
Date and time of collection
Date of examination
Remarks, if any

Physical Characteristics

Temperature ^{0}C
Turbidity (NTU)
pH

Chemical Characteristics *

Phenolphthalein Alkalinity ($CaCO_3$)
Total alkalinity ($CaCO_3$)
Total solids

Dissolved solids
Total hardness ($CaCO_3$)
Carbonate hardness ($CaCO_3$)
Non-carbonate hardness ($CaCO_3$)
Calcium (Ca)
Magnesium (Mg)
Chlorides (Cl)
Sulphates (SO_4)
Iron (Fe)
Manganese (Mn)
Silica (SiO_2)
Sodium (Na)
Potassium (K)
Fluorides (F)
Residual chlorine (Cl_2)
COD/Permanganate value
Dissolved oxygen

Bacteriological Quality

Coliform (MPN/100 ml)
Faecal coliform (MPN/100 ml)
E. Coli (MPN/100 ml)
Faecal Streptococci (MPN/100 ml)
All values except pH are expressed as mg/L.

16. Proforma for characteristics of water works wastes

(From sedimentation tank/clarifier and spent wash water)

Name/Location of Plant

General

Nature and source of sample
Date of collection
Date of analysis
Remarks, if any

Physico-chemical characteristics *

BOD (5 days)
COD
pH
Total solids
Volatile solids
Total suspended solids
Volatile suspended solids
* Except pH all values expressed in mg/L.

Annexure III

CHECKLIST FOR EVALUATION OF WATER TREATMENT PLANT

Name/Location of Plant

Intake

Observe and collect information on :

* Condition and upkeep of the screens, problems in maintenance
* Inlet port location(s), provision for isolation and selection of ports, area of openings, etc.
* Problems due to silt accumulation and its removal
* Ease of access for maintenance and repairs
* Source and nature of pollution in the vicinity of the intake.

Pumping and flow measurement

* Availability of tools and spares
* Facilities for day today maintenance
* Problems in priming, if any
* Standby unit (any provision for)
* Standby power

Working condition of

* Flow measuring device
* Flow recorder and integrator (if used)
* Raw water flow control device

If not working, reasons thereof.

In case of small plants (less than 5 mgd), record how the plant inflow is regulated when a filter is shut down for backwash.

Water Quality

Record physico-chemical and bacteriological quality of water at different stages of treatment in the appropriate proforma.

Pre-treatment

* Frequency of tests for alum purity
* Frequency of jar test
* How does the actual dose compare with the jar test dose

Chemical dosing

* Physical condition of alum solution and storage tanks, dosing equipment, regulating valves, etc.
* Protection against corrosion

* Material of pipe carrying alum solution
* Observations on alum storage and handling
* Continuity in alum dosing

Chemical Mixing and Flocculation
* Working condition of mixers
* Material for mixer paddle
* Problems due to corrosion, if any

Observe
* Floc formation - weak/satisfactory
* Settleability of flocs

Sedimentation
* Clarity of settled water
* Observed surface overflow rate
* Observed weir loading
* Compare these with the design values
* Flow through time and displacement efficiency

Filtration

Observe
* Influent turbidity
* Filtrate turbidity
* Rate of filtration
* Initial headloss
* Final headloss
* Length of run
* Duration of :
    i) Air scour
    ii) Backwash
* Down-time due to backwashing operation
* Number of filters that can be washed at a time

At the time of backwashing observe :
* Uniformity in air agitation
* Degree of sand expansion
* Quality of wash water at the end of backwash
* Clearance between wash water trough/gullet top and expanded sand bed
* Physical condition of bed for presence of cracks, craters and undulations

Condition of filter appurtenances and problems, if any, with
* Rate setter
* Rater controller
* Rate of flow indicator
* Headloss indicator
* Valves etc.

Routine maintenance/servicing of the above and frequency

Chlorination

* Separate chlorine room - provided/not provided
* Weighing platform - provided/not provided
* Frequency of tests for chlorine demand
* If bleaching powder is used, frequency of test for available chlorine
* Strength of solution used
* Actual dose of chlorine applied
* Working condition of dosing equipment (chlorinator), solution tower
* Type and condition of materials used for carrying chlorine solution
* Observe for leaks of chlorine gas
* Provision for ventilation
* Safety equipment - available/not available

Waterworks Waste

* Characteristics of sludge from sedimentation tank / clarifier/washwater (Record data in appropriate proforma)
* Volume of waterworks waste (Total plant inflow - Total plant outflow)

Annexure IV

NOTE ON PLANT APPRAISAL

The object of appraisal is to verify and improve the functional efficiency of the plant components, to discover any utilizable reserve capacity for additional supply and to ensure that adequate stocks of spares, accessories and consumable stores are available. The following guidelines may help in such appraisal.

Pumping Stations

The survey should assess : freedom from flood hazards, the cleanliness of pump pits, priming arrangements, and the freedom of suction wells, suction pipes, and valve chambers from sources of pollution ; the quality, rating, capacity range and reliability of *pump sets* ; performance curves and reserve capacity for emergency intake and filtered water pumps ; power adequacy and availability.

Chemical Dosing

It is useful to check whether the dosage is in accordance with laboratory tests, and to carry out a simple jar test on the spot for confirmation. The check should also ensure that solution perparation and storage and chemical feeding conform to the standard directions and that no improvizations have been adopted to cover stock deficiency or plant disorder. Such deficiencies should be pointed out immediately and recorded.

Coagulation and Flocculation

Flash mixers and flocculators should be checked and their working conditions recorded.

Dosing efficiency and floc formation should be verified.

Points of excessively high or low velocity in the flocculation chambers and bad short-circuiting should be investigated.

Sedimentation

The characteristics and functional efficiency of sedimentation basins are influenced by their shape and size, the method of influent entry, the hydraulics of the tank, effluent weir location and sludge removal arrangements.

The basins should deliver clear effluents. The overflow rate and weir loading should be checked. sludge accumulation and decrease in quality of the passing water are the usual defects to be looked for. Algal contamination can be decreased by prechlorination ; if such contamination persists the quality and turbidity of the influent raw water should be examined with a view to more radical measures.

In addition to the usual design norms for surface loading and weir overflow rates, the displacement efficiency as between theoretical detention period and actual flow through period should be a reliable parameter for a welldesigned basin. The degree of effluent clarity and its uniformity are good indications of the soundness of the design. Normally, a displacement efficiency of about 60 per cent is ideal, while a figure between 30 per cent and 50 per cent may be considered good ; if it is less than 30 per cent some improvements are needed. The reserve capacity available from a basin may be gauged by testing its displacement efficiency. If the efficiency is high enough, the basin may be overloaded in an emergency. If it is low, the test itself may help to expose the aspects of the basin that need improvement. It is also necessary to check that the machinery for sludge scraping and sludge removal is maintained in good working order.

Filtration

The turbidity of the influent and effluent water is reliable index of the efficiency of filtration and also of the removal of bacteria in the case of slow sand filters.

In order to assess the level of filter efficiency and its capacity for overload in an emergency, a critical study of the following factors would be necessary; the length of the filter runs, filter-head buildups, the periodicity of filter cleaning and overhauling, the depth and texture of the sand layer in the filter and the condition of the filter gravel and underdrain system.

In rapid sand gravity filters, a critical study would be required of the length of filter runs, the filtration rates, the duration of washing, washwater consumption, the efficiecy of filter washing, the hydraulics of filter washing, the reliability and efficiency of surface wash and air wash aids where provided, spacing of laterals, mudballs formation, loss of sand and displacement of gravel, undulations and cracks in the filter surface, consistency of filter effluent quality, general reliability of filter appurtenances, rate controllers, valves and indicators.

The actual output from the filter plant, should be studied, in quality and quantity, and the scope for available reserve capacity may be assessed. The necessity for temporary additions at the inlet and outlet controls to cater for such overload may also be studied, if the initial design did not cover this aspect.

The inherent deficiencies of pressure filters also influence plant performance. The vertical type should be more satisfactory than the horizontal type. The survey should examine whether filter washing is done only with filtered water; whether inlet and outlet pressure indicators are reliable; whether effluent quality is uniform; and whether frequency of washing and consumption of washwater are normal. The search for a reserve capacity in such types of filter is somewhat restricted as visual inspection of the filter bed is not possible at the time of cleaning. If the raw water is stable and clean, it can be assumed that a marginal reserve capacity exists and could be used by increasing the pressure as much as possible with the available pumps and by strict postchlorination; extra capacity could also be gained by working the filters for longer hours if normal demands required only part time working.

Chlorination

The survey should examine the points of application from the point of view of adequacy and of the method provided; the rating, capacity range, quality and reliability of the equipment; the condition of the working parts of the chlorinators and the safety measures against escape of chlorine gas; whether the chlorine dosage is based on laboratory tests and is applied correctly; whether the residual chlorine is maintained in the most distant parts of the system; and the frequency and adequacy of sampling and laboratory test.

Annexure V

CPHEEO STANDARDS FOR DRINKING WATER

A) Physical and Chemical Standards :

The physical and chemical quality of water should not exceed the limits shown in the table below :

S.No.	Characteristics	*Acceptable	**Cause for rejection
1.	Turbidity (Units on J.T.U. scale)	2.5	10
2.	Colour (Units on platinum cobalt scale)	5.0	25
3.	Taste and Odour	Unobjectionable	Unobjectionable
4.	pH	7.0 to 8.5	6.5 to 9.2
5.	Total dissolved solids (mg/L)	500	1500
6.	Total hardness as $CaCO_3$ (mg/L)	200	600
7.	Chlorides as Cl (mg/L)	200	1000
8.	Sulphates as SO_4 (mg/L)	200	400
9.	Fluorides as F (mg/L)	1.0	1.5
10.	Nitrates as NO_3 (mg/L)	45	45
11.	Calcium as Ca (mg/L)	75	200
12.	Magnesium as Mg (mg/L)	>30	150

If there are 250 mg/L of sulphates, magnesium content can be increased to a maximum of 125 mg/L with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphate

S.No.	Characteristics,	*Acceptable	**Cause for rejection
13.	Iron as Fe (mg/L)	0.1	1.0
14.	Manganese as Mn (mg/L)	0.05	0.5
15.	Copper as Cu (mg/L)	0.05	1.5
16.	Zinc as Zn (mg/L)	5.0	15.0
17.	Phenolic compounds as Phenol (mg/L)	0.001	0.002
18.	Anionic detergents as MBAS (mg/L)	0.2	1.0
19.	Mineral Oil (mg/L)	0.01	0.3
	Toxic Materials		
20.	Arsenic as As (mg/L)	0.05	0.05
21.	Cadmium as Cd (mg/L)	0.01	0.01
22.	Chromium as Hexavalent Cr (mg/L)	0.05	0.05
23.	Cyanides as CN (mg/L)	0.05	0.05
24.	Lead as Pb (mg/L)	0.10	0.10
25.	Selenium as Se (mg/L)	0.01	0.01
26.	Mercury as Hg (mg/L)	0.001	0.001
27.	Polynuclear aromatic hydrocarbons (PAH) (ug/L)	0.2	0.2
	Radio Activity		
28.	Gross Alpha activity (pCi/L)	3.0	3.0
29.	Gross Beta activity (pCi/L)	30.0	30.0

Notes :

*1. The figures indicated under the column "acceptable" are the limits upto which the water is generally acceptable to the consumers.

**2. Figures in excess of those mentioned under "acceptable" render the water not-acceptable, but still may be tolerated in the absence of alternative and better source but upto the limits indicated under column "cause for rejection" above which the supply will have to be rejected.

3. It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radionuclides in order to assess the acceptability or otherwise for public consumption.

B) Bacteriological Standards :

i. Water entering the distribution system :

Coliform count in any sample of 100 ml should be zero. A sample of water entering the distribution system that does not conform to this standard calls for an immediate investigation into both the efficacy of the purification process and the method of sampling.

ii. Water in the distribution system shall satisfy all the three criteria indicated below :

* <u>E. Coli</u> count in 100 ml of any sample should be zero.
* Coliform organisms not more than 10 per 100 ml shall be present in any sample.
* Coliform organisms should not be detectable in 100 ml of any two consecutive samples or more than 50 % of the samples collected for the year.

If coliform organisms are found, resampling should be done. The repeated finding of 1 to 10 coliform organisms in 100 ml or the appearance of higher numbers in any sample should necessitate the investigation and removal of the source of pollution.

iii. Individual or small community supplies :

<u>E. Coli</u> count should be zero in any sample of 100 ml and coliform organisms should not be more than 3 per 100 ml. (If repeated samples show the presence of coliform organisms, steps should be taken to discover and remove the source of the pollution. If coliforms exceed 23 per 100 ml, the supply should be disinfected.)

C) Virological Aspects :

0.5 mg/L of free chlorine residual for one hour is sufficient to inactivate virus, even in water that was originally polluted. This free chlorine residual is to be insisted in all disinfected supplies in areas suspected of endemicity of infectious hepatitis to take care of the safety of the supply from virus point of view which incidentally takes care of safety from the bacteriological point of view as well. For other areas 0.2 mg/L of free chlorine residual for half an hour should be insisted.

Annexure VI

PRINCIPLES OF WATER SUPPLY SOURCE PROTECTION

* The contamination, pollution and any degradation of the quality of water supply sources have damaging effects on health, well-being and economy, as well as on the general environment.

* Water, being an essential of life, is one of the most valuable resources of man. Therefore, everyone has a natural right to safe, acceptable quality water for drinking, culinary and other domestic uses.

* The water purveyor, be it an individual, a utility or the municipality, has a natural right to good quality raw water.

* The responsibility for preventing and abating pollution and contamination of raw water sources rests with those who discharge, directly or indirectly, waste products into the raw water sources or the land, as well as with those who cause unacceptable land use conditions within the watershed.

* All water and land users are responsible for taking effective action to identify and reduce to the lowest practical level pollution of raw water sources.

* All levels of government and regional planning and water resources agencies must coordinate their efforts in managing, regulating and monitoring water resources.

* Land, water and air are interrelated resources, and planning for their protection, management and use must consider their mutual impacts and influences in an integrated manner.

* Where reasonable access to other water bodies is available, public water supply source reservoirs must not be used for recreational purposes.

* Primary body contact sports such as swimming, water-skiing and wading must not be allowed in water supply sources.

* Distribution or equalizing reservoirs from which water is supplied directly to the public requires the strictest of controls and must under no conditions or circumstances be used for any type of recreation.

* Control of the quality of water supply sources (including catchment basins, impoundments and distribution reservoirs) is imperative to facilitate the effective and economical production of safe, adequate and aesthetically acceptable water for domestic uses, and to enhance the economic value of the water for municipal and industrial purposes.

WATER SUPPLY SOURCE
MONITORING & INSPECTION CONSIDERATIONS

* **Watershed Inspection**

  Physical Conditions within the watershed, particularly near reservoirs, in relation to :

  - Erosion, sedimentation, silt movement
  - Floating solids, debris, oil, grease, algal mats
  - Excessive vegetative growth, unusually enriched growth of green grass (indicative of sewage contamination, e.g., by failure of septic tanks)
  - Changes to water course path or conditions
  - Slumping, terrain heaving, drift wood etc

* **Waste Disposal**

  . Solid wastes dumping

  . Disposal or spreading of sludges on land

  . Oil drums, large chemical containers, other unwarranted industrial and household materials, equipment, appliances, and goods

  . Liquid waste discharges including septic tank effluents (pumpouts)

  . Channelled or unchannelled surface run-offs or washwater

* **Land Use**

  . Changes in site use (number of people, additions to buildings, repairs or additions to septic systems).

  . Activities in watershed-recreation, waste disposal on land and injection wells, construction, forestry operations etc.

  . Industrial storage facilities for fuels or chemicals.

  . Aerial spraying of chemical pest or weed control agents within or surrounding the watershed.

  . Condition of any road crossing, causeways, beaches, slopes, etc.

  . Grazing of domesticated animals (cattle, sheep, horses) and condition of the yards.

  . Utilization of transportation corridors for the movement of materials which may result in contamination should an accident occur.

Annexure VII

CPHEEO DESIGN NORMS FOR TREATMENT UNITS

S.No.	System component	Design variable	Range
1.	Cascade aerator	Head required	0.5 - 3 m
		Space required	0.5 - 0.65 m^2/mld
2.	Rapid mix unit		
	* Hydraulic	Velocity	2 - 4 mps
		Head loss	15 - 60 cm
	* Mechanical	Velocity gradient	> 300 sec^{-1}
		Detention time	20 - 40 sec
		Head loss	20 - 60 cm of water
		Propeller speed	>100 rpm
		Power requirement	1 - 3 watt /m^3/hr
3.	Slow mix unit	Velocity gradient	20 - 75 sec^{-1}
	* Hydraulic	Velocity in channel space bet.baffles	15 - 45 cm/sec
		Head loss	15 - 60 cm
		Detention time	10 - 30 min
	* Mechanical	Detention time	20 - 30 min
		Head loss	15 cm
		Power input	0.5 - 1 watts/m^3/hr
		Paddle area	10 - 25 % of tank sectional area in the plane of the shaft
		Peripheral velocity of paddles	0.15 - 0.6 mps

Contd...

S.No.	System component	Design variable	Range
4.	Sedimentation unit	Surface overflow rate	
		* Horizontal flow	30 - 40 $m^3/d/m^2$
		* Vertical flow	40 - 50 $m^3/d/m^2$
		Detention time	2 - 2.5 hr
		Weir loading rate	300 - 1500 $m^3/d/m$
		Depth	2.5 - 4 m
5.	Rapid gravity filters	Filtration rate	4.8 - 9.6 m/hr
		Area of one unit	max 100 m^2
		Overall depth	2.6 m
		Ratio of length to width	1.25 - 1.33
		Permissible head loss	1.8 - 2 m
		Depth of sand	60 - 75 cm
		Sand size	E.S. 0.45 - 0.70 mm U.C. 1.3 - 1.7
		Backwash	
		* Air scour rate	600 - 900 lpm/m^2 at 0.35 kg/cm^2 for 5 min
		* Wash water rate	
		. With air scour	24 - 36 m/hr
		. Without air scour	36 m/hr

Annexure VIII

NOTE ON PLANT MAINTENANCE AND RECORDS

The primary goal of maintenance is to provide protection of the investment, whether it be public or private enterprise. There are three special areas of maintenance viz. house keeping, preventive maintenance and corrective maintenance.

Housekeeping

Most of the times, the appearance of grounds and thebuildings is an accurate indication of the preventive and corrective maintenance habits of the plant operator. Good housekeeping can help gain public support, and certainly make a lasting impression on persons visiting the plant.

The water treatment plants (WTP) do not stay new but they can almost always be clean. A schedule for cleaning windows, washing walls and floors, and dusting is necessary. Some maintenance items require daily attention, whereas others require weekly, monthly, or even only annual consideration.

Proper paint is an important factor of housekeeping maintenance. Brightly painted valve handles, clean shiny equipment surfaces and light airy interiors make a once dull plant a pleasant place to work. Grounds beautification should also be considered equally as important as good maintenance of buildings and equipment. A green lawn adjacent to WTP, enhances the appearance tremendously. However, appearance is not the only advantage. A well kept lawn and trees keep the summer temperatures lower in buildings and prevent wind-blown dust from entering the equipment.

Preventive Maintenance

It is of the utmost importance that all operators form the habit of keeping their mechanical equipment in good repair. Successful preventive maintenance depends largely on knowledge, persistent hard work, and a sincere interest. Knowledge can also be gained by experience.

Manufacturers should provide instructions on operation and maintenance, of the equipment which may include the following :

* information on proper method of installation, as correct installation is a prerequisite for proper operation

* lubrication instructions, which should be studied and carried out before the equipment is placed in operation

* an explanation of proper operation, so that incorrect operation can be recognized, as well as pointers to help locate reasons for failure

* procedures for dismantling and reassembling for repairs

* parts list and repair order instructions

In brief, the operator should be provided with all the essential needed for a programme of preventive maintenance in his plant.

Preventive maintenance should be planned and scheduled operation designed to minimize deterioration and correct deficiencies on the spot. It is nothing more than a method of keeping facilities in good condition by assigning specific people to specific tasks on a predetermined schedule. It corrects defects in the early stages before they develop into major repairs or replacements.

Corrective Maintenance

Corrective maintenance means the repair or replacement of badly worn parts, or parts which have physically failed in service. It refers to those situations which have passed the preventive maintenance stage, either gradually through normal wear and tear, or abruptly by physical failure.

For corrective maintenance, a stock of spare parts must be kept up to full inventory, as the replacement part is generally needed yesterday. The supervisor / operator should also know which local supply house can serve him with needed materials, and which local machine and repair shop is equipped and has competent personnel to aid him, if necessary. If an efficient preventive maintenance programmeis carried out, corrective maintenance will be held to a minimum.

Plant Records

Maintaining plant records is the keystone for good plant operation. Records are necessary for various important reasons such as :

* an aid to better operation,

* proof of effective operation, and

* a journal for future reference

To avoid misinterpretation and confusion, records should be clear and concise, and information must be in common units. Uniformity and simplicity is necessary to assist others in making comparisons and analyses of records. With the aid of records, it is possible to determine the best time to take units out of service for repair or maintenance. Trends noted in the records can serve as a guide to changes in operational procedures. This is especially true in a new plant or a remodelled plant where procedures are initially set up arbitrarily.

Records provide the basic data for proof of efficiency of operation. A water treatment plant is designed to perform various functions and remove turbidity of raw water to a desirable limit in various unit operations. The record will indicate whether the plant is obtaining this efficiency. If not, procedures should be studied to determine what changes could increase the efficiency.

The use of records for future reference is of great importance. The plant incharge who will make reviews and studies of the records will be able to plan the operations and maintenance effectively.

Equipment Manuals

Each piece of equipment in operation at the plant has some type of manual, giving all the pertinent information needed for operation, maintenance, spare parts ordering, and lubrication. These manuals should be placed on file and made available to all plant personnel at all times.

Routine Plant Maintenance

This is to be generally accomplished by the shift operator. Each shift has its specific duties which should be placed in a permanent record available to the operator, and subject to change. In conjunction with this, there should be a daily log listing the equipment to be checked each shift.

Routine Operating Procedure

Routine maintenance should be set up as a plant policy. These should be written up and placed in a permanent folder and accessible to the operator at all times. Any changes in operational procedures should be posted so that all the operators know what is going on at all times, no matter which shift they are working.

Grease Chart

The grease chart should include all pieces of equipment that requires greasing, which need lubrication on a monthly basis. All other equipment requiring special lubricants and varied attention may be included in ·annual maintenance schedule.

Equipment Maintenance Inspection

Periodic inspection, other than which appears on regular maintenance schedules, pays dividends. If an operator or maintenance personnel notices that some piece of equipment is not functioning properly, he should try to correct the fault immediately. Whether or not the operation is corrected, the operator should report it to the supervisor.

Annual Maintenance Schedule

This schedule should include all maintenance projects for the entire year, such as housekeeping, preventive and corrective maintenance, whether it occurs weekly, monthly, semiannually, or annually.

Daily Work Layout

A daily sheet which should be posted for three shifts, may include items that appear on the Annual Maintenance Schedule, which are assigned in addition to normal operational duties. There should also be some space for each operator to indicate whether or not his work has been completed and space for his signature. The sheet may also have space for remarks or explanations, if necessary. The daily work sheet should be made out a day ahead, giving the person in charge an opportunity to plan ahead.

Spare Parts Stock Level Control

This record deals with the items which are most responsible for the continuous operation of the plant. The spare parts record should be listed on a separate sheet, following each specific piece of equipment in the maintenance record. Some units will have spare parts as part of the original equipment. Experience will also indicate as to which parts are critical items in the inventory.

Expendable Shop Supplies Control

Bolts, nuts, nails, and screws are items which seem to be those that are never the right size, but an adequate stock of these items will save a lot of time. A separate record, with a running inventory, should be kept which allows time to replenish the supplies before they are depleted.

Tools & Maintenance Equipment

Operators can not be mechanics without tools. A plant must have good tools and a basic amount of these are necessary, which should be available to the operators at all times. By placing all the tools on a panel board for use and inspection, loss will be a negligent matter.

Annexure IX

DETAILED LIST OF MAINTENANCE ACTIVITIES

It must be brought out that any attempt to list maintenance activities necessarily refers to preventive maintenance activities comprising maintenance works and maintenance oriented inspections. Such lists, in absence of any experience, could be developed from the recommendations contained in standard manuals viz. CPHEEO Manual or from the equipment suppliers literature. The frequency recommended for an activity be initially adopted on an adhoc basis, keeping in view the fact that the same are not sacrosanct and that these could and should be modified based on experience gained from time to time. The list of maintenance activities presented hereunder is meant to serve only as an initial guide.

Section/ part to be attended	Maintenance to be carried out	Frequency/Time Interval between two consecutive activities
A. CENTRIFUGAL PUMPS		
1. Bearings	Checking of temperature	2 months
2. Glands	Checking/changing of gland packings	1 month
3. Bearings	Checking/greasing	1 month
	Replacement	6 months
4. Gauges	Calibration	12 months
5. Valves	Changing of gland packing	12 months
6. Exhaust pumps and auxilliaries	Checking/changing of gland packings	12 months
7. Impeller	Checking of impeller blades, sleeves, efficiency, rings, bearings, impeller nut etc.	12 months
B. ELECTRICAL MOTORS		
1. Induction motor, stator and rotor	Cleaning by air blower and general inspection	3 months
2. Slip ring device	Closing of slip rings and adjustment of carbon brushes, short circuiting jaws, oiling clutch etc.	1 month
3. Bearing	Lubrication	1 month
4. Windings	Checking of motor after taking out its rotor, dust blowing, checking of end connections, testing of insulation, no-load testing	24 months

Section/ part to be attended	Maintenance to be carried out	Frequency/Time Interval between two consecutive activities
C. POWER TRANSFORMER		
	1. Checking of silica gel, topping of transformer oil, temperature guage, vent pipe, voltage tap changing switch. (These works are not to be attended to in rainy season)	6 months
	2. Filtration of oil, checking of di-electric strength,viscosity of oil, terminal boxes, insulators, general tightening of fastners, stopping of leakages.	12 months
	3. Functional test	12 months
	4. Checking of core of the transformer and its windings and insulation condition.	60 months
D. SWITCHGEARS (AIR OR OIL CIRCUIT BREAKERS)		
1. Circuit breaker	Checking of fastenings, moving and fixed contacts, no vast coil, overload coil, interlock system, condition of transformer oil, knife switches and insulation.	3 months
2. Oil tank	Cleaning and topping of oil, checking dielectric strength of transformer ' oil.	12 months
3. Contacts	Changing of old and sluggish transformer oil of circuit breaker changing of old and worn out contacts	12 months

Section/ part to be attended	Maintenance to be carried out	Frequency/Time Interval between two consecutive activities
E. ALUM DOSING EQUIPMENT		
1. Saturation tank	Cleaning, checking of acid resistant coating	12 months
2. Pipe and conduits	Cleaning and removal of deposits	1 month
3. Measuring of control devices	Checking and calibration	1 month
F. CLARIFLOCCULATOR AND THEIR DRIVE		
1. Trolley wheels	Lubrication	1 month
2. Reduction gear box	Checking and topping of oil	1 month
3. Turn table mechanism	Checking and topping of oil	3 months
4. Vertical slip ring motor	Dust blowing, checking of carbon brushes, bearing etc.	3 months
5. Rail/track	Checking alignment	6 months
6. Reduction gear box	Checking of helical or spurgear condition	12 months
7. Rubber tyre or Iron wheels	Checking for wear and tear and its positioning	6 months
8. M.S. Serapen	Checking fasteners	12 months
9. Turn table mechanisms	Checking of its sprockets, chains, steel balls and grease boxes	12 months

Section/ part to be attended	Maintenance to be carried out	Frequency/Time Interval between two consecutive activities
G. FILTERS		
1. Filter media	Topping of sand	6 months
2. Filter media	Checking E.S and U.C	60 months
3. Underdrain system	Checking of nozzles, pipes and dust etc.	60 months
4. Sluice valves packing	Changing of gland	12 months
5. Guages and indicators	Checking accuracy and calibration	1 month
6. Filter box	Checking for leakages, cleaning, Lime washing	6 months
H. CHLORINATORS		
1. Indicator	Checking and calibration	1 month
2. Chlorine conveying pipes and valves	Checking and cleaning	1 month
3. Gas masks	Functional checks	1 month
4. Gas leakage	Checking of leakage	daily
5. Liquid trap	Opening and cleaning	1 month
I. SLUICE VALVES		
1. Glands	Checking and changing of glands in case of daily operated valves	12 months
2. Valve function	Functional check in case of rarely operated valves	12 months

Section/ part to be attended	Maintenance to be carried out	Frequency/Time Interval between two consecutive activities
J. CLEAR WATER RESERVOIR		
	1. Cleaning and lime washing of sides	12 months
	2. Check for leakage	36 months
	3. Check condition of accesses and air vents	12 months

Notes :

1) The activities concerning valves, motors, pumps etc. are not repeated as relevant activities will be applicable wherever these units exist

2) Some activities are based on CPHEEO recommendations with appropriate modifications based on experience

Annexure X

RECOMMENDED STAFFING PATTERN FOR WATER WORKS

S.No.	SYSTEM COMPONENT	RECOMMENDED STAFF			REMARKS
1.	Raw water pump house	Pump operator Helper	: :	One/shift One/shift	Pump operator should be ITI certificate (wiremen/ electrician) holder
2.	Raw water rising main	Fitter/Helper	:	One No.	For every eight km length or part thereof
3.	Treatment plant	Filter operator Helpers	: :	One/shift Two/shift	For every 50 mld plant capacity or part thereof
4.	Clear water pump house	Pump operator Helper	: :	One/shift One/shift	Pump operator should be ITI certificate (wiremen/ electrician) holder
5.	Plant laboratory	Chemist Lab. Assistant Lab. Attendant	: : :	One No. One No. One No.	For every 100 mld plant capacity or part thereof

Note :

1. The above staffing pattern provides for the requirements at the water works only
2. Unskilled labour/mazdoor would be extra depending upon the size of the plant and specific needs
3. One Assistant Engineer will be incharge of plants with capacities upto 100 mld
4. For metropolitan cities with plants of capacities larger than 100 mld, the staff may be suitably increased

Annexure XI

MANAGEMENT INFORMATION SYSTEM FORMAT FOR URBAN WATER SUPPLY

IDENTIFICATION PARTICULARS

1.	Name of State/UT	:	
2.	Name of the Town	:	
3.	Population (as per 1981 census)	:	Total SC ST
4.	Class of Town	:	
5.	Area (sq. km,.)	:	
6.	No of households	:	
7.	Slum (a) Nos.	:	
	(b) Population	:	

DATA ON WATER SUPPLY

8.	Source(s) of water supply	:	

PIPED WATER

9.	Installed Capacity (mld)	:	
10.	Actual water production (mld)	:	
11.	Adopted treatment	:	
12.	Year of installation	:	
13.	No of connections as on date		
	(a) House service connections	:	
	(b) Standposts	:	
14.	Present Per capita supply (lpcd)		
	(a) House service connections	:	
	(b) Standposts	:	
15.	Category of present coverage	:	A/B/C/D/E
16.	Population covered by piped water (in per cent)	:	
17.	Approximate length of distribution network (km)	:	
18.	Water quality surveillance		
	Raw Water	:	Yes/No
	Treated Water	:	Yes/No
	Distribution points	:	Yes/No

SPOT SOURCES

19. (a) Number of handpumps :
    (b) Number of other sources :

20. Population covered by spot sources (in per cent) :

OPERATING AND FINANCIAL DATA

21. (a) Average cost of water production : Rs.——/1000 litres
    (b) Annual operation and maintenance expenditure (Rs.) for the preceding three years 1 2 3
    - Wages & salaries :
    - Consumables including chemicals :
    - Others including electricity. :

    Total : --

WATER RATE/TAX/CESS

22. Tariff in effect since (date)
    (i) Tariff (metered)
    a) domestic
    b) industrial
    c) commercial
    d) others
    (ii) Water rate (unmetered)
    (iii) Water tax (unmetered)
    (iv) Cess/others, if any

23. Annual revenue earned in the preceeding three years : 1 2 3
    Rs. ....

24. Name of the operation & maintenance agency :

25. Name & Designation of the officer who furnished the information :

Note A = Town fully covered - requires no augmentation till the year ....
B = Town fully covered - requires augmentation of service level
C = Town partly covered - needs extension
D = Town partly covered - needs augmentation and extension
E = Town having no safe water supply

EXPLANATORY NOTE

Item - 2. Write the name of the town as indicated in the Census (1981). If the town is also known by any other name, that may also be indicated within parenthesis.

Item - 4. The town is classified on the basis of population size as under :

Classification		Population size
I	:	100,000 and above
II	:	50,000 to 99,999
III	:	20,000 to 49,999
IV	:	10,000 to 19,999
V	:	5000 to 9999.
VI	:	less than 5000

Item - 7. These items pertain to slum areas within the town. If no slum area is in the town,negative reply may be given instead of leaving the item blank.

Item - 8. Mention the presently exploited sources of raw water under this item.

Item - 9. State the total capacity of the existing water supply facilities installed. In case of different sources, give the break-up for respective source e.g. ground water (20 mld) surface water from stream (30 mld) impounding reservoirs (5 mld) etc.

Item - 10. Mention present water production.

Item - 11. Indicate the treatment flow sheet. For different sources, if the treatment adopted is different, give details of the same.

Item - 12. This item refers to year of installation of water supply system in the town. In case the water supply has been augmented the year of initial installation and year of augmentation may be stated. Where large diameter tube wells are provided, indicate year-wise installation of number of tube wells.

Item - 15. Under this item strike out the irrelevant code (A/B/C/D/E).

Item - 19. (a) State the number of handpumps if any,provided for drinking water supply in the town.

(b) State the number of other drinking water sources and also indicate the type of the source e.g. dug wells, tanks,ponds etc.

Item - 21. (a) While arriving at the cost of water production - capital investment, debt service, depreciation etc. should be taken into account along with the establishment cost and other cost such as consumables, energy and others.

PART II

INDIVIDUAL PLANT APPRAISAL

MUNICIPAL WATER WORKS - KURNOOL

INTRODUCTION

Kurnool town was first provided with 4.54 mld of protected water supply using slow sand filters in the year 1914 with Tungabhadra river as the source. The supply was augmented to the present level of 29.5 mld by tapping another source, viz. K.C. canal. The canal is fed from the barrage constructed across the river Tungabhadra at Sunkesula. Presently, the Kurnool water works comprises four separate treatment plants. The plant with a design capacity of 6.8 mld with conventional pre-treatment and rapid sand filtration has been evaluated for its performance. The plant layout is shown in Fig 1.1 and the plant summary data is presented in Table 1.1. The plant is maintainted by the Kurnool Municipal Council.

PLANT APPRAISAL

Raw water quality and flow measurement

The K.C. Canal remains closed for two months in a year for annual maintenance when the entire requirement is met from the river source. However, occasional water scarcity has been reported particularly during summer. During such periods, difficulties are experienced due to change in the river flow regime. Instances have been recorded when the river flow had to be diverted to the intake over a distance of 1-2 km by digging channels. Adequate provision for standby pumps has been made at both the river and canal pump houses.

Raw water from both the sources is blended at the inlet chamber of pre-sedimentation tanks. These tanks, intended to serve as storage-cum-sedimentation units prior to slow sand filtration, have a total capacity of 15.9 million litres. While settled raw water flows under gravity to slow sand filters, low lift pumps have been installed to pump settled (raw) water to the conventional treatment units, since gravity flow is not feasible. Water quality data for raw and finished water during different visits to the plant is given in Table 1.2.

The flow measuring device, i.e. 'V' notch installed at the raw water inlet channel at the pre-sedimentation tanks was found corroded and in disuse. A Venturi flume has been provided at the inlet channel receiving raw water through low lift pumps to measure the plant inflow to the conventional treatment plant. The flow indicator was non-operational during the visit, and hence the plant inflow was computed by measuring the rise in water level in the clariflocculator over a known period. While the design capacity of the plant is 6.8 mld, actual inflow was 6.4 mld and 8.17 mld as observed during the two visits to the plant.

Pre-treatment

Alum is used as the chemical coagulant. The chemical dosing was found far from satisfactory. Neither alum solution of uniform strength was prepared nor the dose was regulated. The mechanical flash mix unit was out of order and hence non-functional. Although the flocculators and sludge scraper mechanism were working, the floc formation was found poor. Not withstanding the fact that all the pre-treatment units satisfy the design criteria recommended by CPHEEO, their performance was poor,primarily due to incorrect alum dose and ineffective rapid mixing. This was evident from the settled water turbidity of 9.5 NTU as against the raw water turbidity of 10 NTU (Table 1.3).

Filtration

The filter equipment,viz. rate setters, rate of flow controllers and loss of head indicators were found non-functional. Filter cleaning by air-scour followed by water wash was satisfactory. The filters produced a filtrate of turbidity consistently less than 2.5 NTU.

Disinfection

The filtered water is disinfected using bleaching powder. The storage and handling of bleaching powder was far from satisfactory. There was very little available chlorine in the bleaching powder resulting in inadequate chlorination. This was confirmed from the absence of residual chlorine in the finished water The turbidity of finished water was more than that of the filtrate during one of the visits caused due to the addition of bleaching powder

Laboratory facilities

The laboratory equipment available at the plant include ; pH meter, conductivity meter, jar-test apparatus and chloroscope.These were not in use as no chemist has beenposted at the plant for water quality testing and plant control.

Plant staff

The staff at the plant include: Assistant Engineer (1 no.), Filter-bed supervisor (6 nos.), Electrical operators (19 nos.), Fitters (3 nos.) and Helpers (12 nos.).

None of the plant personnel had undergone any formal training in water works operation and maintenance.

RECOMMENDATIONS

* The raw water flow measuring/indicating devices should be maintained properly since the knowledge of plant inflow is essential for proper control of chemical dosages and plant operation.

* Steps should be taken to keep the rapid mix units in working condition to achieve chemical pre-treatment.

* Proper functioning of filter rate controllers and loss of head indicators is necessary for control of filter operation. These equipment should, therefore, be got repaired/replaced.

* Proper dosage of chlorine as determined by chlorine demand test must be ensured to maintain the desired level of residual chlorine in the finished water. The bleaching powder should confirm to the relevant IS specifications. As the combined capacity of the plants is large, use of gas chlorinators should be explored.

* A turbidity meter of the Hach type should be procured and the available laboratory equipment at the plant should be made use for the routine water quality testing and plant control by appointing a trained chemist.

* The staff at the water works should be given formal training in operation and control of water treatment plant.

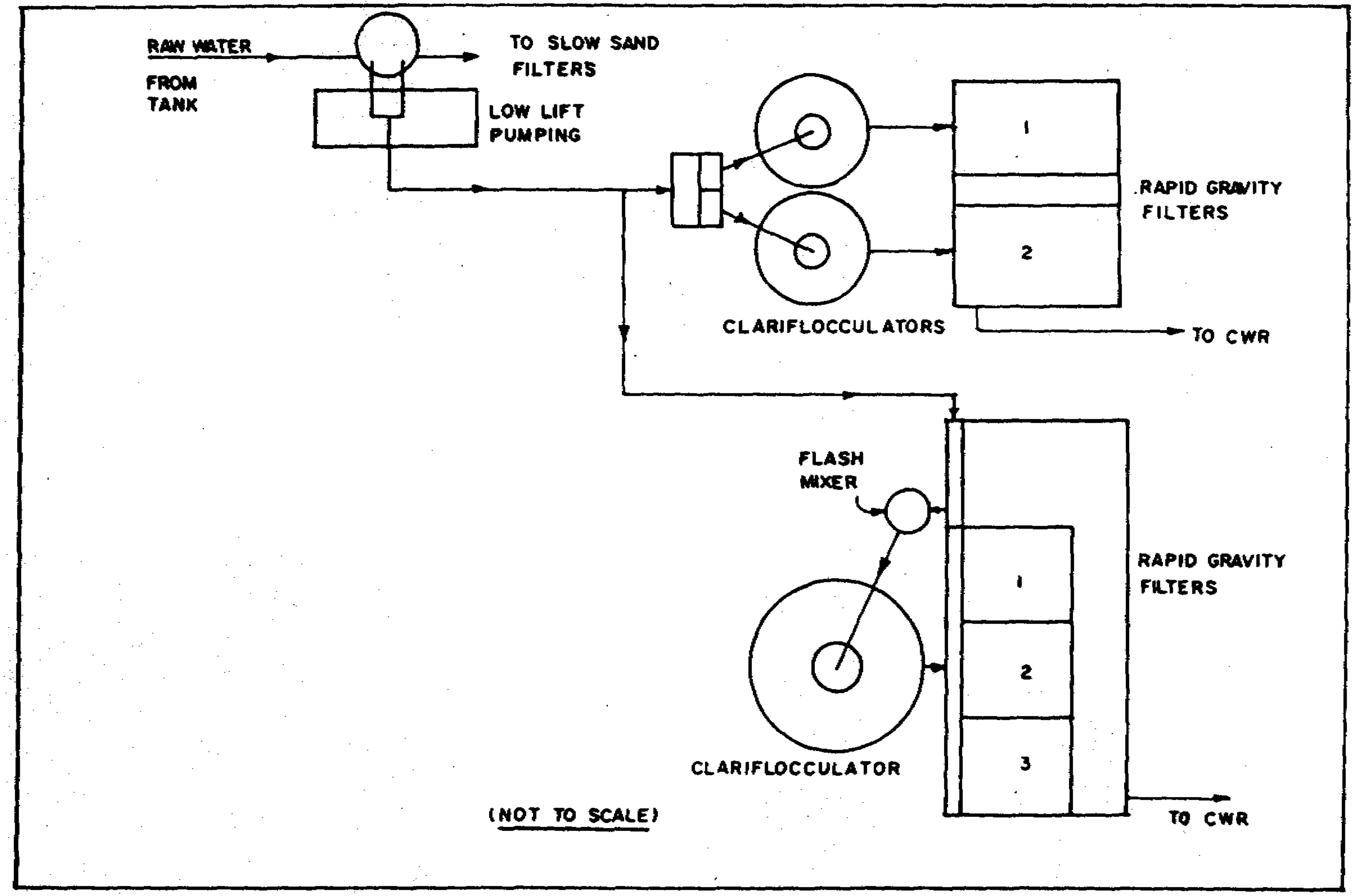


FIG 1.1 LAYOUT PLAN OF WATER TREATMENT PLANT, KURNOOL

TABLE 1.1

PLANT SUMMARY DATA -KURNOOL

GENERAL

Name and location	: Kurnool Municipal Water Works, Near Railway Station.
Year of construction	: 1965
Design capacity	: 6.81 mld
O & M Agency	: Kurnool Municipality.
Raw water source	: Tungabhadra river & K.C. Canal
Treatment flowsheet	: Conventional with rapid sand filters

ENGINEERING

Raw Water Pumping	: Tungabhadra river pump house. -- 2 Nos., 125 HP & 100HP with discharge capacity of 10,760 & 6356 lpm respectively K.C.Canal pump house -- 3 Nos.,19,21 & 25 HP with discharge capacity of 1000,1450 & 1490 lpm respectively
Raw water flow measurement	: V-notch and Parshall flume
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Mechanical
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 1 Nos., 4.88 m dia, 4.4 m SWD
- Detention time	: 20 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 1 Nos., 15.25 m dia, 3.5 SWD
- Surface overflow rate	: 1.9 m/hr
- Detention time	: 2 hr 30 min

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 3 Nos., 4.27 x 4.57 m
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.5 mm, U.C.-1.5
. Depth of sand	: 75 cm
. Supporting gravel depth	: 45 cm
- Backwash arrangements	
- Method	: Air scour followed by water wash

Disinfection

- Chlorine gas /Bl.powder	: Chlorine gas & Bleaching powder

Clear Water Reservoir

- Type,No. & Capacity	: R.C.C., 2 No.,0.68 million litres
- Pump details	: 50 HP-2 Nos, 15 HP-3 Nos, & 10 HP-4 Nos.

TABLE 1.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

KURNOOL MUNICIPAL WATER WORKS - KURNOOL

PARAMETER	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	10	4.5	1	0.8	60	-
pH	8.7	8.7	8.7	8.7	7.5	-
Total Alkalinity ($CaCO_3$)	178	172	188	182	140	-
Hardness ($CaCO_3$)						
Total	206	204	160	156	156	-
Carbonate	178	172	160	156	124	-
Non Carbonate	28	32	NIL	NIL	NIL	-
Calcium (Ca)	39.2	40	32.8	32	37	-
Magnesium (Mg)	26.2	26.2	18.9	18.4	11	-
Chlorides (Cl)	100	102	133	133	61	-
Sulphates (SO_4)	35.2	33	22	23	74	-
Iron (Fe)	0.1	NIL	NIL	NIL	NIL	-
Fluoride (F)	0.9	0.9	1.5	1.4	0.6	-
Bacteriological (MPN/100 ML)						
Total coliform	93	NIL	75	NIL	9300	460
Fecal coliform	43	NIL	75	NIL	2400	440
E.coli	43	NIL	75	NIL	2400	NIL
Fecal streptococci	15	NIL	43	NIL	2400	NIL

All the values except pH and turbidity are expressed as mg/l

TABLE 1.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

KURNOOL MUNICIPAL WATER WORKS - KURNOOL

PARAMETERS	VISITS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	10	9.5	2.5	4.5
	II	1	1	1	0.8
T. Coliform (MPN/100 ML)	I	93	240	150	NIL
	II	75	930	9	NIL
E. Coli (MPN/100 ML)	I	43	240	9	3
	II	75	430	9	NIL

RAJAHMUNDRY WATER WORKS - RAJAHMUNDRY

INTRODUCTION

Rajahmundry water works consists of three separate treatment plants. The oldest plant is in operation since 1933 and the new one has been commissioned in 1988. The treatment plant of 12.71 mld design capacity constructed in the year 1974 with Godavari river as source was selected for performance evaluation. The plant provides for conventional pre-treatment with alum followed by sedimentation, rapid sand filtration and post-chlorination. The schematic flow sheet is shown in Fig 1.2 and the plant summary data is presented in Table 1.4. The plant is operated and maintained by the Rajahmundry Municipality.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water is drawn from river Godavari which is a perennial source. A bathing ghat is located at a distance of about 300 m upstream of the intake which contributes to the pollution potential of the source. This is evident from the high coliform count in raw water (Table 1.5). Adequate measures for protection from floods have been taken at the head works.

Raw water is pumped to the treatment plant where a Venturi flume has been provided to measure the plant inflow.The flow indicator installed at the flume was, however, non-functional.The plant inflow, as measured manually at the 'V' notch during one of the visits, was found to be 10.91 mld as against the design value of 12.71 mld.

Pre-treatment

Alum is used as the chemical coagulant. Although alum solution tanks have been provided they were not in use. A crude method of alum addition, i.e. dumping of alum cakes in the raw water channel was practised. The rapid mix unit was also found non-functional. Although mechanical flocculators were found working, uncontrolled dose of alum coupled with inadequate rapid mixing was found to result in poor coagulation-flocculation. Notwithstanding the fact that the plant was underloaded, considerable flooding of orifices at the clarifier outlet was noticed. This was because of the obstruction to the flow caused by the slimy growth at the orifices. The turbidity removal efficiency of clarifier was found very poor as evident from the settled water turbidity of 7 NTU when the raw water turbidity was only 8 NTU (Table 1.6)

Filtration

The filter sand used in the rapid gravity filters was found to conform to standard specifications. The filter backwashing operation - air scour followed by water wash-was found satisfactory. The quantity of backwash water used was about 2.5 per cent of the total throughput from the filters. The filters were found to produce a good quality of effluent with a turbidity of 1 NTU or less.

Disinfection

The new chlorinators installed at the plant were functioning satisfactorily. For a chlorine demand of 1 mg/l, estimated in the laboratory, the applied dose was observed to be 2 mg/l. The residual chlorine in the finished water at the clear water sump was recorded as 1 mg/l.

Laboratory facilities

No laboratory facilities are available at the waterworks excepting a chloroscope.

Plant staff

The operating staff at the treatment plant, apart from the Assistant Engineer-incharge, includes Electricians (5 nos.), Filter-bed-operators (3 nos.), Fitter (1 no.), Cleaners (13 nos.). The staff have not been provided with any formal training in plant operation and maintenance.

Financial aspects

From the records, it was noted that the combined annual O & M cost in respect of the above plant and the 8.17 mld unit amounts to Rs. 26 lakhs while the revenue to the municipality from water charges is of the order of about 10 lakh per year. The cost of treatment works out to Rs. 0.56/m^3.

RECOMMENDATIONS

* The bathing ghat situated close to the intake is a potential source of pollution. Steps should be taken to shift the bathing ghat to the downstream side of the intake.

* Uncontrolled dumping of alum cakes into the raw water channel must be discontinued. The practice of preparing alum solution of required strength and the application of the dose on the basis of jar test should be followed.

* Steps should be taken to keep the flash mixer in working condition to achieve effective coagulation.

* Proper house keeping by regular cleaning of clarifier orifices should be ensured to prevent flooding and performance deterioration.

* A school is located inside the water works. It is necessary to shift the school premises from the water works compound for the safety of the children and protection of treatment works from unauthorised entry by the public.

* The plant should be provided with minimum laboratory equipment such as pH meter, turbidimeter and jar-test apparatus for better control of water treatment plant and the staff trained in operation and maintenance.

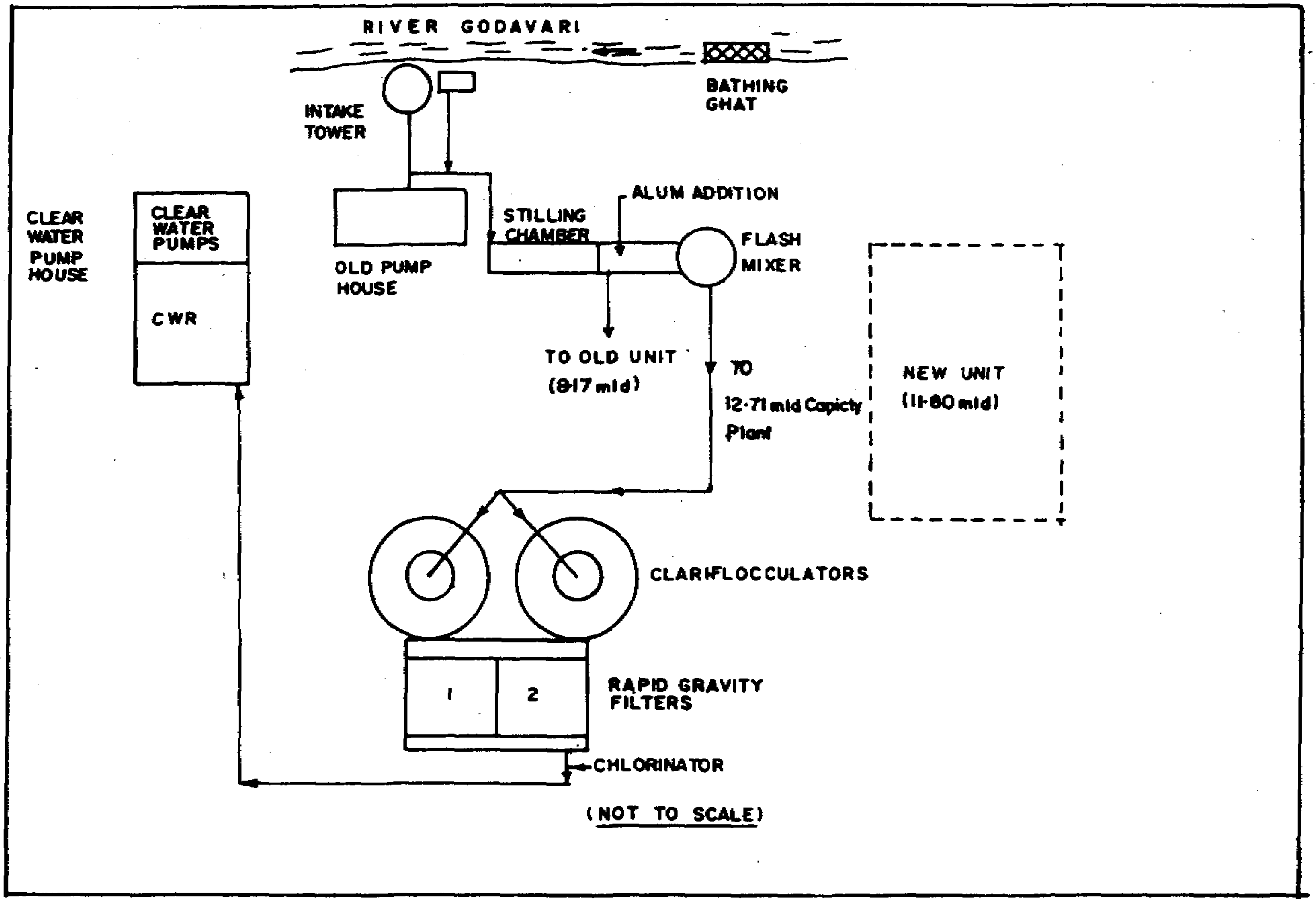


FIG 1.2 LAYOUT PLAN OF RAJAHMUNDRY WATER SUPPLY SCHEME

TABLE 1.4

PLANT SUMMARY DATA - RAJAHMUNDRY

GENERAL

Name and location	: Rajahmundry Municipal Water Works, near old Railway bridge
Year of construction	: 1974
Design capacity	: 12.71 mld
O & M Agency	: Rajahmundry Municipality
Raw water source	: Godavari river
Treatment flowsheet	: Conventional with rapid sand filters

ENGINEERING

Raw water pumping	: 2 Nos, 25 HP, each 3 Nos, 45 HP, each
-Rising main	: 350 mm dia. 300 m length
Raw water flow measurement	: V-notch and a flume with a flow indicator
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing with	: Mechanical mixer details 1 No.,2.3 m dia, 3.65 m SWD 60 sec. detention time
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos each 8.5 m dia. 4.5 m SWD
- Detention time	: 45 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 17.7 m dia. 3.5 m SWD
- Surface overflow rate	: 1.45 m/hr
- Detention time	: 2 hrs 30 minutes

Filtration

- Type of unit(s)	: Rapid gravity
- No. & size of unit(s)	: 2 Nos., each 7 m x 7 m
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.7 mm, U.C.-1.5
. Depth of sand	: 60 cm
. Supporting Gravel	: 50 cm. depth
- Backwash arrangements	
. Method	: Air scour followed by water wash

Disinfection

- Bleaching powder/ chlorine gas	: Chlorine gas

Clear Water Reservoir

- Type, No. & Capacity	: R.C.C., 1 No. 0.2 million litres
- Pump details	: 2 Nos,. 100 HP each

TABLE 1.5

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

RAJAHMUNDRY MUNICIPAL WATER WORKS - RAJAHMUNDRY

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	8	1	2.5	0.5
pH	8.2	8.0	8.1	8.0
Total Alkalinity ($CaCO_3$)	92	84	94	94
Hardness ($CaCO_3$)				
Total	106	104	86	84
Carbonate	92	84	86	84
Non Carbonate	14	20	NIL	NIL
Calcium (Ca)	20	20	18	19
Magnesium (Mg)	14	13	10	11
Chlorides (Cl)	11	13	17	18
Sulphates (SO_4)	7	7	13	13
Iron (Fe)	NIL	NIL	NIL	NIL
Bacteriological (MPN/100 ML)				
Total coliform	24000	NIL	4600	NIL
Fecal coliform	24000	NIL	4600	NIL
E.coli	24000	NIL	4600	NIL
Fecal streptococci	2400	NIL	2400	NIL

All the values except pH and turbidity are expressed as mg/l

TABLE 1.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

RAJAHMUNDRY MUNICIPAL WATER WORKS - RAJAHMUNDRY

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	8	7	1	1
	II	2.5	0.8	0.5	0.5
T. Coliform (MPN/100 ML)	I	24000	9300	4600	NIL
	II	4600	9300	9300	NIL
E.Coli (MPN/100 ML)	I	24000	4300	460	NIL
	II	4600	2400	2400	NIL

TATIPUDI WATER TREATMENT PLANT VISAKHAPATNAM

INTRODUCTION

The first water treatment plant for Visakhapatnam with a design capacity of 2.73 mld was installed in the year 1903 since then the capacity has been increased from time to time to the present level of 109 mld. Water supply is drawn from different sources, viz. Hanumanth reservoir, river bed infiltration works and Tatipudi reservoir (Gosthani river). The plant with a design capacity of 45.4 mld commissioned in the year 1976 was evaluated for its performance. The schematic flow sheet and plant summary data are given in Fig.1.3 and Table 1.7 respectively. The plant is maintained by the Municipal Corporation of Visakhapatnam.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Tatipudi reservoir flows by gravity through a distance of 5 km to the treatment plant at Krishnapuram. The yield from the source has been quite satisfactory and no scarcity of water has been experienced so far. Raw water is of very high quality with exceptionally low turbidity (<1.0 NTU) during fair season. It is, however, reported that the turbidity is moderate during rainy season. The raw water quality is given in Table 1.9.

A Parshall flume has been provided at the raw water inlet channel for measurement of plant inflow. The flow indicator installed at the flume was non-functional. During the visit, the plant inflow was computed by noting the rise in water level in the clarifier in known time and was found in the range of 45 to 54.5 mld against the design capacity of 45.4 mld.

Pre-treatment

Alum solution is applied at a single point in the raw water inlet channel just upstream of the flume. Solution tanks have been provided in the chemical house and a system for regulating the dose of alum solution also exists. However, during the visit, alum addition was found discontinued due to low turbidity of raw water. The solution dosing system was, however, found unreliable.

The rotational speed of the mechanical mixer was found very low (6 to 8 rpm) which is inadequate for effective mixing. The flocculators were working satisfactorily. During one of the visits when the plant was overloaded to the extent of about 20 %, no deterioration in the performance of the individual units was observed, perhaps because of the low turbidity of raw water.

Filtration

The depth of sand in all the filters was found in the range of 65-70 cms. The average length of filter run has been reported as 24 hours and the filters are cleaned using air-scour followed by water-wash. The quantity of backwash water works out to 180 m^3, which is about 3 per cent of the total throughput of the filters. The filters were found to produce a filtrate turbidity within the limits recommended by CPHEEO.

Disinfection

Although chlorinators have been installed at the water works, the dose of chlorine applied was arbitrary in the absence of proper dose regulating system.

Laboratory facilities

The plant has been provided with minimum necessary equipment such as Turbidimeter, pH meter, Jar-test apparatus and Chloroscope. However, the instruments are not in use and no chemist has been employed at the plant.

Plant staff

The satff at the Tatipudi water works include Asst. Engineer (incharge), electricians (2 nos), fitter (1 no), Filter bed operators (4 nos), helpers (6 nos), filter bed cleaners (4 nos), a watchman and a gardener. The operating staff at the water works have not undergone any formal training for the job assigned. The plant housekeeping, in general, was found poor.

Financial aspects

The annual cost of operation and maintenance of the treatment plant has been reported as Rs. 56.7 lakhs and the cost of water treatment works out to Rs. 0.35/m^3.

RECOMMENDATIONS

* The raw water flow indicating device installed at the plant shold be got repaired/replaced and maintained properly to enable proper operation and control of the treatment plant.

* Conditioning of low turbidity raw waters by application of a nominal dose of alum is necessary for effective removal of turbidity and bacteria during filtration. It is,therefore, desirable to continue alum addition even when raw water turbidities are low.

* Single point application of alum be discontinued and the solution added across the width of the channel through a perforated pipe. This would ensure proper dispersion of the coagulant into the incoming raw water.

* The alum solution doser should be got repaired and its functionality ensured for application of appropriate dosages.

* Measures should be taken to increase the present speed (6-8 rpm) of the mechanical rapid mixer to about 100 rpm for achieving effective coagulation.

* There is no equipment for proper metering and regulation of chlorine dose. The present practice of bubbling chlorine gas directly into the filtered water channel should be discontinued and measures taken to instal a chlorinator of appropriate capacity.

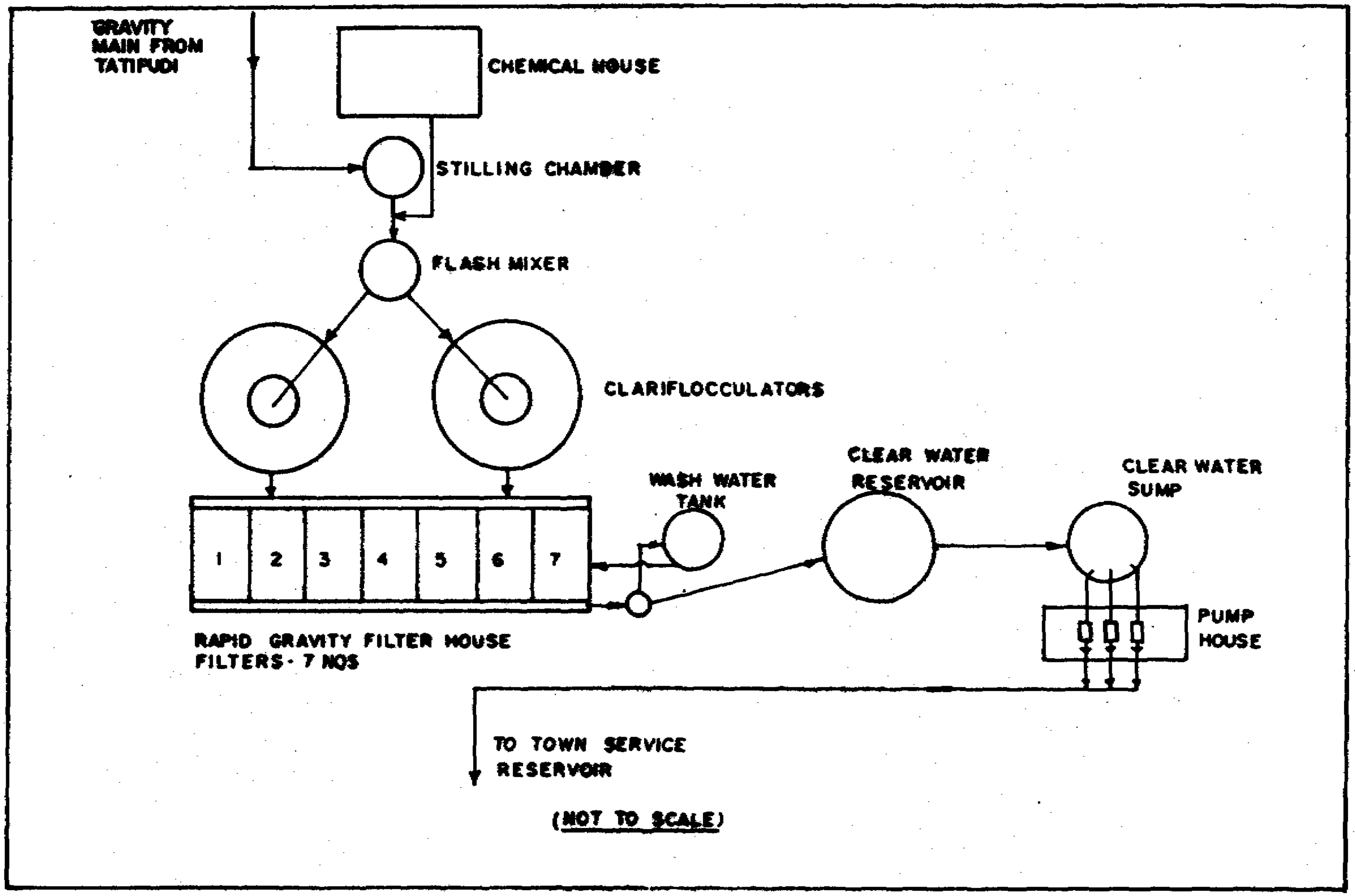


FIG 1.3 LAYOUT PLAN OF VISAKHAPATNAM WATER TREATMENT PLANT

TABLE 1.7

PLANT SUMMARY DATA - VISAKHAPATNAM

GENERAL

Name and location	: Tatipudi Water Treatment Plant, Krishnapuram, Visakhapatnam
Year of construction	: 1967
Design capacity	: 45.4 mld
O & M Agency	: Visakhapatnam Municipal Corporation
Raw water source	: Tatipudi Reservoir across Gosthani river
Treatment flowsheet	: Conventional with rapid sand filters

ENGINEERING

Raw water gravity main	: 5762 m length, Prestressed Concrete, 900 mm dia
Raw water flow measurement	: Parshall flume with Flow indicator of capacity 0-2500 m^3/hr.

Pre-treatment

Coagulation

- Chemical used	: Alum
- Type of mixing with	: Mechanical mixer details 1 No., 2.5 m dia, 3.75 SWD

Flocculation

- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos., each 13.3 m dia.
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 30.5 m dia. 3.75 SWD
- Surface overflow rate	: 1.65 m/hr
- Detention time	: 3 hrs

Filtration

- Type of unit(s)	: Rapid gravity
- No. & size of unit(s)	: 7 Nos., each 9.45 x 7.0 m
- Rate of filtration	: 6.0 m/hr
- Filter media	
. Sand size	: E.S.-0.7 mm, U.C.-1.4
. Depth of sand	: 70 cm
. Supporting gravel	: 45 cm depth
- Backwash arrangements	
. Method	: Air scour followed by water wash
Washwater tank cap.	: 180 m^3

Disinfection

- Bleaching powder/ Chlorine gas	: Chlorine gas

Clear Water Reservoir

- Type, No. & Capacity	: R.C.C., 1 No., 900 m^3
- Pump details	: 3 Nos., 270 HP each with a discharge capacity of 32900 lpm.

TABLE 1.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

TATIPUDI WATER TREATMENT PLANT - VISAKHAPATNAM

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	150	3	0.1	0.1
pH	7.8	7.8	8.2	8.2
Total Alkalinity ($CaCO_3$)	64	56	94	94
Hardness ($CaCO_3$)				
Total	84	90	86	86
Carbonate	64	56	86	86
Non Carbonate	20	34	NIL	NIL
Calcium (Ca)	14	15	18	22
Magnesium (Mg)	12	13	10	7
Chlorides (Cl)	9	10	11	12
Sulphates (SO_4)	9	30	NIL	NIL
Iron (Fe)	0.7	Tr.	NIL	NIL
Fluoride (F)	0.2	0.2	0.8	0.6
Bacteriological (MPN/100 ML)				
Total coliform	NIL	9	NIL	NIL
Fecal coliform	43	NIL	4	NIL
E.coli	43	NIL	4	NIL
Fecal streptococci	39	NIL	2400	NIL

All the values except pH and turbidity are expressed as mg/l

TABLE 1.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

TATIPUDI WATER TREATMENT PLANT - VISAKHAPATNAM

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	150	8.5	3.0	3.0
	II	0.1	0.1	0.1	0.1
T. Coliform (MPN/100 ML)	I	240	29	23	NIL
	II	9	NIL	930	NIL
E. Coli (MPN/100 ML)	I	43	9	9	NIL
	II	4	NIL	93.	NIL

PRATAPRUDRA WATER WORKS - WARANGAL

INTRODUCTION

The city of Warangal had its first water supply system of 8.17 mld commissioned in the year 1939 with Dharmasagar tank as the source. The supply was augmented to 11.35 mld in the year 1968. In view of the limited capacity of the original source, the subsequent augmentation in the year 1982 has been based on Kakatiya Canal as the source of supply. The canal is fed from the lower Maneru dam constructed across river Godavari in Karimnagar District. The raw water is drawn from two locations, viz. behind Kakatiya University campus and near Autonagar at Desaipet and pumped to Prataprudra and Rudrambha water works respectively. The Prataprudra water treatment plant with a design capacity of 37.23 mld has been evaluated for its performance. The schematic flow sheet and the plant summary data are given in Fig. 1.4 and Table 1.10 respectively. The plant is maintained by the State PHED and Warangal Municipality.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Kakatiya canal is pumped to the treatment plant except during the canal closure period when raw water is drawn from Dharmasagar Tank by gravity. Provision,therefore, has been made to pump canal water to Dharmasagar tank and buildup storage to meet the requirement as above. No major source of pollution was observed in the vicinity of the canal intake. Data on raw water quality is given in Table 1.11.

A Parshall flume along with a flow indicator device has been installed in the raw water channel to measure the plant inflow. The plant inflow, as observed during the visits, was found in agreement with the design value of 1550 m^3/hr. The plant is operated only for 16 hours day.

Pre-treatment

Alum solution was applied in the raw water channel just upstream of the flume. The dose of alum was not regulated properly as the solution dosing system was defunct. The division of alum coagulated water between the two clariflocculators was found unequal, due to defective construction resulting in difference in the MWL of the two clariflocculators. The mechanical sludge scrapers in both the clariflocculators were found in disuse. The settled water had a turbidity of 3 NTU while the raw water turbidity was 3.5 NTU (Table 1.12).

Filtration

The specifications of the filter media used were found to comply with the CPHEEO recommendations. The filter appurtenances were functioning satisfactorily. The filter initial headloss was found in the range 20-30 cm for a filtration rate of 6 m/hr. The backwashing operation with air-scour followed by water wash was satisfactory. The backwash water consumption was found to be about 2.5 % of the total throughput of the filter. Although the filters produced a filtrate of acceptable turbidity, the reduction in turbidity was only marginal.

Disinfection

The chlorinator installed at the treatment plant was not in use due to non-availability of chlorine gas and hence bleaching powder was used for disinfection. The available chlorine in the bleaching powder was found to be very low (10 %), due to improper storage and handling.

Laboratory facilities

The laboratory equipment available at the treatment plant includes turbidimeter,pH meter and chloroscope. No qualified chemist has been posted at the plant.

Plant staff

The staff at the plant includes Assistant Engineer Incharge (1 no),Filter-bed operators (5 nos),Pump operators (8 nos) and Helpers (14 nos). The plant staff have not undergone any formal training in the operation and control of water works.

Financial aspect

The annual operation and maintenance cost of the plant was reported to be Rs. 35.26 lakhs. The cost. of treatment works out to Rs. 0.26/ m^3.

RECOMMENDATIONS

* At present single point application of alum dose just upstream of the flume is practised. To ensure uniform dispersion of chemical coagulant, the alum solution should be added through a perforated pipe placed across the width of the channel.

* The functionality of mechanical equipment for the calriflocculators and filters should be restored and maintained.

* Inequitable distribution of the plant inflow between the two clariflocculators should be got rectified to avoid overloading of one of the units.

* The bleaching powder used for disinfection should not be stocked for long periods to avoid loss of chlorine. The quality of bleaching powder should be got tested frequently to ensure a minimum available chlorine of 30 per cent.

* Jar-test apparatus is necessary to fix optimum dose of alum for varying raw water turbidities.

* The staff at the water works need adequate training to ensure proper operation and control of the plant.

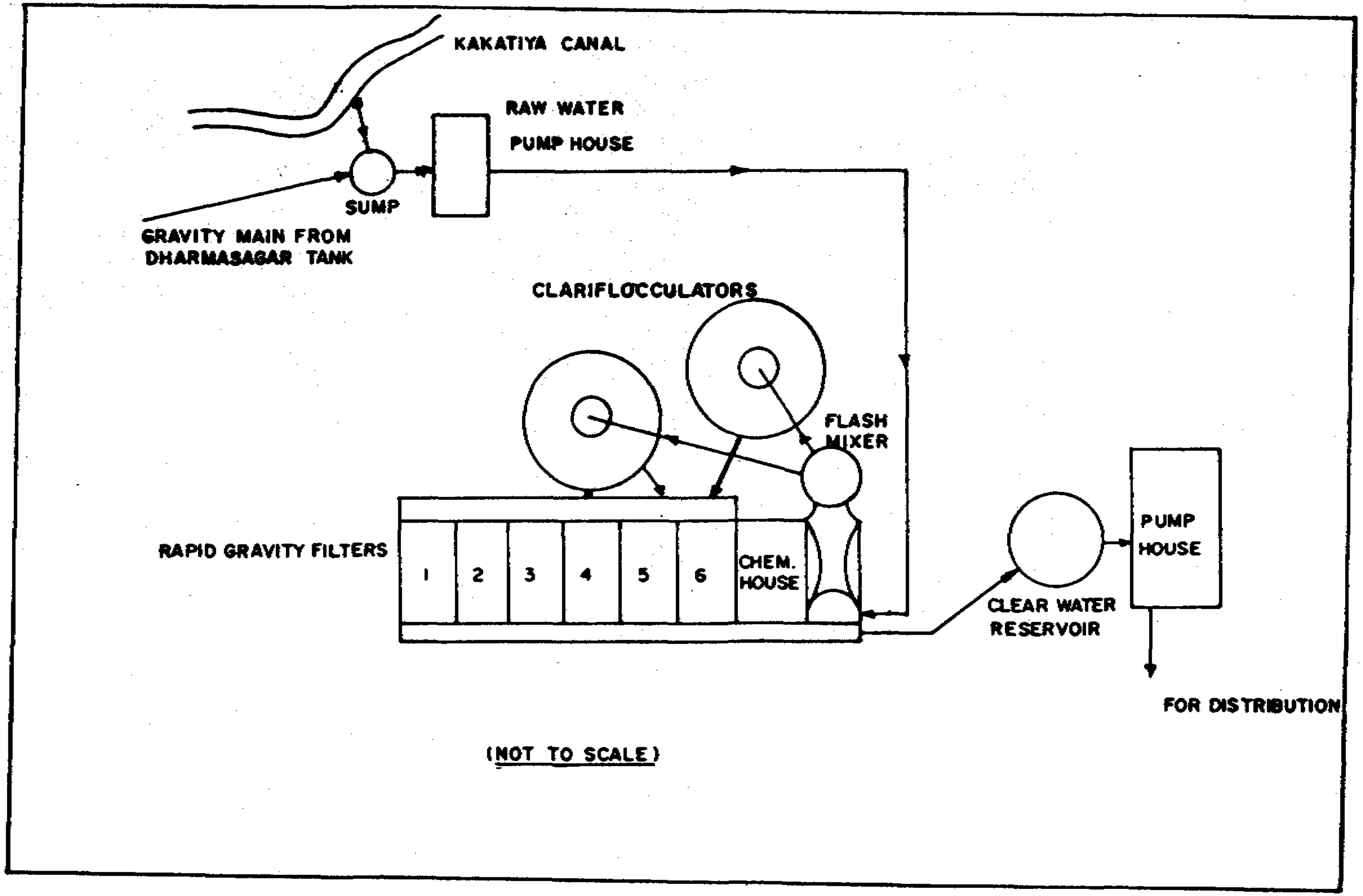


FIG 1.4 LAYOUT PLAN OF PRATAPRUDRA TREATMENT WORKS, WARANGAL

TABLE 1.10

PLANT SUMMARY DATA - WARANGAL

GENERAL	
Name and location	: Prataprudra water Works Desaipet, Warangal
Year of construction	: 1984
Design capacity	: 37.2 mld
O & M Agency	: Public Health Engineering Department/ Warangal Municipality
Raw water source	: Kakatiya Canal
Treatment flowsheet	: Conventional with rapid sand filters
ENGINEERING	
Raw water gravity main	: 2 Nos., 100 HP each with a discharge capacity of 13170 lpm
Raw water flow measurement	: Parshall flume with flow indicator of range 0-2000 m^3/hr
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Method of mixing with	: Mechanical mixer 1 No. details 2.3 m dia., with 3.5 m SWD, detention time- 30 sec
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos, each 10.4 m dia. 4.9 m SWD
- Detention time	: 30 minutes

Sedimentation	
- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 27.6 m dia 3.86 m SWD
- Surface overflow rate	: 1.45 m/hr
- Detention time	: 2 hr 40 min
Filtration	
- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 6 Nos. each 6.6 x 6.6
- Rate of filtration	: 6.0 m/hr
- Filter media	
. Sand size	: E.S -0.7 mm, U.C -2.0
, Depth of sand	: 80 cm
.Supporting graveldepth	: 45 cm
- Backwash arrangements	: Air scour followed by water wash
Disinfection	
- Bleaching powder/Chlorine gas	: Chlorine gas & Bleaching powder
Clear Water Reservoir	
- Type,No. & Capacity	: R.C.C.Circular, 1 No. 1 million litre capacity
- Pump details	: 2 Nos, 335 HP each with a discharge capacity of 30,600 lpm

TABLE 1.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

PRATAPRUDRA WATER WORKS - WARANGAL

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	1.5	0.2	3	1	3.5	-
pH	8.9	8.7	8.6	8.8	8.2	-
Total Alkalinity ($CaCO_3$)	124	118	96	96	114	-
Hardness ($CaCO_3$)						
Total	110	110	60	78	88	-
Carbonate	110	110	60	78	88	-
Non Carbonate	NIL	NIL	NIL	NIL	NIL	-
Calcium as (Ca)	23	22	14	13	21	-
Magnesium (Mg)	13	13	6	6	10	-
Chlorides as (Cl)	16	18	19	17	20	-
Sulphates (SO_4)	35	35	27	27	20	-
Iron (Fe)	NIL	NIL	NIL	NIL	0.2	-
Fluoride (F)	0.6	0.6	0.8	0.7	0.5	-
Bacteriological (MPN/100 ML)						
Total coliform	460	NIL	750	NIL	-	-
Fecal coliform	93	NIL	730	NIL	-	-
E.coli	93	NIL	750	NIL	-	-
Fecal streptococci	150	NIL	730	NIL	-	-

All the values except pH and turbidity are expressed as mg/l

TABLE 1.12

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

PRATAPRUDRA WATER WORKS - WARANGAL

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	1.5	1	0.2	0.2
	II	3	2	1.5	1.0
	III	3.5	3.0	2.5	-
T. Coliform (MPN/100 ML)	I	460	460	93	NIL
	II	750	1500	93	NIL
<u>E. Coli</u> (MPN/100 ML)	I	93	240	23	NIL
	II	750	1500	93	NIL

GAUHATI WATER TREATMENT PLANT - GAUHATI

INTRODUCTION

Gauhati is the capital city of Assam and is most important centre of commerce, industry, communication and education in North-Eastern India. An attempt by the Corporation to supply potable water to the city through deep tubewells has not been successful. Presently the city draws its water supply from river Brahmaputra.

The water treatment plant of 11.2 mld located at Panbazar was commissioned in the year 1976. The treatment flow sheet comprises of aeration, coagulation, flocculation, clarification,rapid gravity filtration and post-chlorination. The schematic flow sheet of the plant is shown in Fig.2.1 and summary data is presented in Table 2.1. At present only 25 % of the corporation area is covered with piped water supply.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from river Brahmaputra is pumped to the treatment plant from an intake fixed on the floating barge in the river. No source of pollution was observed in the vicinity of the intake.Being a river source, considerable variation in rawwater turbidity is reported. During the visits, the turbidity of raw water was in the range of 27-48 NTU and chlorine demand was in the range of 1.2-1.4 mg/l (Table 2.2).

A rectangular weir with a float operated pedestal type flow rate indicator has been provided at the plant for raw water flow measurement. The plant inflow was found to be 12.8 mld and the plant was overloaded to the extent of 13 %.

Pre-treatment

Due to low alkalinity of raw water, lime is used along with alum for coagulation. The applied alum dose was reported to be 38 mg/l. However, the actual dose applied was found to be 20 mg/l. Chemical mixing and dosing units were in working condition. The performance of the clarifier was satisfactory and the settled water turbidity was in the range of 5.2-9.0 NTU (Table 2.3).

Filtration

The depth of sand in the filters was 56-60 cm with an E.S of 0.8 mm and U.C of 1.3. The filters were backwashed after 24 hours of run. Backwashing was found to be inadequate and ineffective as seen by the presence of mud balls in the filters. The filtered water turbidity was 1.2 NTU. The headloss indicators of the filters were not working properly.

Disinfection

Bleaching powder is used for disinfection. The chlorine demand of filtered water was found to be 0.7 mg/l. Finished water had a residual chlorine of more than 1.0 mg/l and was free from coliforms.

Laboratory facilities

Laboratory facilities with necessary minimum equipment and reagents are provided at the plant. Most of the equipments were found in working condition.

RECOMMENDATIONS

* The filter appurtenances should be repaired/replaced for better operation and control of the filters.

* Effective backwashing of the filters should be carried out to avoid mudball formation.

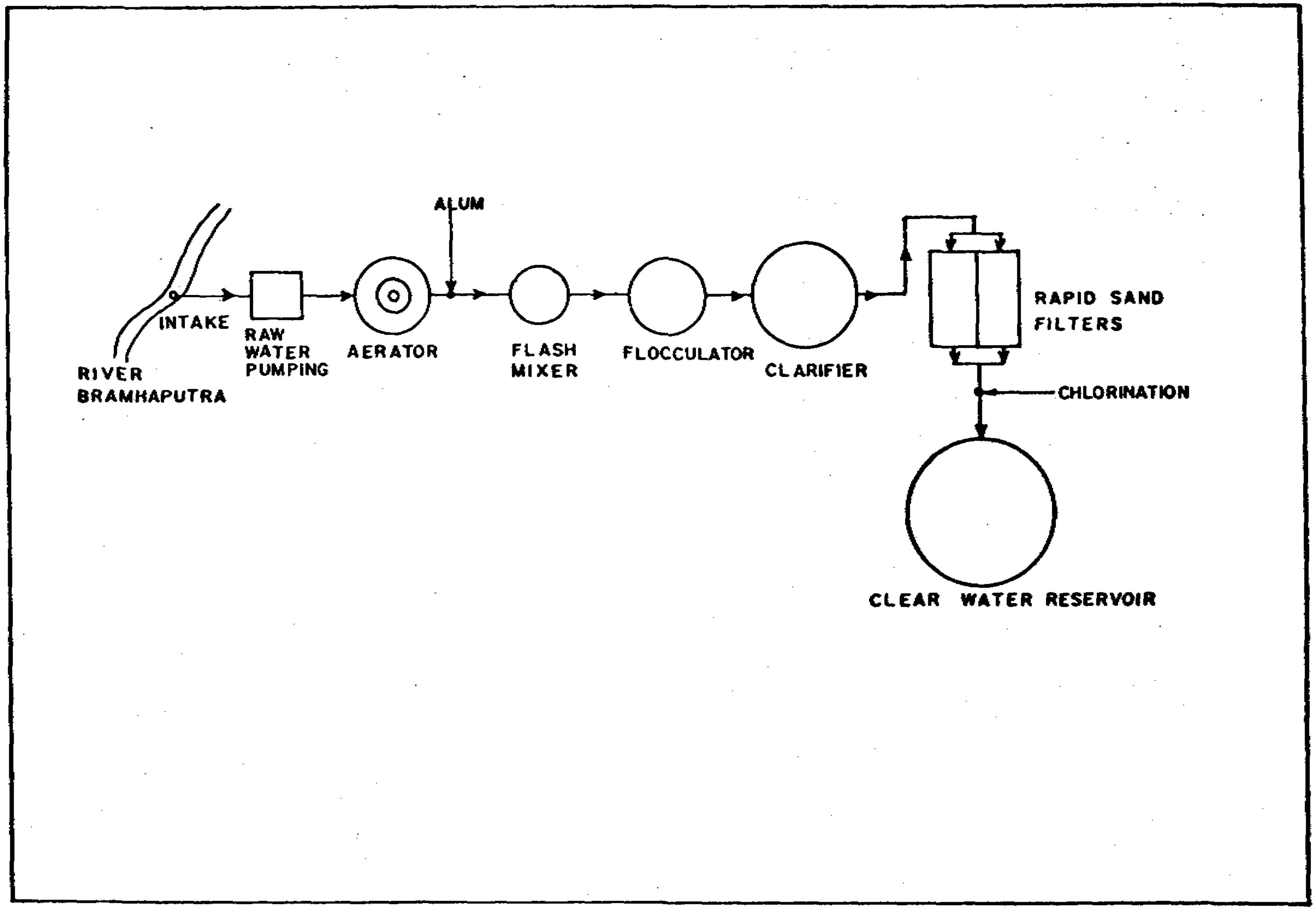


FIG 2.1 GAUHATI WATER TREATMENT PLANT - SCHEMATIC

TABLE 2.1

PLANT SUMMARY DATA - GAUHATI

GENERAL	
Name and location	: Gauhati Water Treatment Plant, Gauhati
Year of construction (Augmentation if any)	: 1976
Design capacity	: 11.2 mld
O & M Agency	: Public Health Engineering Department, Gauhati
Raw water source	: River Brahmaputra
Treatment flowsheet	: Conventional with Rapid Sand Filters
ENGINEERING	
Raw water pumping	: 6 nos, centrifugal pumps 75 HP - 3 nos 80 HP - 3 nos, (two Standby)
-Rising main diameter	: 200 mm
Raw water flow measurement	: Rectangular weir, 90 x 45 cm
Pre-treatment	
Aeration	: Cascade aerator
Coagulation	
- Chemicals used	: Alum & lime (solution feed)
- Type of mixing	: Mechanical flash mixer
- Detention time	: 25 sec
Flocculation	
- Method / Type of unit	: Mechanical flocculator
- No. & Dimensions	: One, 8.76 m dia, 3.9 m depth
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Mechanical Clarifier
- No. & size of unit(s)	: One no, 19.6 m dia. and 3.9 m depth
- Surface overflow rate	: 1.56 m/hr
- Detention time	: 2 hrs 30 mimutes

Filtration

- Type of unit(s)	: Rapid Sand Filters
- No. & size of unit(s)	: 2 nos, 3.05 x 7.9 m each (twin bed)
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.- 0.8 mm, U.C.-1.23
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Air scour & Water wash
. Wash water tank cap.	: 198 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Reservoir

- Type, No. & Capacity	: RCC, one, 245 m^3
- Pump details	: 8 nos, centrifugal pumps 5 nos, 100 HP each 3 nos, 50 HP each

TABLE 2.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

GAUHATI WATER TREATMENT PLANT - GAUHATI

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	27	1.2	48	5.0
pH	-	-	7.6	7.2
Total Alkalinity ($CaCO_3$)	56	48	44	46
Conductivity (µS/cm)	150	150	180	190
Hardness ($CaCO_3$)				
Total	80	85	76	78
Carbonate	56	48	44	46
Non Carbonate	24	37	32	32
Calcium (Ca)	16	17	15	15
Magnesium (Mg)	10	10	9	10
Chlorides (Cl)	4	4	3	3
Sulphates (SO_4)	14	23	11	20
Iron (Fe)	1.5	ND	1.3	ND
Fluoride (F)	ND	ND	0.2	0.1
Nitrate (NO_3)	0.4	0.3	0.4	0.4
Bacteriological (MPN/100 ml)				
Total coliform	790	0	7900	0
Fecal coliform	170	0	4900	0
E.coli	110	0	790	0
Fecal streptococci	68	0	140	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l

ND - Not detectable

SWARNAREKHA WATER WORKS - RANCHI

INTRODUCTION

The Swarnarekha water supply scheme has been commissioned in the year 1972 to provide piped water supply to the city of Ranchi. Raw water from Getalsud dam constructed across river Swarnarekha is pumped to treatment works located at Rukka which is 25 km east of Ranchi. The present capacity of the plant is 111.2 mld which provides for prechlorination, coagulation, flocculation, sedimentation, rapid gravity filtration and post-chlorination. The schematic flowsheet of the plant is shown in Fig. 3.1 and summary data is presented in Table 3.1. The plant is maintained by the PHED, Govt. of Bihar. Further augmentation of the capacity to 170.2 mld is in an advanced stage of completion.

PLANT APPRAISAL

Raw water quality

Raw water intake situated at about 1 km from the treatment plant is surrounded by hilly areas. No potential sources of pollution were observed in the vicinity of the intake. Due to impoundment, the raw water quality was good. During the visits, the raw water had turbidity in the range of 7-21 NTU, chlorine demand of 1.6-1.7 mg/l and MPN coliform count in the range of 490-680 per 100 ml (Table 3.2).

Pre-treatment

Raw water is prechlorinated using bleaching powder solution. The flow meter (Mahindra and Mahindra make) provided at the plant for raw water flow measurement was not in working condition. Due to low alkalinity in raw water, lime was used as a coagulant aid. Reported doses of alum and lime were 14 ppm and 7 ppm respectively. Alum slabs were added at the Parshall flume in the raw water channel. The mechanical flash mixer provided at the plant was not in working condition. The mixing paddles of the clariflocculators were not working during the visits. The turbidity of settled water was 3.7-14 NTU (Table 3.3).

Filtration

Out of 20 rapid gravity filters, at present only 12 were being used. The depth of sand in the filter was 56-61 cm. The rate of flow and headloss indicators were not in working condition. Filters were backwashed after 18-24 hours of filter run using compressed air and water. Filter cracks and undulations were observed in the filters indicating inadequate backwashing and poor maintenance of the filters.

Disinfection

Chlorine gas was used for post-chlorination. The chlorine demand of the filtered water was 0.7-0.8 mg/l. Due to non-functioning of chlorinators, chlorine gas from cylinders was directly applied into the water. The finished water had a residual chlorine of more than 1.0 ppm and was free from coliforms.

Laboratory facilities

A laboratory fairly equipped with necessary instruments and other facilities has been provided at the plant but most of the instruments were not in working condition. The posts of chemist and laboratory assistant for the plant are vacant.

RECOMMENDATIONS

* The raw water flow measuring and indicating devices should be repaired and put into order to facilitate plant control operations.

* Flash mixer should be repaired and put into commission for effective pre-treatment.

* Filters should be backwashed properly to avoid the formation of cracks and mud-balls.

* Instruments in the laboratory should be got repaired and necessary trained prersonnel posted to ensure cost-effective treatment and a product water meeting the quality standards.

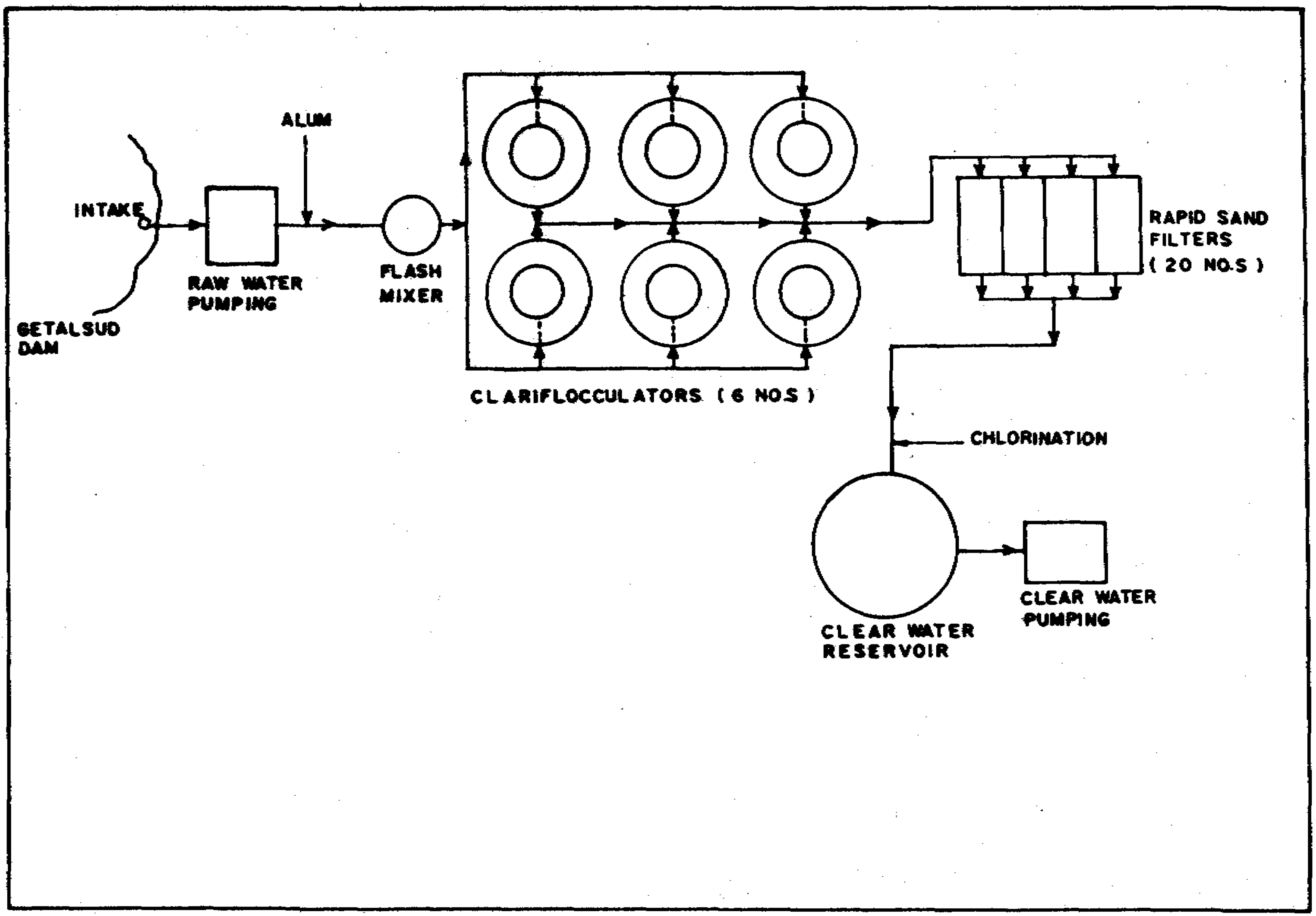


FIG 3.1 SWARNAREKHA WATER TREATMENT PLANT (RANCHI) - SCHEMATIC

TABLE 3.1

PLANT SUMMARY DATA RANCHI

GENERAL

Name and location	: Swarnarekha Water Supply Scheme, Rukka, Ranchi
Year of construction (Augmentation if any)	: 1972, (Augmented in 1985)
Design capacity	: 111.2 mld
O & M Agency	: PHED, Ranchi
Raw water source	: Getalsud dam on Swarnarekha River
Treatment flowsheet	: Conventional with Rapid Sand Filters

ENGINEERING

Raw water pumping	: 8 Nos., Vertical turbine pumps (5 nos. standby) 175 HP - 5 nos. 150 HP - 3 nos.
-Rising main diameter	: 1000 mm
Raw water flow measurement	: Mahindra and Mahindra Flowmeter
Pre-treatment	
Coagulation	
- Chemicals used	: Alum and lime (solution)
- Type of mixing	: Flash mixer 3 m dia, 5.4 m deep
- Detention time	: 30 sec
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Dimensions	: Six nos.,each 13.7 m dia., 5.2 m SWD
- Detention time	: 60 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: Six nos., each 36.5 m dia, 3.7 m SWD
- Surface overflow rate	: 0.86 m/hr
- Detention time	: 4.3 hrs

Filtration

- Type of unit(s)	: Rapid Sand Filters
- No. & size of unit(s)	: 12 Nos, 78 m^2 each (twin bed)
- Rate of filtration	: 4.5 m/hr
- Filter media	
. Sand size	: E.S.- 0.56 mm, U.C.- 1.54
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Air scour and water wash
- Wash water tank cap.	: 341 m^3

Disinfection

- Chemicals used	: Bleaching powder for prechlorination Chlorine gas for postchlorination
- Type of feed	: Direct feed

Clear Water Reservoir

- Type, No. & Capacity	: RCC, one no, 4500 m^3
- Pump details	: 8 nos., Centrifugal pumps 400 HP each

TABLE 3.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

SWARNAREKHA WATER WORKS - RANCHI

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	7	1.0	21	3.5
pH	7	7.0	7	7
Total Alkalinity ($CaCO_3$)	36	36	46	46
Conductivity (uS/cm)	179	199	197	216
Hardness ($CaCO_3$)				
Total	28	34	38	40
Carbonate	28	34	38	40
Non Carbonate	0	0	0	0
Calcium (Ca)	10	12	12	13
Magnesium (Mg)	1	1	2	2
Chlorides (Cl)	22	26	4	5
Sulphates (SO_4)	14	18	7	11
Iron (Fe)	1.2	Tr.	0.6	Tr.
Fluoride (F)	0.2	0.2	0.4	0.4
Nitrates (NO_3)	0.2	0.2	0.8	0.7
Bacteriological (MPN/100 ml)				
Total coliform	490	0	680	0
Fecal coliform	170	0	680	0
E.coli	110	0	680	0
Fecal streptococci	170	0	130	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l
Tr. - Traces

TABLE 3.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

SWARNAREKHA WATER WORKS - RANCHI

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	7	3.7	-	1.0
	II	21	4	-	3.5
T.Coliform (MPN/100 ml)	I	490	68	0	0
	II	680	49	45	0
E.Coli (MPN/100 ml)	I	110	20	0	0
	II	680	23	2	0

CHANDIGARH WATER WORKS - CHANDIGARH

INTRODUCTION

The union territory of Chandigarh draws its water supply from both surface and ground water sources. The city, with a population of 4.5 lakhs (1981 census) is supplied with 155 mld of treated water. About 100 tubewells account for 86 mld of water supply. Surface water drawn from Bhakra Main Line (BML) canal after treatment in two plants of 22.7 mld and 45 mld capacity augments the supply to the city. Two more plants of 68 and 22.7 mld capacity are under construction to further augment the water supply. The 45 mld plant commissioned in 1983 and situated near Sector 39 has been selected for study.

The treatment consists of alum addition and rapid mixing at the Parshall flume followed by tapered flocculation, sedimentation in rectangular horizontal flow settling tanks, rapid gravity filtration and disinfection by chlorination. The plant layout is shown in Fig 4.1 and the plant summary data is given in Table 4.1.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from BML canal near village Kajauli is pumped through a 27 km long RCC conduit to the treatment plant. The quality of raw water is good throughout the year due to impoundment at the Bhakra dam (Table 4.2). The high velocity of flow in the canal and the steep slopes of the canal banks minimise the chances of pollution due to human activities.

Three pumps each of 45 mld capacity have been provided for pumping raw water. Two pumps run at a time ; one delivering raw water to treatment plant and the other through a storage tank to the 22.7 mld capacity plant in Sector 12 and for irrigation (without treatment). Provision has been made to draw, in times of emergency, raw water from the storage tank for treatment at the 45 mld plant. Two diesel pumps each of 22.7 mld capacity have been provided as standby.

The pumping station at Kajauli is so located as to have always a positive suction head. Facilities for day to day maintenance and necessary tools and spares are available.

Raw water enters the treatment plant through an inlet chamber (3 m x 3 m) and flows through a flow measuring Parshall flume. At the time of the visit, the plant inflow as indicated by the flow rate indicator was 21.2 x 100 m^3/hr (51.88 mld).

Pre-treatment

Alum in solution form is added at the Parshall flume where mixing is achieved by the hydraulic jump and three fins provided in the channel down stream. Three tanks each of 13160 litres capacity have been provided for preparation of alum solution. The alum solutionising and dosing arrangements were found in good working condition and alum mixing was complete as confirmed by tests for sulphate content in the alum dosed water.

Tapered flocculation is achieved in three chambers in series. The sweep of paddles, H.P. of motor and rpm of mixer have been so designed that 'G' value progressively decreases from 90-1 sec to 30 sec-1. Detention time provided in each chamber is 10 minutes. As the raw water turbidity was very low (less than 5 NTU) floc formation could not be readingly observed. All metal parts of the flocculators are painted during annual shut down for cleaning and maintenance.

The performance of horizontal flow rectangular settling tanks was satisfactory as shown by the settled water turbidity. Considerable reduction in coliforms and E.Coli was also achieved due to settling (Table 4.3).

Filtration

Four rapid gravity filters are designed to operate on declining rate principle. The filters are open to sky and only the operating gallery is housed under a cover. One of the rapid gravity filters is a dual media filter using coconut shell as the top layer. There is no flow restricting orifice in the outlet pipe of the filter and the maximum allowable rate is controlled by manipulating the filtered water outlet valve. Filters are backwashed when water reaches to predetermined level in the filter box. Length of filter run reported was 12 to 36 hours. The filtrate turbidity was less than 1 NTU throughout the observation period. Thereby meeting the CPHEEO recommendations. In dual media filter, the top coconut shell layer has been washed out during backwashing operation and recently additional sand has been placed to make up for the overall depth of media. It was also reported that whenever prechlorination was used, yellowish colour was leached out from the coconut shell media.

Filter backwashing is preceded by air scour for 5 minutes and is washed with water for almost 10 to 15 minutes longer than necessary. The turbidity of spent wash water was as low as 6.5 NTU at the fag end of the operation. No mud balls, cracks, etc. were observed in the filter beds indicating satisfactory performance operation and maintenance.

Disinfection

Chlorinators were not available at plant to regulate and monitor the dose of chlorine, which was fixed by trial and error. Chlorine gas is fed to a solutionizing tower and the chlorine solution is then mixed in the filtrate channel. Residual chlorine in the finished water was 0.5 mg/l. It was reported that prechlorination using bleaching powder solution is practised at the zonal pumping stations, when necessary.

Laboratory facilities

Laboratory facilities available at the plant are adequate and all the instruments/ equipment are in working condition. Water quality analysis is done regularly and records maintained properly.

Plant staff

The 45 mld plant is managed by four officers and 38 supporting staff both skilled and unskilled. Operators and Laboratory Assistants are qualified with ITI certificates. Only helpers and chowkidars are non-metric. Officers have received formal training in operation and maintenance of water treatment plants. The water works is one of the best maintained and operated treatment plants evaluated.

RECOMMENDATION

* Alum solution tanks are provided in the second floor of the laboratory building. It is cumbersome and labour intensive to manually lift alum slabs through a height of 10 m. The alum solutionising tanks can be provided at the ground level and the alum solution pumped to the dosing tanks for gravity feed. This arrangement could be simple and cost effective.

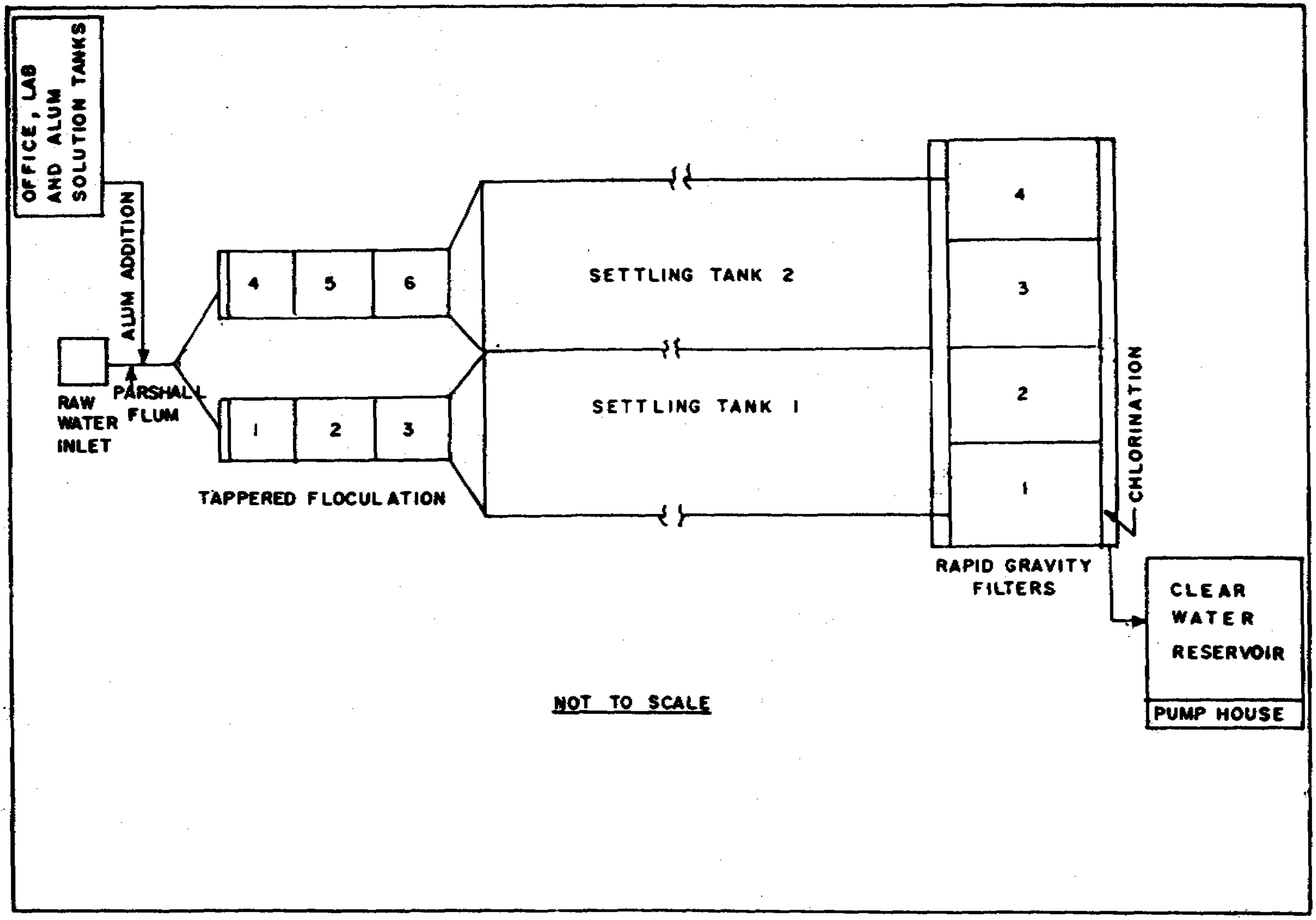


FIG 4.1 LAYOUT PLAN OF WATER TREATMENT PLANT, CHANDIGARH

TABLE 4.1

PLANT SUMMARY DATA - CHANDIGARH

GENERAL	
Name and location	: Water Treatment Plant in sector 39
Year of construction	: 1983
Design capacity	: 45 mld
O & M Agency	: Executive Engineer Public Health Division No. 1
Raw water source	: Canal from Bhakra Main Line
Treatment flowsheet	: Tapered flocculation, sedimentation with rapid sand, declining rate filtration and chlorination
ENGINEERING	
Raw water pumping	: Centrifugal, 3 nos., capacity 45 mld each standby 2 nos. diesel - 22.5 mld each
-Rising main diameter	: 1200 mm, M.S. cement
Pre-treatment	
Coagulation	
- Chemicals used	: Alum feric grade II
- Type of mixing	: Hydraulic near Parshall flume
- Method of mixing	: Addition of alum solution 5 per cent
Flocculation	
- Method / Type of unit	: Tapered flocculators
- No. & Dimensions	: 3 nos., 6830 x 6830 mm each
- Detention time	: 10 minutes each

Sedimentation

- Type of unit(s)	:	Rectangular,
- No. & size of unit(s)	:	2 nos., 122 x 38.5 x 4.55 m
- Surface overflow rate	:	0.4 m^3/m2/hr.
- Weir loading	:	210 m^3/m/day
- Detention time	:	2.2 hrs

Filtration

- Type of unit(s)	:	Rapid gravity with declining rate
- No. & size of unit(s)	:	4 nos.,7.2 x 3 x 1.8 m each
- Filter media		
. Sand size and	:	12 to 24 mash, 760 mm depth of sand single, sand media, dual media 380 mm coconut shell, 380 mm sand
. Gravel size (mm)	:	3-6,12-20,20-25,25-37,37-50
. Depth of each layer(mm)	:	200, 75, 75, 75, 75
- Backwash arrangements		
. Method	:	air scour and water wash
. Wash water tank cap.	:	227 m^3

Disinfection

- Chemicals used	:	Chlorine gas
- Type of feed	:	Gravity feed
- Chlorinator Details	:	4 kg/hr Banco make

Clear Water Reservoir

- Type, No. & Capacity	:	RCC, 2 nos., 4540 m^3 each
- Pump details	:	2 nos., 150 HP cap. 45 mld each

TABLE 4.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

CHANDIGARH WATER WORKS - CHANDIGARH

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	3.1	0.8	8.0	1.0
pH	7.7	7.4	8.8	7.6
Total Alkalinity ($CaCO_3$)	74	69	71	70
Conductivity(µS/cm)	235	235	292	255
Hardness ($CaCO_3$) Total	91	91	110	110
Carbonate	74	69	71	70
Non carbonate	17	22	39	40
Calcium (Ca)	26	26	30	30
Magnesium (Mg)	6.3	6.3	10	10
Chlorides (Cl)	3	7	17	17
Sulphates (SO_4)	26	28	27	34
Iron (Fe)	0.2	Tr	Tr	Tr
Fluoride (F)	0.2	0.2	0.5	0.5
Nitrates (NO_3)	1.6	1.9	2.0	2.2
Bacteriological (MPN/100 ML)				
Total coliform	1600	0	540	0
E.coli	300	0	-	-
Fecal streptococci	8	0	-	-

Results are expressed as mg/L except for pH, conductivity and Turbidity, Tr - Traces

TABLE 4.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

CHANDIGARH WATER WORKS - CHANDIGARH

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	3.1	2.6	0.8	0.8
	II	8.0	6.6	1.1	1.0
T.Coliform (MPN/100 ML)	I	1600	280	30-130	0
	II	540	60	20	0
E.Coli (MPN/100 ML)	I	300	26	2-30	0

CHANDRAWAL WATER WORKS No. II - DELHI

INTRODUCTION

Delhi, the national capital, has an urban population of about 80 lakhs. The city is divided into two administrative blocks, the Delhi Municipal Corporation, and the New Delhi Municipal Corporation, the latter being an enclave within the Delhi Municipal Corporation Area.

The water supply to Delhi is looked after by the Delhi Water Supply and Sewage Disposal Undertaking (DWS&SDU)of the Delhi Municipal Corporation. There are now five main water works with a total capacity of about 1680 mld serving the city. Besides, a number of Ranney wells put down along the left bank of the Jamuna yield about 90 mld. The per-capita water supply to the city at present is reported to be about 225 litres per day.

In consultation with the DWS & SDU, the Chandrawal Water Works No. II has been selected for evaluation. There are two water treatment plants at Chandrawal Water Works II, The Paterson Plant with a design capacity of 115 mld and the Hindustan Construction Company (HCC) plant with a design capacity of 135 mld. The Paterson Plant alone has been taken up for evaluation. The plant layout is shown in Fig.5.1 and summary data is presented in Table 5.1.

PLANT APPRAISAL

Raw Water quality and flow measurement

Raw water is drawn from the river Jamuna upstream of a barrage constructed at Wazirabad. The intake point lies well upstream of the various wastewater discharges into the river. There are no major sources of pollution of the river immediately above except for a bathing ghat at Wazirabad village about 1.5 km upstream. However, it is reported that about 16 km upstream, the effluents from some tanneries are being ponded up and that these wastes enter the river at times.

Data on raw water quality collected during different seasons is shown in Table 5.2. The turbidity of the raw water is reported to go upto about 3000 NTU maximum during floods in the river. However, during the period of study, such high turbidities were not experienced due to failure of rains. In low flow season, the turbidity is quite low. The coliform count is generally not very high (under 5000 per 100 ml.) except during freshes. In summer months, there is appreciable growth of algae in the impoundment at the intake created by the Wazirabad barrage.

There is considerable silt deposition around the intake which may be due to the effect of the Wazirabad barrage. Dragline excavators and dredger boats have been provided to remove silt deposits and keep the waterways to the intakes clear.

There are 3 pumping stations at Wazirabad and they together serve the three treatment plants. The total pumping capacity is 1863 mld whereas the peak pumpage is 1200 mld. The standby pumping capacity being 50 % is adequate. The head works has two bulk electricity feeder lines and generally there has been no problem due to power failure/shortage. A fully equipped workshop is maintained by the Water Works Authority at Chandrawal Water Works II where minor and major repairs of the pumping plants can be carried out.

There is no arrangement for measuring the pump discharges and at present flow estimates are being made on the rated capacity of the pumps which can not be considered reliable. The flow to Chandrawal Water Works II is regulated by regulating the pumping at the headworks. At times, excess water is also wasted through clarifier scours. There are no flow indicating or flow intergrating devices at the measuring weirs in the channel to the Paterson plant. Moreover, the M.S. weir plates have collapsed. Measurement of flow by surface float method indicated that the plant is overloaded to the extent of 30-40 %. Facilities for proper division of flow between various units are lacking.

Pretreatment

Prechlorination is carried out at the water works year round with a view to improving alum coagulation controlling algal problems experienced in summer and ensuring effective post disinfection. Chlorine demand of the water is determined daily to regulate the prechlorination dose. Two vacuum type chlorinators have been provided for prechlorination. The chlorine demand of the raw water is in the range 0.5 - 0.8 mg/l. Chlorine is added as solution at two points and as gas at one point in the main raw water channel. Chlorine dose control is difficult to achieve due to lack of accurate information on plant inflow. As the prechlorination plant is at some distance from the main plant, the supervision of the process is inadequate.

Filter alum is the coagulant used at the plant. Though jar test is being done regularly, there is no means for translating the determined dose into the quantity of alum to be added in a shift because of lack of raw water flow data.

An alum house has been constructed in two floors out of which first floor is used for preparing and storing alum solution from where it is fed by gravity to the raw water channel. The floors and walls of the alum storage room are affected by corrosion.

The alum solution pipings are of rigid PVC with CI sluice valves and they are in good condition. The air-mixing arrangements in the solution storage tanks are not operating. Facilities for proper dosing and control of alum are absent. Alum solution is "Point - added" at two points below the 3.8 m long measuring weir in the raw water channel. There is no provision for rapid (flash) mixing. Mixing takes place in the sub-channels feeding the three clarifiers. Complete mixing of the chemical in the entire bulk of water is not achieved as confirmed by the considerable variation in the alum concentration (estimate based on SO4 increase) at the inlets to the different flocculators of the plant.

The design detention times in the three flocculators are 23 min, 23 min, and 20 min. respectively. Floc formation in the flocculators was satisfactory when alum addition was proper and there was no overloading. The design surface overflow rate for the clarifiers is in the range 38 m/day-43 m/day. The clarifiers, however, are being overloaded to varying degrees.

All three clarifiers have been equipped with travelling sludge scrapers. Due to mechanical problems, the scrapers often get stalled.

Filtration

The Paterson plant has 16 filter beds arranged in two rows on either side of a common clear water channel-cum-filter gallery. Some of the filter inlet valves and wash water drain-out valves are leaking resulting in wastage of water. The glands of many of the filter valves are also leaking. The filter-rate-controller and the rate-setter are not working in any of the filters and the filters are, in effect, operating at variable rates. The filter rate indicator and the loss of head gauges are no longer functioning in any of the filters. The auxiliary floats in the filter beds are not operational. The air lock arrangements of the syphons are not working in most of the filter-beds. Filter washing is not satisfactory. All the filters (5 Nos) to be washed in a shift are shut down simultaneously which causes a high rise in the water level in other filters and also overflow of clarified water from the inlet channel. Washwater and air distribution are not uniform over the filter beds. There is mud ball formation in the filters and mounding of sand at places. The sand surfaces have developed cracks. The wash water tank is leaking and is not in use. Water for filter wash is drawn from the clear water pumping main.

Disinfection

Filtered water is chlorinated at the head of the central filtered water channel using two pressure feed chlorinators. The chlorine gas after measurement is directly let into a 150 mm dia. rigid PVC pipeline into which filtered water is also let-in. The line runs for a length about 100 m before entering into the filtered water channel.

The post-chlorination dose is fixed on a nominal basis. There is considerable leakage of chlorine from the chlorinators and from the connections from the chlorine cylinders to the chlorinators and at the dosing point in the filtered water channel.

Laboratory Facilities

The testing facilities of the Delhi Water Supply Undertaking consist of a Central Laboratory at Wazirabad Water Works and plant laboratories at each water works. The Central Laboratory facilities are adequate for routine water testing except for turbidity test for which facilities are lacking.

RECOMMENDATIONS

* In view of the potential danger of pollution of river Jamuna due to domestic and industrial discharges upstream, a regular programme of raw water quality monitoring and surveillance should be considered to facilitate preventive and corrective measures.

* Adequate arrangements for raw water flow measurement and regulation need to be provided for effective operation and control of water treatment units.

* The feasibility of interposing a detritus tank in the raw water conveyance system to intercept the silt from reaching the clarifiers should be explored.

* For chlorination (pre,intermediate and post) the practice of directly connecting the chlorine cylinders/tonne containers to the flow of water in the channel should be discontinued and replaced by sound and appropriate system of chlorination with competent supervision.

* Considering the large quantity of chemicals used and the high cost involved, careful control over chemical dosing should be ensured for optimum results. Preparation of alum solution in ground level tanks and lifting it to dosing tanks with chemical pumps should be considered as cost effective alternative to the present system.

* The practice of point addition of alum solution downstream of the weir, should be dispensed with in favour of applying alum solution through a perforated pipe along the entire width of the channel upstream of the weir for effective mixing.

* The condition of filters and appurtenances and their operation and maintenance are far from satisfactory. The system needs a planned overhaul so that the plant output is not reduced significantly. The feasibility of operating the filters on declining rate principle should be explored on an experimental basis.

* Measures need to be taken to prevent the pollution and nuisance caused by large number of pigeons in the filter house.

* The Central Laboratory and the plant laboratory should be provided with a direct reading turbidimeter such as that of Hach Company and facilities for testing of water for toxic heavy metals and trace organics at regular intervals.

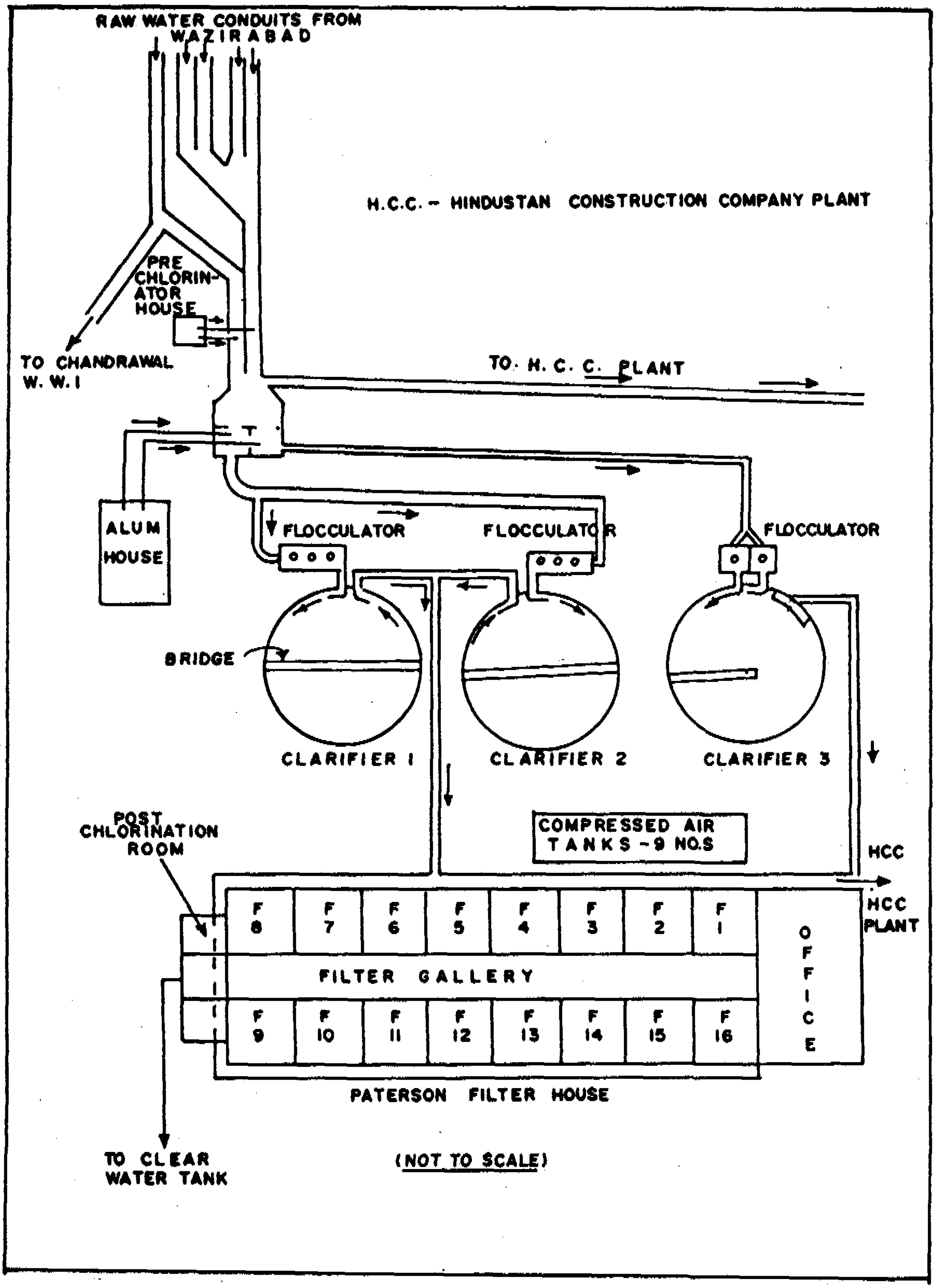


FIG 5.1 LAYOUT PLAN OF PATERSON WATER TREATMENT PLANT - DELHI

TABLE 5.1

PLANT SUMMARY DATA - DELHI

GENERAL

Name and location	:	Chandrawal Water Works No.II,Paterson Plant, North Delhi
Year of construction	:	1954
Design capacity	:	115 mld
O & M Agency	:	Delhi Water Supply & Sewage Disposal undertakings
Raw water source	:	River Jamuna
Treatment flowsheet	:	Conventional with rapid sand filters

ENGINEERING

Raw water pumping	:	8 Vertical shaft turbine pumps + 18 Horizontal centrifugal pumps, total capacity 1863 mld
-Rising main diameter	:	2 nos.-900 mm each & 3 nos.-1050 mm each
Raw water flow measurement	:	Rectangular sharp crested weirs 2 nos., 2.86 m long another 2.1 m long with design capacity 1.3 m^3/sec

Pre-treatment

Coagulation

- Chemicals used	:	Alum
- Type of mixing	:	Hydraulic
- Mixing Details	:	Length of channel 40 m,106 m, 127 m, and detention time 20 sec,120 sec, 180 sec, respectively to clarifiers 1,2,& 3; velocity in channel 1.3 m/hr

Flocculation

- Method / Type of unit	:	Mechanical, Flocculators
- No. & Dimensions	:	3 nos, first two units 18.3 x 6.0 x 4.9 m each & Third unit 7.6 x 7.6 x 5.5 m,in 2 parallel compartment.
- Detention time	:	2 Nos. 23 minutes each & third unit 20 minutes

Sedimentation

- Type of unit(s)	: Spiral flow (tangential bottom inlet,tangential top outlet)
- No. & size of unit(s)	: 2 Nos,33.7 m dia x 6.0 SWD 1 no. 36.5 m dia x 5.47 m SWD
- Surface overflow rate	: 2 units 38 $m^3/d/m^2$ & in third unit 43 $m^3/d/m^2$
- Detention Time	: In 2 nos.,4 hrs each and in third unit 3 hrs

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 16 nos., 7.6 x 10 m in two sections
- Rate of filtration	: Ave : 3.94 $m^3/h/m^2$, Max :4.93 $m^3/h/m^2$
- Filter media	
. Sand size	: E.S.- 0.45-0.60 mm, U.C.-1.6
. Depth of sand	: 63 cm
- Backwash arrangements	
. Method	: Air scour followed by water wash
. Wash water tank cap.	: 9 tanks of 9.18 m^3 capacity each

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Both direct and solution feed
- Chlorinator Details	: 2 Nos., vacuum feed of capacity 10 kg/hr for prechlorination 2 Nos., pressure feed of capacity 11.0 kg/hr used for post chlorination

Clear Water Pumping

- Pump details	: 3 nos.- 450 HP each, 3 nos. -480 HP each, 2 nos.- 800 HP each.

TABLE 5.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

CHANDRAWAL WATER WORKS II - DELHI

PARAMETERS	I VISIT	II VISIT	III VISIT	IV VISIT	
	RAW	RAW	RAW	RAW	FINISHED
Physico-chemical					
Turbidity(NTU)	600	18	5	30	0.4
pH	8.0	7.8	8.5	8.0	7.2
Total Alkalinity ($CaCO_3$)	90	130	144	72	68
Conductivity (µS/cm)	185	250	414	210	225
Hardness ($CaCO_3$)					
Total	93	138	248	86	-
Carbonate	90	130	144	86	-
Non Carbonate	3.0	8.0	104	0	-
Calcium (Ca)	28	22	42	22	-
Magnesium (Mg)	6.0	20	35	8	-
Chlorides (Cl)	7.0	13	58	16	18
Sulphates(SO_4)	10	15	45	20	-
Iron (Fe)	Tr	Tr	Tr	Tr	Tr
Fluoride (F)	0.2	0.2	0.4	0.3	-
Bacteriological (MPN/100 ML)					
Total coliform	5400	940	700	170	-
Fecal coliform	-	-	170	33	Nil

All values except pH ,Turbidity and Conductivity are expressed as mg/l.

TABLE 5.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

CHANDRAWAL WATER WORKS II - DELHI

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	30	1.5-5	0.3-1.7	0.4
T.Coliform (MPN/100 ML)	170	2	5	Nil

NIMETA WATER TREATMENT PLANT - BARODA

INTRODUCTION

The city of Baroda, with a population of 7 lakhs draws its water supply from Shri. Sayaji Rao Sarovar located at a distance of 22 km from the city. Raw water from the reservoir flows by gravity to a treatment plant of 45 mld capacity providing conventional pre-treatment with alum coagulation followed by rapid sand filtration and disinfection. The plant is maintained by Municipal Corporation, Baroda. The schematic flow sheet is shown in Fig. 6.1 and the plant summary data is presented in Table 6.1.Because of scanty rain fall and drought for the last three years, the Nimeta water works has not been getting adequate raw water supply. During the evaluation study only a few of the total component units were under operation.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Shri. Sayaji Rao Sarovar is drawn through a 910 mm dia. gravity main to the treatment plant. The raw water quality in the reservoir has been fairly good during the period of evaluation (Table 6.2). During the drought period when the water level in the reservoir goes down making it difficult to draw water under gravity, a standby arrangement comprising a sort of balancing reservoir with 5 pumps of 30 HP each has been provided. Raw water is first drawn into the balancing reservoir and then pumped to the inlet chamber of the treatment plant.

A rectangular weir has been provided in the raw water channel to measure the raw water inflow to the plant. The plant inflow during the period of evaluation was in the range of 6.4 to 15.7 mld as against the design flow of 45 mld and the plant was thus very much underloaded.

Pre-treatment

Alum solution was applied at a single point at the upstream of the weir in the raw water channel. The dosing system for controlled addition of alum was defunct. The applied dose of alum was found to be less than that determined by the jar test though adequate stock of alum was available. Flocculation is achieved in a baffled channel leading to horizontal-flow rectangular settling tanks.

Due to underloading, the computed surface overflow rate was in the range of 2.1 to 5.1 m^3/m^2/day as against the design value of 14.8 m^3/m^2/day. Consequently, the detention time was more than the design value. The settled water turbidity was less than 10.0 NTU (Table 6.3).

Filtration

Only one filter out of 10 was in operation during the visit and it was overloaded. The filtration rate varied from 5.7 to 12.1 m/hr as against the design rate of 3.9 m/hr. The performance of the filter was not satisfactory and the filtrate turbidity was in the range of 3-5 NTU (Table 6.3). None of the filter appurtenances was in working condition. Backwashing was carried out after 24 hrs of filter run using air and water.

Disinfection

Chlorination was practised at the filtered water channel. Average chlorine dose was recorded as 0.5 to 1.0 mg/l. The contact period provided was 45 minutes. The finished water had a residual chlorine of 0.3 mg/l at the plant which is inadequate.The finished water was not always safe from bacteriological point of view.

Laboratory facilities

There are no laboratory facilities except that a residual chlorine test kit is available. No chemist is posted at the plant site and no regular monitoring of water quality at various stages of treatment is done.

RECOMMENDATIONS

* Necessary arrangement for visual indication of raw water inflow need to be provided for effective operation and control of the treatment units.

* The practice of point addition of alum solution at the upstream of the rectangular weir should be dispensed with infavour of applying alum through a perforated pipe along the entire width of the channel. This will ensure effective mixing

* The required alum dose for effective coagulation should be based on jar test experiments performed from time to time.

* All filter appurtenances which are defunct need be repaired and put into working order for effective operation and maintenance of filters.

* Minimum laboratory equipment such as pH meter, turbidimeter, jar test apparatus etc. and qualified, competent personnel should be provided at the plant for effective operation and control. Existing staff should be imparted training in their respective day-to-day routine.

* Proper operation and maintenance records for the plant should be maintained.

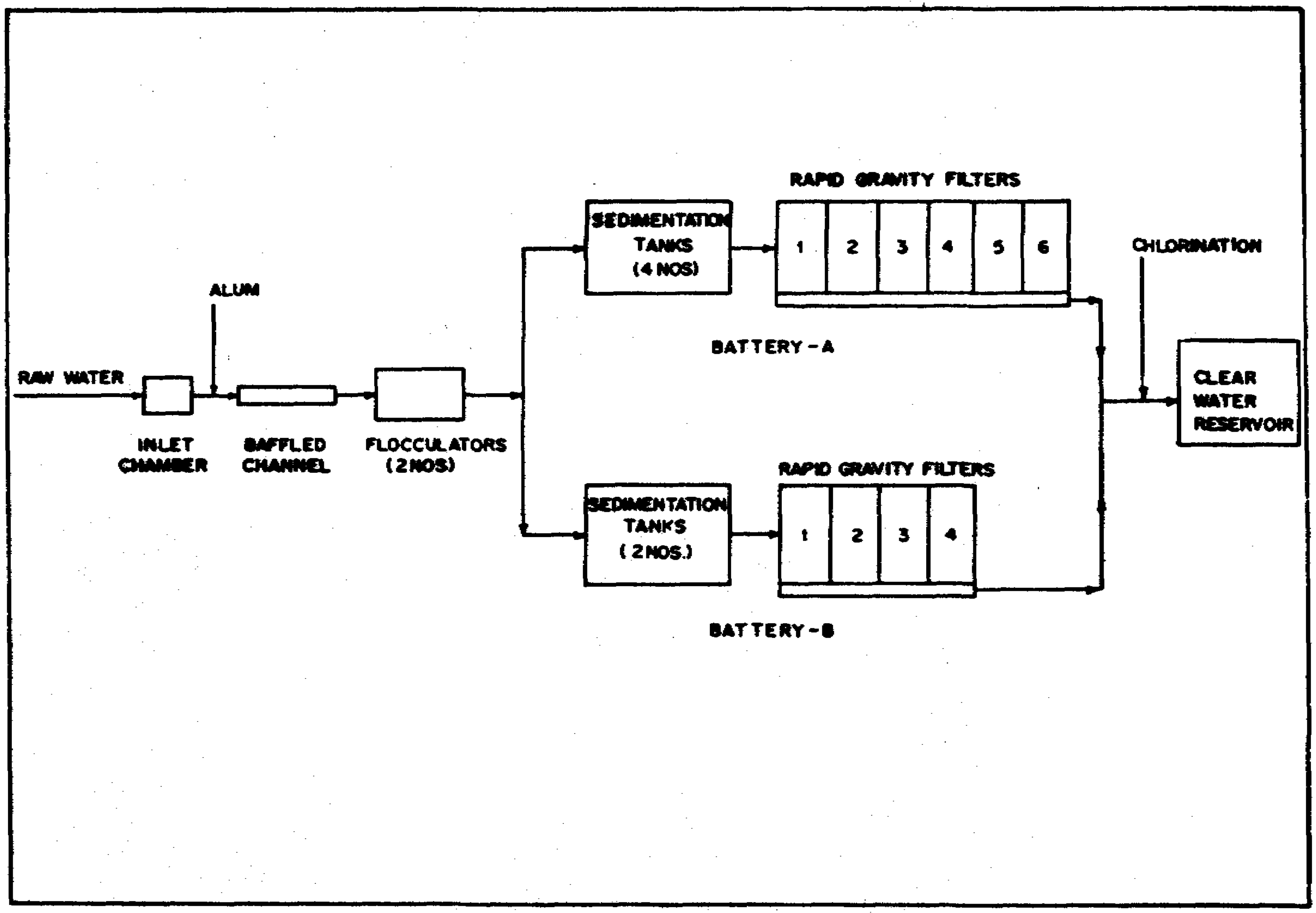


FIG 6.1 NIMETA WATER TREATMENT PLANT (SCHEMATIC) - BARODA

TABLE 6.1

PLANT SUMMARY DATA - BARODA

GENERAL		
Name and location	:	Nimeta Water Treatment Plant, Baroda (Gujarat)
Design capacity	:	45 mld
O & M Agency	:	Municipal Corporation, Baroda
Raw water source	:	Reservoir
Treatment flowsheet	:	Conventional with rapid sand filters
ENGINEERING		
Raw water pumping	:	Normally gravity flow (pumps-5nos x 30 HP, used when raw water level goes down)
-Rising main diameter	:	910 mm ; 760 mm
Raw water flow measurement	:	Rectangular weir
Pre-treatment		
Coagulation		
- Chemicals used	:	Alum
- Method of mixing	:	Hydraulic (baffled channel)
Flocculation		
- Method / Type of unit	:	Mechanical
- No. & size of unit(s)	:	2 Nos, 21.9 m x 10 m x 5.15 m SWD
- Detention time	:	15 minutes

Sedimentation	:	Battery A	Battery B
- Type of unit(s)	:	Rectangular,	Horizontal flow
- No. & size of unit(s)	:	4 nos, each 33.75m x 15.05m	2 Nos,each 34.7m x 14.95m
- Surface overflow rate	:	14.8 m/day	
- Detention time	:	6.4 hr	6.1 hr

Filtration

- Type of unit(s)	:	Rapid Gravity Filters	
- No. & size of unit(s)	:	6 Nos.,each 4.85m x 6.1 m	4 Nos.,each 8.15m x 5.71 m
- Rate of filtration	:	3.9 m/hr	3.34 m/hr
- Filter media			
. Depth of sand	:	0.55 m	0.75 m
- Backwash arrangements			
. Method	:	Air scour and water wash	

Disinfection

- Chemicals used	:	Chlorine gas
- Type of feed	:	Solution feed

Clear Water Reservoir

- Capacity	:	13638 m^3

TABLE 6.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

NIMETA WATER TREATMENT PLANT-BARODA

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FILTERED	RAW	FILTERED	RAW	FILTERED
Physico-chemical						
Turbidity (NTU)	80	5	4.5	3.0	35	3.4
pH	7.9	8.0	7.7	8.0	8.2	7.8
Total Alkalinity ($CaCO_3$)	100	70	160	150	160	170
Conductivity (µS/cm)	349	379	420	420	513	51
Hardness ($CaCO_3$)						
Total	70	70	140	140	92	92
Carbonate	70	70	140	140	92	92
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	16	16	22	22	21	21
Magnesium (Mg)	7	7	20	20	10	10
Chlorides (Cl)	50	40	50	50	60	50
Sulphates (SO_4)	18	61	21	29	40	46
Nitrates (NO_3)	2	1	4	1	1	1
Bacteriological (MPN/100 ML)						
Total coliform	430	93	240	23	2400	29
E.coli	230	23	93	9	210	0
Fecal streptococci	93	9	93	9	93	9

All values except pH,Turbidity and Conductivity are expressed as mg/l

TABLE 6.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

NIMETA WATER TREATMENT PLANT-BARODA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER
Turbidity (NTU)	I	80	7.0	5.0
	II	4.5	3.5	3.0
	III	35	10	3.4
T.Coliform (MPN/100 ML)	I	430	-	93
	II	240	-	23
	III	2400	-	29
E.coli (MPN/100 ML)	I	230	-	23
	II	93	-	9
	III	210	-	0

TAKTESHWAR FILTER PLANT, KRISHNANAGAR - BHAVNAGAR

INTRODUCTION

The city of Bhavnagar with a population of 3.5 lakhs draws its water supply from two sources namely Shetrunji reservoir and Gaurishankar lake located at a distance of 47 km and 5 km respectively from the water works at Takteshwar. The treatment plant consists of three distinct streams with a total capacity of 31.7 mld. The first and second streams (designated battery A and B for reporting) each of 11.35 mld capacity commissioned in 1932 and 1935 respectively were taken up for performance evaluation. Battery A consists of two settling tanks and three filters and battery B has two pre-settling tanks, two settling tanks and three filters. The third stream of 9 mld added in the year 1962 consists of one clariflocculator and two rapid gravity filters and was non-operational during the study period. Depending upon the availability of raw water, the inflow to this battery is diverted to the other two batteries. The schematic flow sheet is shown in Fig. 6.2 and the plant summary data is presented in Table 6.4. The treatment works are maintained by the Municipal Corporation of Bhavnagar.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Shetrunji reservoir after two stage pumping flows by gravity to the treatment works while from Gaurishankar lake it flows by gravity first and then is pumped (dia. of rising main 600 mm.) to the treatment plant. Provision for standby pumps is adequate. Raw waters from Shetrunji reservoir and Gaurishankar lake are blended at the inlet chamber of the treatment plant.

Raw water quality in the reservoir and lake has been fairly good during the period of evaluation (Table 6.5). No potential sources of pollution exist in the vicinity of intake.

Two rectangular weirs have been provided in the inlet chamber to measure the raw water inflow to battery A and battery B. The plant inflow during the period of evaluation was in the range of 7.6 to 17 mld in battery A and 5.6 to 16.8 mld in battery B as against the rated flow of 11.35 mld for both.

Pre-treatment

Alum solution was applied at a single point at the upstream of the weir in the raw water channel. The dosing system for controlled addition of alum was defunct.

In battery A, flocculation was achieved in a baffled channel leading to horizontal flow rectangular settling tanks. In battery B, a separate flocculation chamber has been provided. The settling tanks of both battery A and B were highly overloaded.

The computed SOR of settling tanks of battery A was in the range of 12.5 to 28 $m^3/m^2/day$ as against the design value of 18.7 $m^3/m^2/day$, while the corresponding figures for battery B was 11.1 to 33.3 $m^3/m^2/day$ as against the design value of 22.5 $m^3/m^2/day$. Consequently, the detention time was in the range of 2.7 to 6 hrs as against the design value of 4 hrs. However, in case of battery B the detention time was 2.1 to 6.4 hrs as against the design value of 3.2 hrs. The settled water turbidity was more or less the same as that of the raw water (Table 6.6).

Filtration

The filters in both the batteries were overloaded and their performance was far from satisfactory. The filtration rate varied from 2.6 to 5.7 m/hr in battery A and in battery B it varied from 1.9 to 5.6 m/hr as against the design rate of 3.8 m/hr. The depth of sand in the filters was only 25 cm and practically there was no reduction in turbidity due to filtration (Table 6.6). Reportedly, the depth of sand was reduced from the original value of 75 cm to facilitate overloading.

The filter appurtenances such as rate controller, rate of flow indicator and headloss indicator in all the filters were not in working condition. Filters were backwashed as a matter of routine once in 24 hrs. The sludge from settling tanks and spent filter backwash water are disposed off into the sea through an underground channel.

Disinfection

Chlorine gas was used for disinfection. As the chlorinator was out of order, chlorine gas was directly applied at the filtered water channel leading to the clear water reservoir. Average chlorine dose for the filtered water was recorded as 0.5-1.0 mg/l. The contact period provided was 45 min. The finished water had a residual chlorine of 0.2 mg/l at the plant which is inadequate. The finished water was not always safe from bacteriological point of view.

Laboratory facilities

A small laboratory headed by a laboratory assistant has been provided at the plant with necessary equipment like jar test machine, turbidimeter (Aplab), pH meter (colour comparator) and chloroscope. However, the laboratory staff had not undergone any formal training for routine quality control. Record keeping with respect to plant operation was also found unsatisfactory.

RECOMMENDATIONS

* Necessary arrangement for visual indication of raw water inflow needs to be provided for effective operation and control of the treatment units.

* The practice of point addition of alum solution at the upstream of the rectangular weir should be dispensed with infavour of applying alum through a perforated pipe along the entire width of the channel to ensure effective mixing.

* The optimum alum dose for coagulation should be determined from the jar test experiments performed from time to time.

* Overhauling of the filters should be carried out by replacing existing sand with properly graded sand of required depth and repairing/replacing filter appurtenances which are defunct.

* The practice of direct application of chlorine gas in uncontrolled manner at the filtered water channel should be discontinued and measures taken to put into commission the existing chlorination equipment for effective chlorination.

* The existing laboratory instruments/equipments should be made serviceable and augmented. The chemist posted at the plant should be provided with formal training in water analysis and laboratory control.

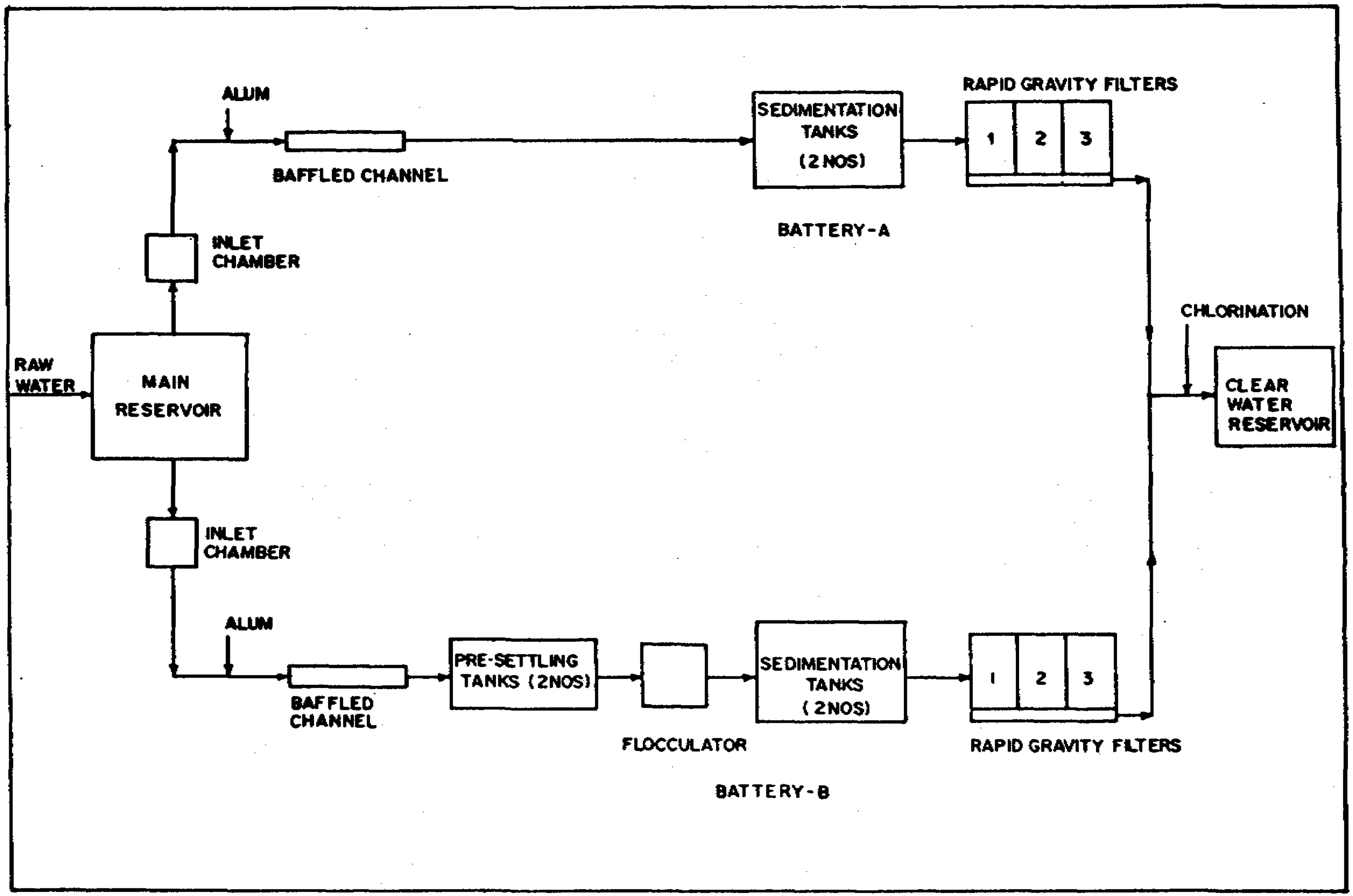


FIG 6.2 TAKTESWAR WATER TREATMENT PLANT (SCHEMATIC) - BHAVNAGAR

TABLE 6.4

PLANT SUMMARY DATA - BHAVNAGAR

GENERAL

Name and location	:	Takteshwar Filter Plant, Krishna Nagar, Bhavnagar	
Year of construction (Augmentation if any)	:	1934 and 1963 (Augmentation)	
Design capacity	:	31.7 mld	
O & M Agency	:	Municipal Corporation, Bhavnagar	
Raw water source	:	Reservoir and lake	
Treatment flowsheet	:	Conventional with Rapid sand filters	
ENGINEERING			
Raw water pumping	:	Reservoir 220 HP x 6 nos (Submersible and Centrifugal)	Lake 60 HP x 3 nos. 85 HP x 1 no. 150 HP x 1 no.
- Rising main diameter	:	1000 mm (2 stages)	450 mm (gravity main) -2 nos. 600 mm
Raw water flow measurement	:	Rectangular weirs	
Pre-treatment			
- Balancing reservoir size	:	15.2 m x 18.3 m x 2 m	
- Detention time	:	38 minutes	
- Pre-settling tanks	:	battery A	battery B
- No. & size of unit(s)	:	-	2 nos, each 9.2 m x 8.8 m x 4 m SWD
Coagulation			
- Chemicals used	:	Alum	Alum
- Type of mixing	:	Hydraulic (baffled channel)	

Flocculation

- Method / Type of unit	:	Hydraulic	Mechanical
- No. & size of unit	:	-	1 no.,4.7 m x 5.8 m
Sedimentation		battery A	battery B
- Type of unit(s)	:	Rectangular	Rectangular
- No. & size of unit(s)	:	2 nos.,each 13.66 m x 22.25 m x 3.14 SWD	2 nos.,each 27.4 m x 9.2 m x 2.99 m SWD
Surface overflow rate	:	0.78 m/hr	0.9 m/hr
- Detention time	:	4 hrs	3.2 hrs

Filtration

- Type of unit(s) : Rapid gravity filters

- No. & size of unit(s) : 6 nos.(single bed) each 7.5 m x 5.5 m

- Rate of filtration : 3.8 m/hr

- Filter media

. Sand size : E.S - 0.5 mm
U.C - 1.8

. Depth of sand : 0.75 m

- Backwash arrangements

. Method : Air scour and water wash

Disinfection

- Chemicals used : Chlorine gas

- Type of feed : Solution feed

Clear Water Reservoir

- Capacity : 17200 m^3

- Pump details : 75 HP x 2 nos.,
30 HP x 1 no.

TABLE 6.5

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

TAKTESHWAR FILTER PLANT -BHAVNAGAR

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	7.8	5.6	8.2	8.2	20	13
pH	8.2	8.2	8.2	8.2	8.6	8.6
Total Alkalinity ($CaCO_3$)	110	120	130	130	170	170
Conductivity (µS/cm)	401	401	411	411	485	485
Hardness ($CaCO_3$)						
Total	110	120	130	140	200	180
Carbonate	110	120	130	130	170	170
Non Carbonate	0	0	0	10	30	10
Calcium (Ca)	21	16	19	19	30	27
Magnesium (Mg)	14	16	20	20	30	27
Chlorides (Cl)	50	50	55	55	70	70
Sulphates (SO_4)	-	-	37	37	24	24
Nitrates (NO_3)	0.9	1.0	0.9	1.3	1.8	1.5
Bacteriological (MPN/100 ML)						
Total coliform	93	3	93	0	93	21
E.coli	43	0	23	0	43	0
Fecal streptococci	43	0	23	0	43	14

All values except pH,Turbidity and Conductivity are expressed as mg/l

TABLE 6.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

TAKTESHER FILTER PLANT - BHAVNAGAR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FINISHED WATER
Turbidity (NTU)	I	7.8	6.8	5.6
	II	8.2	8.2	8.2
	III	20	19	13
T.Coliform (MPN/100 ML)	I	93	-	3
	II	93	-	0
	III	93	-	21
E.coli (MPN/100 ML)	I	43	-	0
	II	23	-	0
	III	43	-	0

OPA WATER WORKS - GOA

INTRODUCTION

Panjim, the capital of Goa has a population of about 4.5 lakhs (1981 census) and receives its water supply from Opa water works situated about 27 Km away from city. The water works of 54 mld capacity commissioned in 1972 draws raw water from river Khandepar. The treatment comprises aeration, pre-treatment with alum coagulation and sedimentation followed by rapid sand filtration and post-chlorination. The schematic flow sheet is shown in Fig.7.1 and the plant summary data is presented in Table 7.1. The plant is maintained by PWD, Goa.

PLANT APPRAISAL

Raw water quality and flow measurement

A weir across the river Khandepar has been constructed downstream of the intake to ensure adequate supply of raw water throughout the year. There are no potential sources of pollution in the vicinity of the intake. Due to impoundment, the raw water quality is quite good (Table 7.2). The intake has M.S. removable screens which are cleaned manually. Six raw water pumps have been provided of which 2 are standby. During the evaluation study it was observed that the standby pumps were also in use to increase the output. The flow recorder and integrator installed at the Venturi flume were not working and the actual flow measured indicated overloading of the plant by 15%.

Pre-treatment

Chemical dosing and mixing tanks have been provided for preparation of alum and bleaching powder solutions. Alum mixing is achieved at the hydraulic jump. Bleaching powder is used, whenever necessary, for prechlorination. The mechanical equipment in the clariflocculator was found in good working condition and though the plant was overloaded, the settled water quality was still satisfactory (Table 7.3).

Filtration

The filters were properly operated and well maintained. However, the filter head loss gauges were out of order. Coarse sand was reported to have been used in two filters to facilitate higher filtration rates. The quality of filtrate was satisfying the standards prescribed by CPHEEO (Table 7.3).

Disinfection

The gas chlorinators were in good working condition. Chlorination was found to be effective as confirmed by the absence of E.coli in the treated water (Table 7.3). Bleaching powder is also stocked at the plant for emergency use.

Laboratory Facilities

A well equipped laboratory has been provided at the plant. A qualified chemist and a microbiologist have been posted for routine analysis and control of the treatment processes.

RECOMMENDATION

* The flow recorders and filter headloss guages should be got repaired to facilitate effective plant control and filter operation.

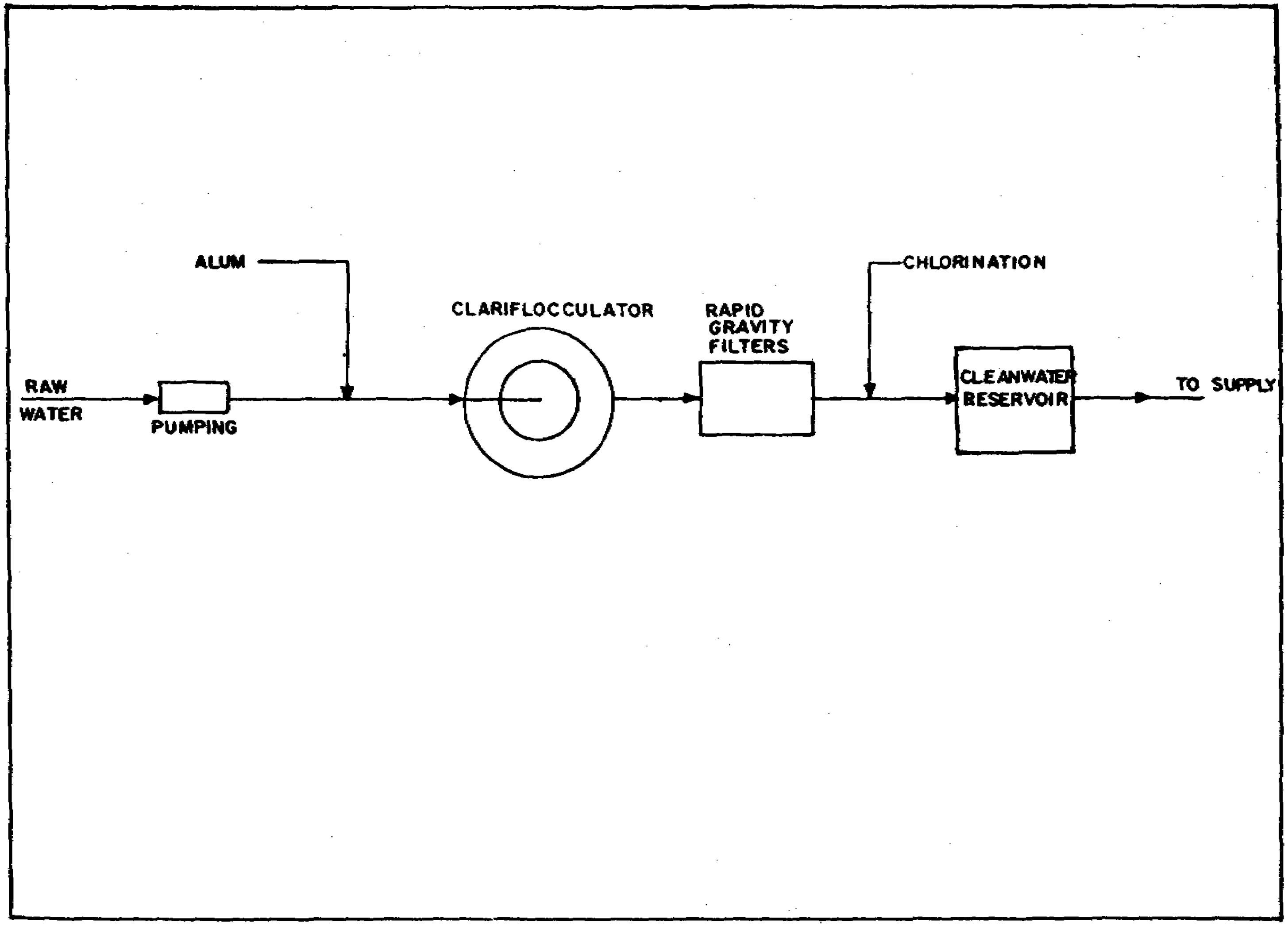


FIG 7.1 OPA - WATER TREATMENT PLANT (SCHEMATIC), GOA

TABLE 7.1

PLANT SUMMARY DATA - GOA

GENERAL		
Name & Location	:	Opa Water Works.Opa Khandepar, Ponda, Goa
Year of Construction	:	1972
Design Capacity	:	54 mld
O & M agency	:	Public Works Department, Goa
Raw water source	:	River Khandepar
Treatment Flowsheet	:	Conventional with rapid gravity filters
ENGINEERING		
Raw water Pumping	:	6 Nos. of 13.5 mld cap. each including 2 standby
- Rising main Diameter	:	750 mm.
Raw water flow measurement	:	Venturi flume with Mahindra Electro flow meter
Pre-treatment		
Aeration	:	Cascade type
Coagulation		
- Chemicals used for	:	Alum, lime
- Method of mixing	:	Hydraulic, Channel 3.5 m long
Flocculation		
- Method (type of unit)	:	Mechanical(Clariflocculator)
- No.and size of unit(s)	:	2 Nos., 18 m dia.each.
- Detention time	:	30 minutes

Sedimentation

- Type of unit(s)	:	Circular clarifiers
- No. & size of units	:	2 Nos., 36 m dia. each.
- Surface over flow rate	:	1.12 m/hr
- Detention time	:	2 hours

Filtration

- Type of unit(s)	:	Rapid gravity filters
- No. & size of unit(s)	:	6 Nos.,12.2m x 7.6m each.
- Rate of filtration	:	4.9 m/hr
-Filter media		
. Sand size	:	E.S.-0.6 mm, U.C.-1.8
. Depth of sand	:	70 cm
. Gravel size	:	6-12 mm 12-18 mm
. Depth of each layer	:	25 cm 12 cm
-Backwash arrangements		
. Method	:	Air scour & Water wash
. Wash water tank cap.	:	Not provided,direct pumping

Disinfection

- Chemicals used	:	Chlorine gas + bl. powder
- Method of feeding	:	Solution feed
- Chlorinator Details	:	Two Nos., Pressure type Aqua Pura Corporaton 7 kg/hr. capacity
- Contact period	:	3 hrs

Clear Water Reservoir

- Type, No., & capacity	:	RCC, 3 tanks of 3030 m^3 capacity each
- Clear Water Pumping	:	Gravity Flow

TABLE 7.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

OPA WATER WORKS PLANT - GOA

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity(NTU)	0.5	0.8	5.5	0.5	9.3	2.5
pH	7.4	7.0	7.4	7.3	7.3	7.5
Total Alkalinity ($CaCO_3$)	26	26	48	50	24	24
Hardness($CaCO_3$)						
Total	32	32	48	50	30	30
Carbonate	26	26	48	50	24	24
Non Carbonate	6	6	0	0	6	6
Calcium (Ca)	6	6	16	16	8	8
Magnesium (Mg)	4	4	1.5	2	2.4	2.4
Chlorides (Cl)	12	12	5	5	20	18
Sulphates (SO_4)	Tr	Tr	Tr	Tr	Tr	Tr
Iron (Fe)	0.2	-	0.2	-	Tr	-
Bacteriological (MPN/100 ML)						
Total coliform	2400	Nil	1100	Nil	>140	Nil
Fecal coliform	930	Nil	240	Nil	Nil	Nil
E.coli	150	Nil	4	Nil	Nil	Nil
Fecal streptococci	43	Nil	28	Nil	Nil	Nil

All values except pH and turbidity are expressed as mg/l
Tr - Traces

TABLE 7.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

OPA WATER WORKS PLANT - GOA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	5.0	5.0	-	0.8
	II	5.5	5.0	-	0.5
	III	9.3	5.5	-	2.5
T.Coliform (MPN/100 ML)	I	2400	460	93	0
	II	1100	460	7	0
	III	>140	140	4	0
E.Coli (MPN/100 ML)	I	150	23	0	0
	II	4	0	0	0
	III	0	0	0	0

HANSI WATER TREATMENT PLANT - HANSI

INTRODUCTION

Hansi town in Haryana has a population of 60,000 as per 1981 census. Presently, the city has two water treatment plants, viz. the old plant using conventional media (4090 m^3/day) and the recently commissioned dual media (coconut shell and sand) filtration plant (4546 m^3/day) located on Hansi-Jind road about 2 km from Hansi town. Since the new plant is still to be fully operational, the old plant alone has been taken up for evaluation. Canal water after storage is pumped to the treatment plant which provides for conventional pre-treatment with alum coagulation and sedimentation followed by rapid sand filtration and disinfection. The plant commissioned in 1962 is maintained by the PHED, Govt. of Haryana. The plant layout is shown in Fig.8.1 and summary data is presented in Table.8.1

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from the Petwar Distributory of the Western Jamuna Canal is drawn by gravity to storage-cum-sedimentation tanks of 28 days capacity. Due to the long storage, the raw water is of high quality with low turbidity and coliform counts (Table 8.2). Stored water is drawn through a floating intake to a sump from where it is pumped to the treatment plant. There is no provision for measuring the plant inflow and flow regulation is achieved either by throttling the pump delivery valve or stopping the pump. Actual flow measurement at the time of visit indicated that the plant inflow was only 56 per cent of the design flow.

Pre-treatment

Alum in solution form is used as the coagulant. The dose of alum is fixed based on past experience and not determined by jar tests. There is no provision for constant or proportionate dosing of alum solution. Alum mixing and flocculation is achieved in a baffled channel.

The coagulated and flocculated water is clarified in horizontal flow rectangular settling tanks with hopper bottoms. The flocculated water enters the tank through 8 numbers of C.I. pipes placed along the width of the tank. As raw water turbidity itself was very low, the reduction due to sedimentation was not significant (Table 8.3).

Filtration and disinfection

Three open to sky filters have been provided each measuring 4 m x 4 m of actual filter surfaces. No rate controllers have been provided and the filters are operated on declining rate principle. No provision has been made for air scour and filters are backwashed using water only. Backwashing was ineffective and considerable mud ball formation was noticed in the filters. Filtered water is chlorinated using a solution of bleaching powder. The finished water was free from coliform.

Laboratory facilities

The plant has no laboratory facilities to conduct the routine tests.

RECOMMENDATIONS

* Proper arrangement for raw water flow measurement should be provided to facilitate plant operation and control.

* Maintenance of filter bed needs to be improved by adequate/ more frequent back washing.

* Arrangements should be made for periodic testing of water quality and to fix the dose of chemicals in a rational way.

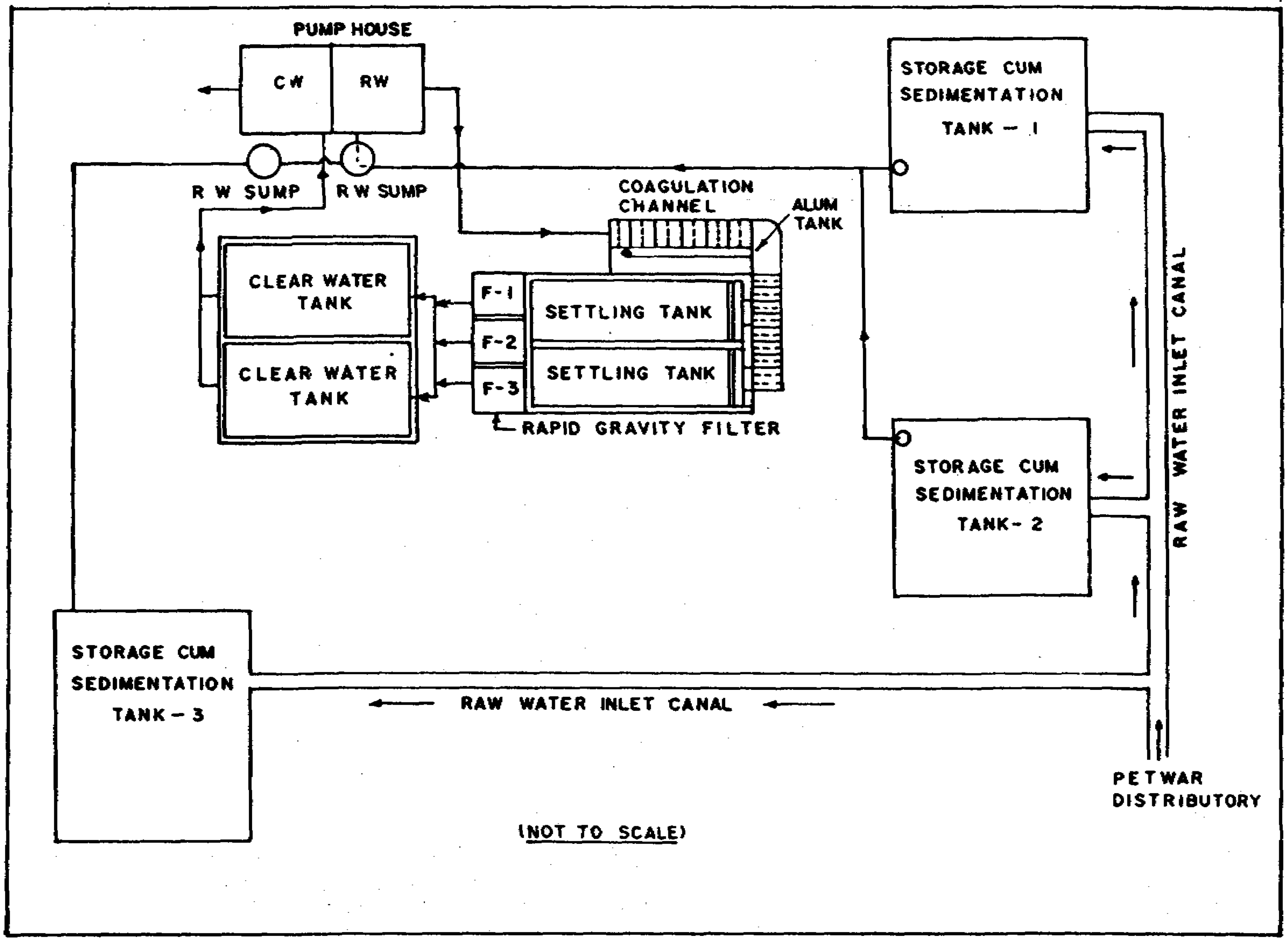


FIG 8.1 LAYOUT PLAN OF HANSI WATER TREATMENT PLANT

TABLE 8.1

PLANT SUMMARY DATA - HANSI

GENERAL

Name and location	: Hansi Water Treatment Plant Hansi (Haryana)
Year of construction	: 1962
Design capacity	: 4.5 mld
O & M Agency	: Public Health Engineering Department,(Haryana)
Raw water source	: Western Jamuna Canal
Treatment flowsheet	: Conventional with rapid sand filters

ENGINEERING

Raw water pumping	: 2 nos.,25 HP each, Centrifugal pump of 3.86 m^3/min. capacity
-Rising main diameter	: 300 mm.
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Hydraulic
- Details of mixing	: Open baffled channel 37 nos.RCC baffles to S.T No.1 43 nos. RCC baffles to S.T No.2
Flocculation	
- Method / Type of unit	: Hydraulic baffled channel (over and underflow)
- Dimensions	: Length of channel 28 m to S.T 1 and 37.5 m to S.T 2 Total no. of baffles 43

Sedimentation

- Type of unit(s)	: Clarifiers (Rectangular)
- No. & size of unit(s)	: 2 nos., each 28m x 7.8m & 2.4m depth
- Surface Overflow Rate	: 9.45 m^3/m^2/day
- Detention time	: 5 hrs. 25 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 3 nos.,each 4 m x 4 m
- Rate of filtration	: 4.0 m^3/m^2/hr.
- Filter media	
. Sand size	: E.S.-0.2 to 0.4 mm
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Waterwash only
. Wash water tank cap.	: 180 m^3 (common to both old and new plants)

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Pumping

- Type, No. & Capacity	: 2 nos., 27 m x 9 m x 2.8 m each
- Pump details	: 2 nos., centrifugal pumps of capacity 232 m^3/hr, 50 HP each

TABLE 8.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

HANSI WATER TREATMENT PLANT - HANSI

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	3	2.0	13	4
pH	7.8	7.2	9.0	8.3
Total Alkalinity ($CaCO_3$)	88	86	40	56
Conductivity (µS/cm)	270	256	102	120
Hardness ($CaCO_3$) Total	118	134	56	80
Carbonate	88	86	40	56
Non Carbonate	30	48	16	24
Calcium (Ca)	28	31	14	22
Magnesium (Mg)	12	14	5	5
Chlorides (Cl)	16	18	7	13
Sulphates (SO_4)	28	35	23	28
Iron (Fe)	0.1	0.1	Tr.	0.1
Bacteriological (MPN/100 ML)				
Total coliform	8	NIL	94	NIL
Fecal coliform	NIL	NIL	23	NIL
Fecal streptococci	2	NIL	23	NIL

All values except pH ,Turbidity and Conductivity are expressed as mg/l.

TABLE 8.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

HANSI WATER TREATMENT PLANT - HANSI

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	3	2	1.7	2.0
	II	13	12	5	4.0
T.Coliform (MPN/100 ML)	I	8	5	2	NIL
	II	94	49	13	NIL

MAIN WATER WORKS - HISSAR

INTRODUCTION

Hissar, a major commercial-cum-industrial town of Haryana, with a present population of about 1.2 lakhs is served by two water works, viz.(i) The Main Water Works (9.0 mld) and (ii) The Second Water Works (5.9 mld). The plant capacities are being augmented by 10.0 mld and 1.0 mld respectively.

The Main Water Works, commissioned in 1970 was taken up for evaluation study. Canal water drawn through storage tanks is pumped to the treatment plant which provides for alum coagulation, flocculation, sedimentation in upflow sludge blanket clarifiers, rapid sand filtration and post-chlorination. The plant owned by the Municipal Committee of Hissar is managed by the Public Health Engineering Department, Govt. of Haryana. The plant layout is shown in Fig.8.2 and summary data is presented in Table.8.4.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water from the Western Jamuna Canal is drawn through Hissar Major Distributory. Two storage-cum-sedimentation tanks of 28 days capacity are provided, to tide over canal closure period. A bar screen has been installed in the inlet channel to remove gross floating debris. There are no point sources of pollution in the Hissar Major Distributory; however, there is bathing and washing of clothes by people and cattle wading in the channel. Raw water from storage tanks is drawn into a suction well through a floating intake and pumped to the treatment plant. The flow indicator-cum-integrator and recorder originally installed at the raw water inlet channel are in disrepair. No special arrangement exists for regulating plant inflow and it is effected either by stopping the pump or by throttling the delivery valve of the pump. Due to large detention time provided in the storage tank, considerable improvement in raw water quality is observed (Table 8.5).

Pre-treatment

Adequate provision has been made for alum solutionising and mixing tanks. Mixing is achieved through hand operated mixing paddles. Alum solution is fed at the head end of a baffled mixing channel. Flocculation and sedimentation is achieved in the upflow sludge blanket clarifiers with a detention time of 2.83 hrs and surface overflow rate of 1.33 m/hr. The performance of the sludge blanket clarifiers was satisfactory and the settled water turbidity was less than 5 NTU (Table 8.6).

Filtration

Two rapid gravity filters of 7 m x 7 m each have been provided with a design filtration rate of 4.8 m/hr. The filters are backwashed using only filtered water as the air-blower provided for scour was out of order. The filter rate controllers, rate of flow indicators and loss of head-gauges in all the filters were not in working condition. Filter backwashing was not effective and large cracks were observed in the filter beds. The performance of the filters has not been satisfactory and the filtered water turbidity was 1.8 to 4.0 NTU (Table 8.6).

Disinfection

The disinfection of filtered water is carried out using bleaching powder solution. The dose is controlled by trial and error and not based on test for chlorine demand. Residual chlorine in finished water was 1.5 to 3 mg/l and the finished water was free from coliforms.

Laboratory facilities

No laboratory facilities are available at the plant site.

RECOMMENDATIONS

* Adequate arrangement should be provided for measurement and recording of plant inflow.

* The rapid sand filters which are in a bad condition need to be overhauled, damaged laterals, if any, be replaced and supporting gravel and filter sand of appropriate depth and grading be placed in the filters. Effective backwashing of the filters should be ensured to prevent recurrence of the problem.

* In view of the expansion of the plant capacity, it is essential to establish a laboratory at the plant. The laboratory should be adequately equipped with necessary facilities and trained staff fo facilitate effective plant control.

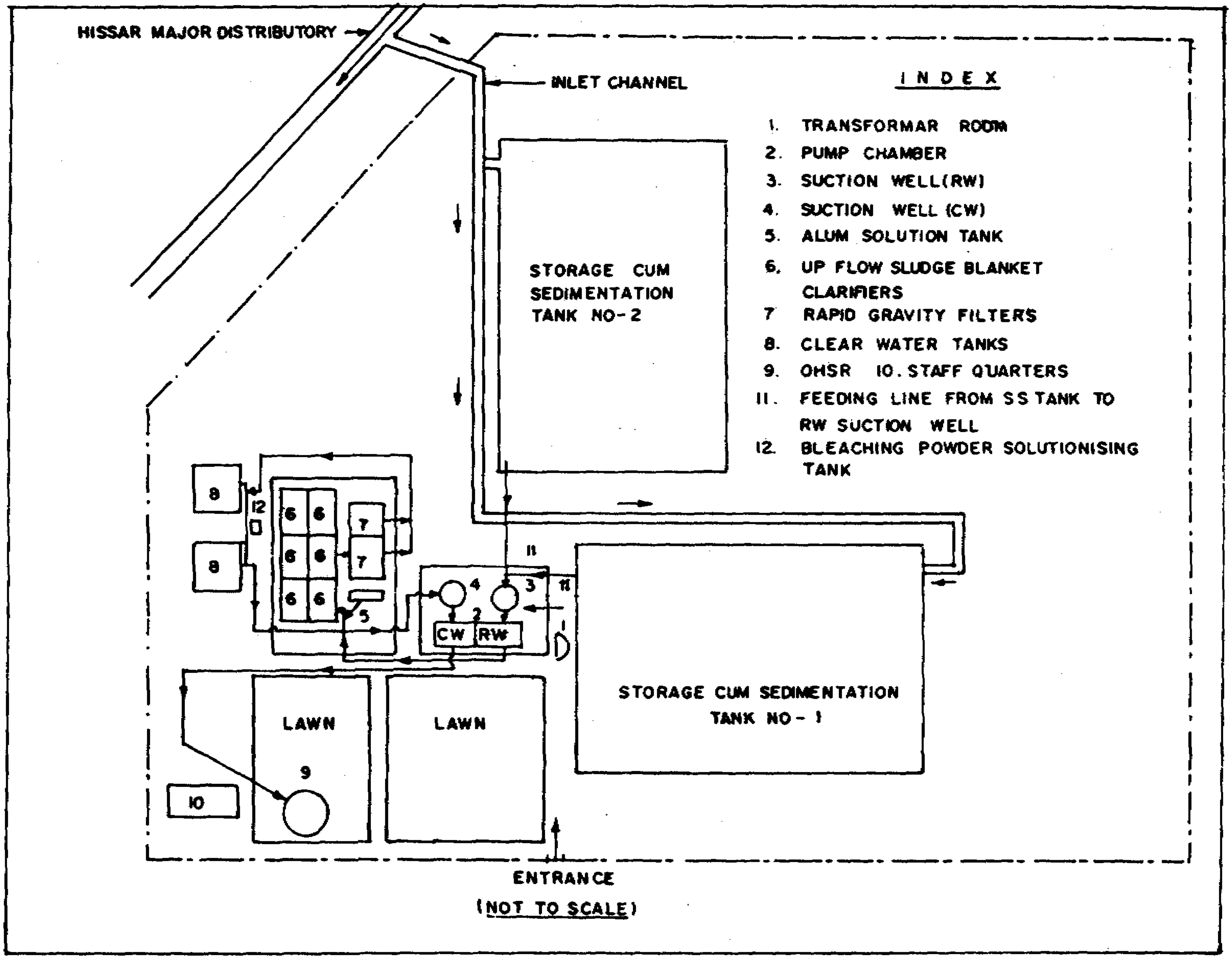


FIG 8.2 LAYOUT PLAN OF MAIN WATER WORKS - HISSAR

TABLE 8.4

PLANT SUMMARY DATA - HISSAR

GENERAL

Name and location	: Main Water Works Hissar, (Haryana)
Year of construction	: 1970
Design capacity	: 9 mld
O & M Agency	: Public Health Engineering Department,(Haryana)
Raw water source	: Western Jamuna Canal
Treatment flowsheet	: Conventional with Rapid Sand Filters

ENGINEERING

Raw water pumping	: 3 nos, Centrifugal pump, 35 HP, 15 HP & 55 HP respectively
-Rising main diameter	: 450 mm
Raw water flow measurement	: Broad crested masonary weir
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Hand operated mixing paddles
Flocculation	
- Method / Type of unit	: Mechanical,Clariflocculator

Sedimentation

- Type of unit(s)	: Sludge Blanket type clarifier
- No. & size of unit(s)	: 6 nos., 7 m x 7 m x 7 m each
- Surface Overflow Rate	: 32 m^3/m^2/day
- Detention time	: 2 hr 50 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 2 nos., 7 m x 7 m each
- Rate of filtration	: 4.8 m^3/m^2/hr
- Filter media	
. Sand size	: E.S.-0.45-0.7 mm U.C. - 1.3 to 1.7
. Depth of sand	: 60 cm
. Gravel size	: 2 layers, first layer 20 mm to 25 mm & second layer 8 mm to 15 mm
. Depth of each layer	: 13.5 cm
- Backwash arrangements	
. Method	: Wash water only

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Pumping

- Type, No. & Capacity	: 2 nos., 22.87 m x 22.87 m x of Reservoir 2.44 m each, 1276 m^3 capacity
- Pump details	: 6 nos., Centrifugal pumps of 160 HP, 2 nos.-70 HP each,75 HP, 65 HP and 45 HP respectively

TABLE 8.5

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

MAIN WATER WORKS - HISSAR

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	4	1.8	5	2	12	1.8
pH	7.6	7.3	8	7.4	8.5	7.9
Total Alkalinity ($CaCO_3$)	80	78	70	62	64	60
Conductivity(μS/cm)	214	220	190	185	184	-
Hardness $CaCO_3$						
Total	102	112	90	86	80	-
Carbonate	80	78	70	62	64	-
Non Carbonate	22	34	20	24	16	-
Calcium (Ca)	34	34	28	-	24	-
Magnesium (Mg)	4	-	5.0	-	5	-
Chlorides (Cl)	9	9	8	9	8	7
Sulphates (SO_4)	12	-	14	-	12	-
Bacteriological (MPN/100 ML)						
Total coliform	8	NIL	23	NIL	540	NIL
Fecal coliform	NIL	NIL	4	NIL	350	NIL

All values except pH ,Turbidity and Conductivity are expressed as mg/l.

TABLE 8.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

MAIN WATER WORKS - HISSAR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	4	1.5	1.4	1.8
	II	5	3	4	2
	III	12	2.5	2.0	1.8
T.Coliform (MPN/100 ML)	I	8	NIL	NIL	NIL
	II	23	4	NIL	NIL
	III	540	170	70	NIL

PHED SECOND WATER WORKS - ROHTAK

INTRODUCTION

Rohtak town in Haryana with a population of about 1.8 lakhs (1981 census) has three water works viz (i) Old Municipal Plant (9.1 mld) (ii) PHED Second Water Works (9.1 mld) and (iii) Medical College Plant (4.5 mld). The source of water supply for all the plants is the Western Jamuna Canal. The PHED second water works was selected for the evaluation study. The plant layout is shown in Fig.8.3 and summary data is presented in Table 8.7. The plant was commissioned in 1979 is maintained by the State PHED.

PLANT APPRAISAL

Raw water quality and flow measurement

There has been scarcity of water in the Western Jamuna Canal during the last one year due to drought. As a result, there is often delay in the release of water into the Sunari Minor branch channel which feeds the raw water storage tank at the water works and water supply to the town gets affected.

There are no point sources of industrial pollution in the Sunari Minor branch ; however, there is cattle wading and washing of clothes and bathing in the channel. The quality of water reaching the water works is fair and the total coliform MPN does not generally exceed 250 per 100 ml (Table 8.8).

Only half the design requirements of raw water storage has been provided for in the first phase. There is heavy growth of rooted aquatic weeds (mainly Hydrilla) in the storage tank. However, there is no significant growth of algae in the water. Because of the difficulty in keeping the storage tank empty without disrupting the water supply, the storage tank has not been deweeded so far. The two float-controlled swing type offtakes in the storge tank are not working and the supply is being drawn from tank bottom all the time which is not desirable. Due to frequent interruption in electric supply to Rohtak region, the plant operation is often restricted to 10-12 hours a day. There is 100% standby capacity for raw water pumping but no standby power.

The raw water flow indicator, integrator and recorder installed at the measuring flume, are not working.

Pre-treatment

Provision has been made for addition of both alum and lime for coagulation. The quality of canal water after storage, being fairly good, alum coagulation is not practised regularly. Alum solution tanks with stirrers have been provided but devices for measuring and constant dosing of chemicals have not been provided. Storage space for chemicals is sufficient.

The standing wave at the raw water measuring flume could have been used for rapid mixing of the coagulant in the raw water. A mechanical flash mixer has been provided but its speed is very low (30 rpm) to be effective. The detention time (60 sec) of the flash mix chamber is adequate.

There is one circular clariflocculator with 10 cm dia. orifices for discharge of clarified water. The placement of the flocculator (one to either side of the centre mounted on the moving bridge) is not satisfactory as it leaves more than 50 % of the plan area unswept by the paddles. During visits to the plant, alum was not being added and functional efficiencies of the flocculator could not be assessed.

The design features of the settling zone of the clariflocculator are found to be satisfactory with regard to side water depth, weir loading, surface overflow rate and detention time. The orifice outlets into the effluent launder of the clarifier were found to get submerged. The tip speed of the clarifier scraper bridge is greater than the desirable maximum speed and is likely to stir up settled sludge. Sludge withdrawal arrangements of the clarifier are satisfactory.

Filtration

The design rate of filtration (4.9 m/hr) is on the lower side. The other design features of the filters are satisfactory except the following.

The underdrain system is inadequate in regard to size of the manifold, number and size of laterals and size and spacing of the perforations in the laterals.

The filter rate setters, the filter rate controllers, the filter rate indicators, the headloss gauges and the auxiliary floats in the filter beds are all not functional. The filters are now operating at variable rates and variable heads, the total flow through the filters being controlled by the rate of raw water pumping.

The air and wash water distribution during filter backwash is not uniform. This is evident by the presence of heavy mounding of sand at places and deep pits elsewhere. There was also mixing of gravel with sand as seen at the surface of sand bed. The filter sand is mostly caked up with mud. There are extensive cracks in the filter surface. There seems to be short-circuiting of water through the filter bed without undergoing any filtration. The poor condition of the filter beds could be the result of deficiencies in the filter wash system. There was loss of sand during washing.

Disinfection

Post-chlorination alone is provided which is adequate. The dose is fixed by trial and error to give the desired residual. A gaseous chlorinator had been installled at the water works but the equipment has never worked. Bleaching powder is being used for chlorination and is added into the two clear water storage tanks separately which cannot effect as through mixing as adding it into the filtered water conduit itself. The bleaching powder dosing arrangement does not ensure dosing of bleaching powder solution at constant strength and therefore is not satisfactory. Sufficient chlorine contact time (about 2 hours minimum) is available before chlorinated water is pumped for distribution. Clear water storage is adequate. No meter has been provided to record the total quantity of water supplied from the waterworks.

Laboratory Facilities and Staff

The laboratory facilities fall far short of the norms recommended by the CPHEEO in terms of laboratory space and equipment. There is no turbidimeter which is an essential equipment for plant control. The jar test equipment provided is not very satisfactory. Junior Engineer partly incharge of the waterworks, is not able to lookafter the O & M requirements properly. There is a temporary chemist. There is no laboratory attendant or technician to assist the chemist. Filter and pump operators have no special training.

Plant records

Daily records are maintained only for raw and clear water pumping operations and residual chlorine tests. No records are kept for filter operation, raw water storage levels etc. Actual flow measurements for raw water entering the works or the water leaving the filters are not done.

RECOMMENDATIONS

* Additional raw water storage capacity may be provided as the storage now provided is only half of the design requirements.

* Float offtake in raw water storage tank and raw water flow measuring device should be repaired.

* Constant rate alum solution feed device should be set right and the point of alum addition may be shifted to achieve adequate mixing.

* Loss of head and filtration rate gauges as well as filter rate controllers need repair.

* The plant should have a laboratory where some important tests such as turbidity, pH, chlorine demand, residual chlorine etc. to check the quality of raw water and finished water can be regularly done by a Chemist/Bacteriologist.

* It is essential that log book records are maintained.

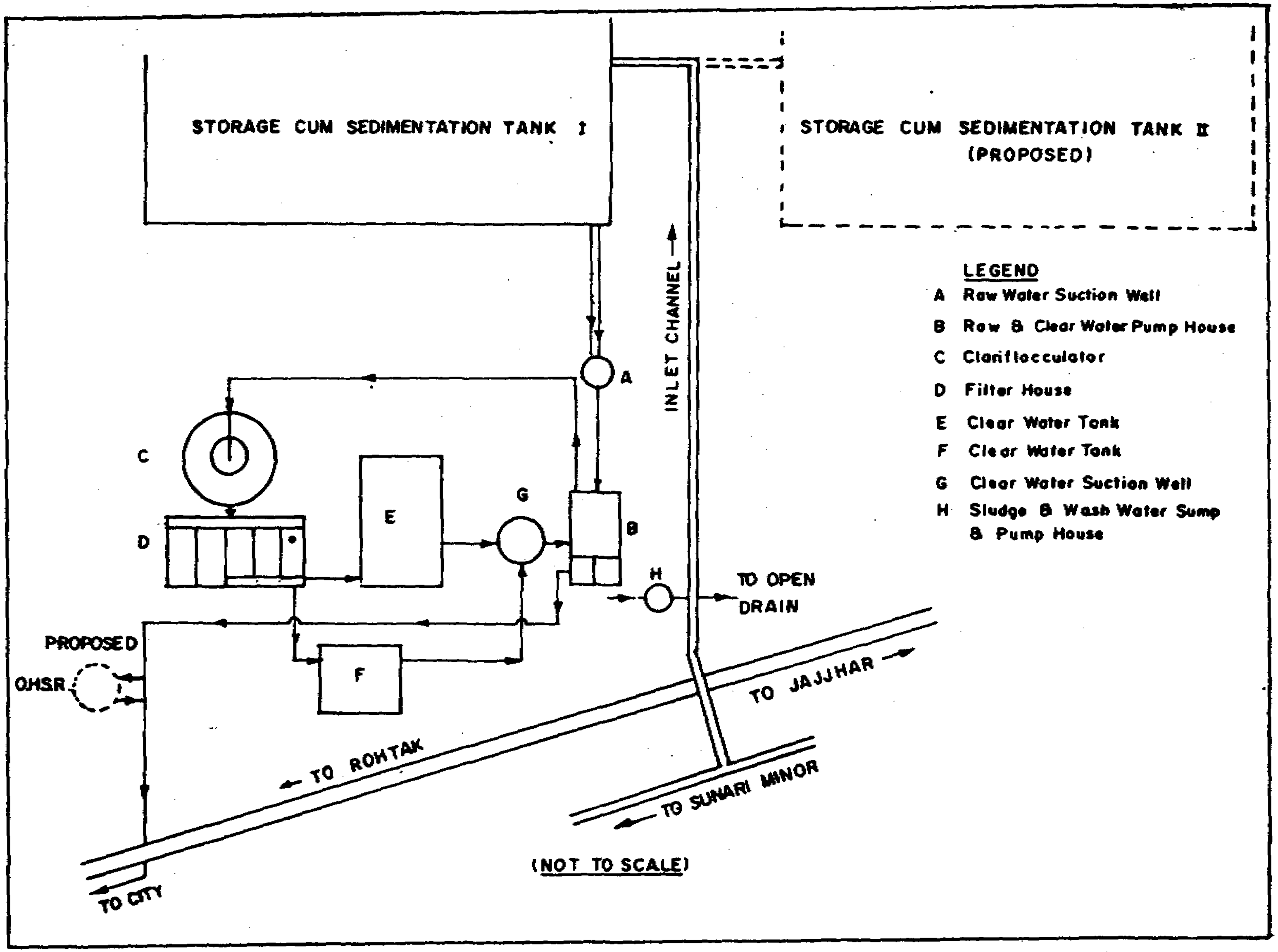


FIG 8.3 LAYOUT PLAN OF PHED SECOND WATER WORKS, ROHTAK

TABLE 8.7

PLANT SUMMARY DATA - ROHTAK

GENERAL	
Name and location	: PHED Second ater Works, Rohtak (Haryana)
Year of construction	: 1979
Design capacity	: 9.1 mld
O & M Agency	: Public Health Engineering Department,(Haryana)
Raw water source	: Western Jamuna Canal
Treatment flowsheet	: Conventional With Rapid Sand Filters
ENGINEERING	
Raw water pumping	: 2 Nos, Centrifugal, 30 HP, 7000 lit/min capacity
-Rising main diameter	: 450 mm
Raw water flow measurement	: Measuring Flume of 450 mm throat width of capacity 1-15 mld
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Mechanical, Motordriven stirrer
- Details of mixing	: 1.2 x 1.2 x 5.0 m mixer chamber size, 2 HP, 60 sec. D.T.
Flocculation	
- Method / Type of unit	: Mechanical,Clariflocculator
- No. & Dimensions	: 1 No, 8.25 m dia, 2 HP
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Vertical entry horizontal flow type clariflocculator
- No. & size of unit(s)	: 1 No., 20.4 m dia, 4.1 m SWD
- Surface overflow rate	: 38 m^3/m^2/day
- Detention time	: 2 hrs.35 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 4 Nos., each 6.5 x 3.35 m
- Rate of filtration	: 4.88 $m^3/h/m^2$
- Filter media	
. Sand size	: E.S.- 0.35 to 0.65 mm U.C.- 1.35 to 1.75 mm
. Depth of sand	: 60 cm
. Gtavel size	: Grit, 6-12 mm, 25-40 mm and 40-50 mm
. Depth of each layer	: 30 cm (each layer 7.5 cm)
- Backwash arrangements	
. Method	: Air scour followed by water wash
. Wash water tank cap.	: 87 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Pumping

- No.& Cap.of reservoir	: 2 No., 2600 m^3 total cap.
- Pump details	: 2 Nos., 75 HP each, 45 m head

TABLE 8.8

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

PHED SECOND WATER WORKS - ROHTAK

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	0.8	<1	1.5	0.8	1.5	1.0
pH	8.5	8.5	7.8	8.0	9.0	8.3
Total Alkalinity ($CaCO_3$)	74	-	72	-	60	-
Conductivity (μS/cm)	138	-	150	-	145	-
Hardness ($CaCO_3$)						
Total	102	-	80	-	88	-
Carbonate	74	-	72	-	60	-
Non Carbonate	28	-	8	-	28	-
Calcium (Ca)	29	-	24	-	22	-
Magnesium (Mg)	7	-	5	-	8	-
Chlorides (Cl)	10	-	6	-	5	-
Sulphates (SO_4)	64	-	45	-	28	-
Iron (Fe)	0.1	-	-	-	0.1	-
Bacteriological (MPN/100 ML)						
Total coliform	23	NIL	50	NIL	30	NIL
Fecal coliform	2	NIL	7	NIL	4	NIL
Fecal streptococci	8	NIL	7	NIL	11	NIL

All values except pH, Turbidity and Conductivity are expressed as mg/l.

TABLE 8.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

PHED SECOND WATER WORKS - ROHTAK

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	0.8	1.0	1.0	<1
	II	1.5	1.2	1.2	0.8
	III	1.5	1.5	1.5	1.0
T.Coliform (MPN/100 ML)	I	23	13	1.0	NIL
	II	50	4	1.2	NIL
	III	30	4	1.5	NIL

DHALLI WATER WORKS - SHIMLA

INTRODUCTION

Shimla, the capital of Himachal Pradesh, had its first water supply scheme commissioned in the year 1875 to serve a population of 16000. The supply was augmented from time to time by tapping raw water from different sources. Presently the total supply to the city is of the order of 30 mld. The two water treatment plants located at Dhalli viz. the slow sand filtration (SSF) plant of 4.5 mld with springs as source of raw water and the conventional rapid gravity filter plant of 8.2 mld capacity receiving raw water from Cherot nullah were evaluated for their performance. The schematic flow sheet is shown in Fig. 9.1 and the plant summary data given in Table 9.1. The treatment works are operated and maintained by the Irrigation and Public Health Department of Himachal Pradesh.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water sources for the 4.5 mld SSF plant are springs from protected, wooded catchment area. Hence, the raw water is of high quality with low turbidity and coliform count (Table 9.2). Spring water after roughing filtration at the source, flows by gravity to the treatment works at Dhalli.

The raw water from Cherot nallah is also of fairly good quality (Table 9.2) and after pre-filtration at the source is pumped against a head of 600 meters to the conventional rapid gravity filter plant at Dhalli. It is reported that the yield from both the sources during summer is inadequate to meet the needs. There is no provision at the treatment works to measure the inflow to the SSF plant. As for the conventional rapid gravity filter plant, the flow measuring weir is defective and does not facilitate accurate flow measurement. However, from the flow estimated at the time of visit, it was found that the plant was underloaded by 60 per cent.

Pre-treatment

As the water quality from springs is good throughout, no pre-treatment is provided before slow sand filtration. For the other plant drawing water from Cherot nallah, alum dosing is practised only during times of high turbidity and the dose is fixed arbitrarily. When alum is added, flocculation is achieved in the baffled channel leading to the settling tanks. At the time of the visit when the raw water turbidity was 3 NTU, alum addition was dispensed with and hence, turbidity removal due to pre-treatment was marginal.

Filtration

As the raw water itself had a turbidity of 0.8 NTU, no significant reduction was achieved in slow sand filters. However, there was considerable improvement in bacteriological quality. At the time of the visit, only 4 filters were in operation (due to reduced plant inflow) while the other two were being resanded. All the filters are housed under a roof and no algal growth on the filters was visible. The sand scraped from the filters is cleaned in a sand washing machine, dried and stored for reuse. It was observed that while resanding, the stored sand is directly placed on the top of existing sand in the filter. This practice is defective and leads to accumulation of impurities in the bottom layers and compaction of bed over a period of time with attendant problems.

The rapid sand filters were underloaded due to inadequate flow at the source. The filter appurtenances were in a state of disrepair. The filters were backwashed with raw water only and was not preceded by air scour as the air blower was out of order. Filter backwashing has not only been ineffective but also most unscientific. The raw water from the rising main is diverted for backwashing all the filters at the same time. The rate of rise of wash water (raw water) is also low and the wash water is not allowed to drain off excepting once in 2 or 3 months, before the filtration cycle is resumed. With the result the impurities in the filter bed are not removed but only loosened temporarily and retained in the bed during the fileration cycle. This practice has not only proved highly ineffective but also counter- productive as confirmed by the presence of large cracks and undulations on the bed and worsening of the filtrate quality after the "so called" backwashing operation.

Disinfection

The filtrate from slow sand filters is not chlorinated before supply while the filtrate from rapid gravity filters is disinfected using bleaching powder solution. The dose applied is not controlled and there is no facility to measure residual chlorine in treated water.

Laboratory facilities

Laboratory facilities available at the plant (turbidimeter and pH meter) are not adequate for effective plant control. A separate laboratory is under construction at the treatment plant.

Plant staff

An Assistant Engineer is incharge of the plant which is managed by 15 regular staff members including a Junior Engineer and a Chemist. In addition 14 daily wage workersare employed. The plant operators are neither qualified nor had undergone formal training in operation and maintenance of water treatment plant.

Financial aspects

The expenditure on operation and maintenance of the plant for the year 1987-88 was Rs. 3.46 lakhs of which the staff salary alone accounted 64 per cent. The entire expenditure is borne by the State Govt. The distribution system is with the Municipal Corporation.

RECOMMENDATIONS

* To prevent cumulative fouling and compaction of the bottom layers of slow sand filters, the "throwing over" method of resanding should be followed.

* The rapid sand filters which are in a very bad condition should be overhauled including replacement of sand, if necessary. The practice of back-washing of filters with raw water should be discontinued in favour of washing with filtered water. Only one filter should be backwashed at a time and it should be ensured that the filter is left in a clean condition before the filtration cycle starts.

* The filtrate from both the slow sand and rapid gravity filters should be chlorinated so as to ensure a minimum residual chlorine as recommended by CPHEEO and the chlorine residual regularly monitored.

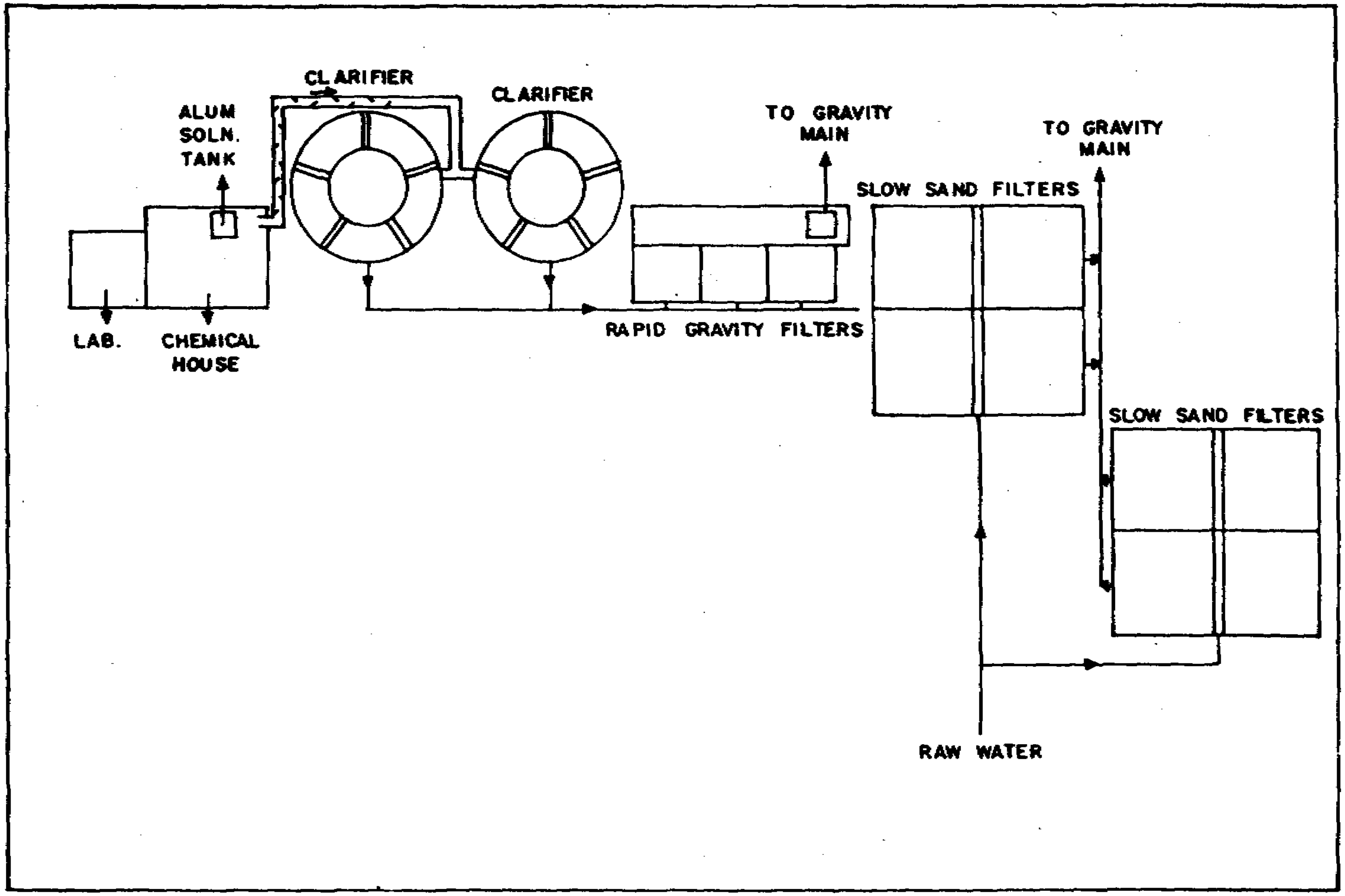


FIG 9.1 LAYOUT PLAN OF DHALLI WATER WORKS, SHIMLA

TABLE 9.1

PLANT SUMMARY DATA - SHIMLA

GENERAL	
Name and location	: Dhalli Water Works, Shimla
Year of construction (Augmentation if any)	: 1875 augmented in 1903 & 1971
Design capacity	: 12.7 mld
O & M Agency	: Irrigation and Public Health Engineering Department, Himachal Pradesh
Raw water source	: Streams from catchment area
Treatment flowsheet	: Prefiltration followed by i) Slow Sand Filters (4.5 mld) ii) Conventional with rapid sand filters
ENGINEERING	
Raw water pumping	: 3 nos centrifugal (1 standby) cap. 227, 127, 150 m^3/hr
-Rising main diameter	: 3 nos. 125 mm - 2 nos. 175 mm - 1 no.
Raw water flow measurement	: Rectangular weir
Pre-treatment	
Coagulation	
- Chemicals used	: Alum solution
- Type of mixing	: Hydraulic
- Method of mixing	: Baffled channel
Flocculation	
- Method / Type of unit	: Hydraulic
- No. & Dimensions	: 28 nos. baffled chnnel
- Detention time	: 1.5 min

Sedimentation

- Type of unit(s)	: Circular clarifier
- No. & size of unit(s)	: 2 nos., each 14 m dia , 3 m SWD
- Surface overflow rate	: 0.74 m/hr
- Detention time	: 3 hrs

Filtration

- Type of unit(s)	: Rapid sand	Slow sand
- No. & size of unit(s)	: 3 nos., each 32.2 m^2	8 nos.,each 232.5 m^2
- Rate of filtration	: 3.5 m/hr	0.1 m/hr
- Filter media		
. Sand size	: E.S - 0.69 mm U.C - 1.8	E.S - 0.24 mm U.C - 2.5
. Depth of sand	: 50 cm	60 cm
- Backwash arrangements		
. Method	: Air scour and raw water wash	

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed
Clear Water Reservoir	: Not provided
- Pump details	: Flow by gravity

TABLE 9.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

DHALLI WATER WORKS - SHIMLA

PARAMETERS	RAPID GRAVITY FILTERS		SLOW SAND FILTERS	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	3.0	1.5	0.8	0.8
pH	7.5	7.5	7.5	7.5
Total Alkalinity ($CaCO_3$)	68	66	44	42
Conductivity(µS/cm)	190	187	110	105
Hardness ($CaCO_3$)				
Total	80	78	50	50
Carbonate	68	66	44	42
Non Corbonate	12	12	6	8
Calcium (Ca)	24	23	14	14
Magnesium (Mg)	5	5	3	3
Chlorides (Cl)	7	7	7	7
Sulphates (SO_4)	16	16	4.4	4.4
Iron (Fe)	Tr	Tr	Tr	Tr
Fluoride (F)	0.5	0.5	0.5	0.5
Nitrates (NO_3)	1.7	5.9	1.3	1.4
Bacteriological (MPN/100 ML)				
Total coliform	140	95	55	10

All results are expressed as mg/L except for pH, Turbidity and conductivity. Tr - Traces

TABLE 9.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

DALLI WATER WORKS - SHIMLA

PARAMETERS		RAW WATER	SETTLED WATER	FILTERED WATER
Turbidity (NTU)	RGF	3.0	2.5	1.5
	SSF	0.8	-	0.8
T.coliform (MPN/100ML)	RGF	140	75	95
	SSF	55	-	10

SITLEE WATER WORKS - JAMMU

INTRODUCTION

Jammu, the winter capital of J & K State, with a present population of about 4.0 lakhs draws its water supply from river Tawi and a battery of tubewells. The Sitlee water works with a designed capacity of 38 mld is located on the bank of river Tawi, 7 km away from the city on Jammu-Udhampur highway. The tube wells numbering 47, provide a supply of about 30 mld. Water from river Tawi is pumped to the treatment plant which provides for pre-sedimentation followed by conventional treatment with alum coagulation, sedimentation, rapid sand filtration and chlorination. The schematic flow sheet is shown in Fig. 10.1 and the plant summary data is presented in Table 10.1. The plant is maintained by the Public Health Engineering Department, J & K Government.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from river Tawi is drawn into an intake well and is pumped to the treatment works. The intake well is provided with inlet ports at different levels operated by sliding gates. The river water carries considerable silt load especially during monsoon season which leads to quick wear and tear of the pumps and problems in operation and maintenance. At the time of the visit the raw water turbidity was essentially colloidal in nature and there was practically no reduction in turbidity in the pre-sedimentation tanks (Table 10.2).

Due to non-availability of continuous power supply, the plant is worked only for about 20 hours a day. The flow measuring/indicating device installed at the raw water channel is not in working condition. Actual flow measurement at the time of the visit indicated that the plant inflow was about 30 mld (underloaded by about 20 per cent) as against the rated capacity of 38 mld.

Pre-treatment

The alum dose applied was reported to vary from 10 kg/hr in fair season to 250 kg/hr during the monsoon period. It was reported that during monsoon period even with high dosage of alum, difficulties were experienced in proper coagulation of the turbid waters. It was noted that the river water had low alkalinity (Table 10.2), insufficient for proper floc formation. The equipment for controlled dosing of alum was out of order. The rapid mixer and the clarifier sludge scraper mechanisms are worked only during times of high turbidity. At the time of the visit, due to non-functioning of the rapid mixer unit, the floc formation was not effective. After pre-treatment with alum coagulation and sedimentation, the turbidity of pre-settled water was reduced from 20 NTU to 10 NTU only (Table 10.3).

Filtration

The rapid sand filters have been renovated recently when the underdrains and the filter media were replaced. While the filter rate controllers were working, the loss of head gauges were out of order. The operation and maintenance of the filters in general was satisfactory.

Disinfection

In the light of difficulties experienced by the water works authority in procuring chlorine cylinders, only bleaching powder is used for disinfection. The supply of bleaching powder is also irregular to meet the daily requirement and to maintain adequate residual chlorine in the water leaving the plant.

Laboratory facilities

The laboratory facilities available for routine plant control are inadequate and no chemist has been posted at the plant.

Plant staff

The total strength of staff for routine operation and maintenance of the plant is 23 including the five supervisory staff of Assistant Engineer/Junior Engineer cadre.

Financial aspects

The water tariff levied is very low (Rs.30 per 12 mm service connection per year) and the revenue receipts on this account is Rs. 18.25 lakhs for the year 1987-88 as against the total expenditure of Rs. 230 lakhs. The shortfall is met by the Government from other sources of revenue.

RECOMMENDATIONS

* Provision for raw water flow measurement should be made to ensure effective chemical dosing and plant control.

* During monsoon season when the raw water turbidity is high and alkalinity is low, lime addition may prove useful in achieving effective coagulation.

* The optimum dosages of chemicals should be decided based on regular jar tests.

* The rapid mix unit and the clariflocculator should be operated continuously for effective removal of turbidity and bacterial load during pre-treatment.

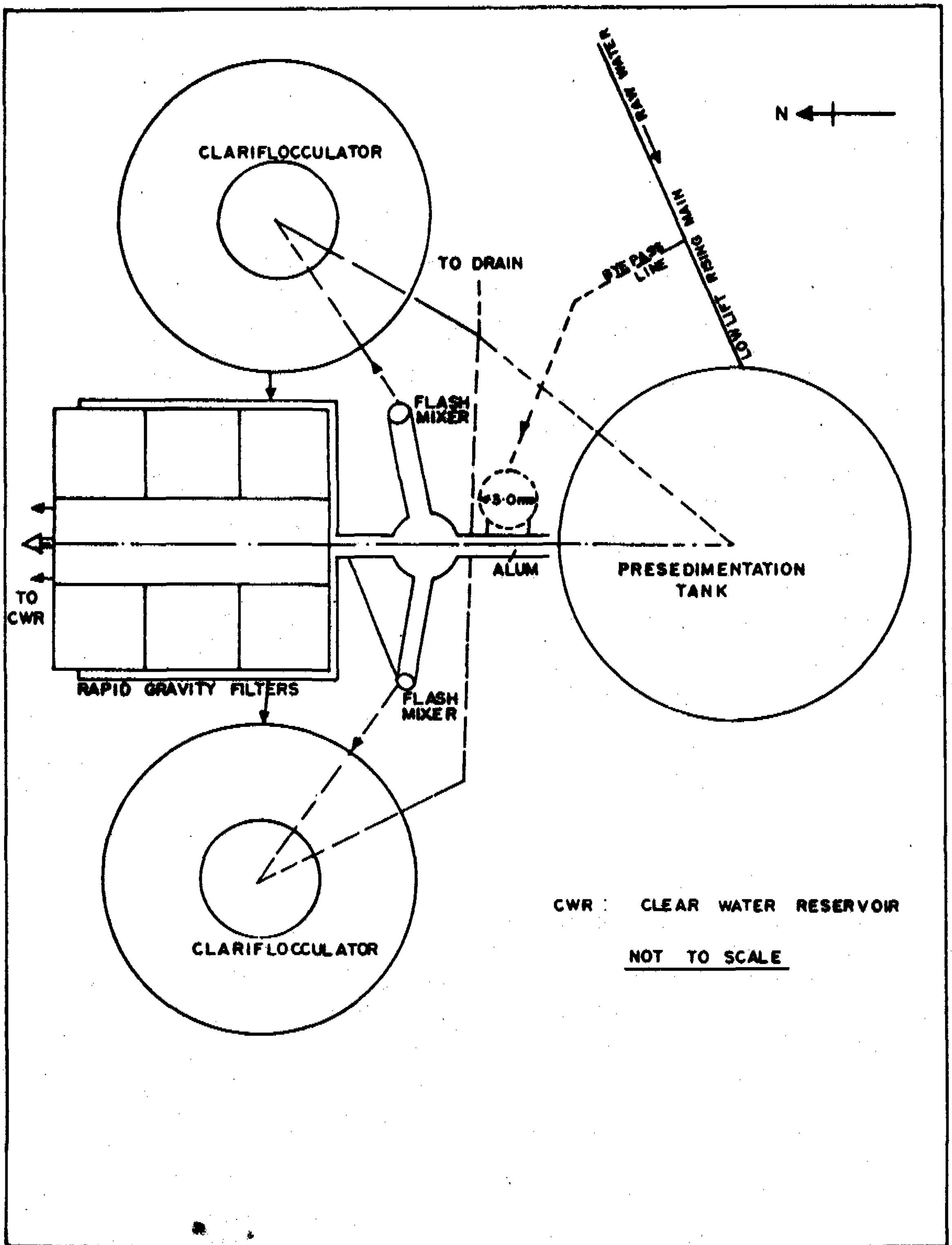


FIG 10.1 LAYOUT PLAN OF SITLEE WATER TREATMENT PLANT, JAMMU

TABLE 10.1

PLANT SUMMARY DATA - JAMMU

GENERAL	
Name and location	: Jammu Water Treatment Plant, Sitlee (Nagrota)
Year of construction	: 1981
Design capacity	: 38 mld
O & M Agency	: Public Health Engineering Department, (J & K)
Raw water source	: Tawi River
Treatment flowsheet	: Conventional with rapid gravity filters
ENGINEERING	
Raw water pumping	: 3 nos., vertical turbine pumps each 150 HP with capacity 817.6 m^3/hr
-Rising main diameter	: 60 cm
Raw water flow measurement	: Mahindra & Mahindra Pedestal type flowmeter
Pre-treatment	
Pre-sedimentation	: Circular tank, 33.5 m dia & 2.75 m SWD with mechanical sludge scraper
Detention time	: 1.5 hr
Coagulation	
- Chemicals used	: Alum (solution)
- Type of mixing	: Mechanical flash mixer, 2 nos-
Detention time	: 30 sec each
Flocculation	
- Method / Type of unit	: Mechanical(clariflocculator)
- No. & Dimensions	: 2 nos., each 10.7 m dia. & 3.5 m SWD
- Detention time	: 30 min

Sedimentation

- Type of unit(s)	: Mechanical clariflocculator
- No. & size of unit(s)	: 2 nos., each 28.65 m dia, 3.5 m SWD
- Surface overflow rate	: 1.4 m/hr
- Detention time	: 2.5 hr

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 6 nos., 7.9 x 7.9 m each
- Rate of filtration	: 5 m/hr
- Filter media	
. Sand size	: E.S. - 0.6 mm, U.C. - 1.4
. Depth of sand	: 75 cm
. Gravel size (mm)	: 50-37, 37-13, 13-10, 10-8
. Depth of each layer	: 75 mm, 75 mm, 100 mm, 100 mm
- Backwash arrangements	
. Method	: Air scour and water wash
. Wash water tank cap.	: 270 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Reservoir

- Type, No. & Capacity	: RCC, 1 no., 159 m^3
- Pump details	: 10 nos.,each 300 HP -9 nos. 7.5 HP - 1 no. 4 standby

TABLE 10.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

SITLEE WATER WORKS - JAMMU

PARAMETERS	RAW	FINISHED
Physico-chemical		
Turbidity (NTU)	18	1.1
pH	8.2	7.9
Total Alkalinity ($CaCO_3$)	76	76
Conductivity(μS/cm)	198	190
Hardness ($CaCO_3$)		
Total	76	76
Carbonate	76	76
Non Corbonate	0	0
Calcium (Ca)	26	26
Magnesium (Mg)	3	3
Chlorides (Cl)	6	6
Sulphates (SO_4)	6	12
Iron (Fe)	Tr	Tr
Fluoride (F)	0.5	0.4
Nitrates (NO_3)	2.9	3.4
Bacteriological (MPN/100 ML)		
Total coliform	840	46

All results are expressed as mg/L except for pH, conductivity and turbidity, Tr - Traces

TABLE 10.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

SITLEE WATER WORKS - JAMMU

PARAMETERS	RAW WATER	PRESETT. WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	18	17	9.2	1.1	1.4
T.coliform (MPN/100ML)	840	660	145	60	26

NISHAT WATER WORKS NO. 3 - SRINAGAR

INTRODUCTION

Srinagar City, the summer capital of the Jammu & Kashmir State, is located at latitude 340N and longitude 750E and approximately 1580 m above MSL. The population of the city was about 570,000 as per 1981 census. The existing water supply to the city has been developed in stages over the years, starting from 1931. At present, the water supply to the city comes from a number of treatment plants as noted below :

	Treatment plant	Source	Capacity
1.	Complex of 4 plants at Nishat	Dachigam stream	68 mld
2.	Alustand Treatment works	Sind Extension canal	22 mld
3.	Doodganga Treatment works	Doodganga stream	17 mld
		Total	107 mld

Besides these surface water supplies, there are a number of tube wells in the city serving localised areas. Further augmentation of treatment capacity is in progress. The Nishat Water Works consists of four water treatment plants commissioned during different times. The plant of 18 mld capacity constructed in 1979 has been selected for the performance evaluation study in consultation with the PHED. The water supply system is constructed, maintained and operated by the State PHED. The plant layout is shown in Fig.10.2 and plant summary data is presented in Table 10.4.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water to the treatment plant complex at Nishat is drawn from four sources, viz. Harwan Reservoir, Sharaf Khul Canal, Dachigam Stream and Dal Lake. The supply from the Dachigam stream diminishes in extreme winter due to freezing of the stream in the upper reaches. However, as alternate sources are available, no scarcity is experienced in winter. The supply is also temporarily affected by silt deposits at the off-takes in the river during heavy rains.

The Dachigam stream is not subject to any significant pollution. The stream water is of low turbidity (Table 10.5) most of the time except during rains in the catchment when the turbidity and silt load goes up temporarily. The Harwan reservoir supply is presettled and is always low in turbidity.

The Dal lake source at the point of tapping has been extensively monitored by NEERI and is found to be of good quality, physically, chemically and bacteriologically satisfying the criteria for waters which can be used for drinking water supply with only chlorination. Raw water from Dal lake is used only during emergencies and involves pumping.

The Harwan Reservoir has an intake tower with a single inlet port at the bottom. From the intake tower, an RCC conduit 200 mm dia. 5000 m long conveys the water to the treatment works. There is no device for measuring the discharge in the conduit but its design capacity is 10 mld. From the S.K. canal, two plain pipe draw-offs have been provided, one to feed a roughing filter serving plants 2 and 3 and another directly feeding plant no.I. The direct offtake from the Dachigam stream consists of a small chamber on the stream bank with an inlet port protected by bar screens.

The off-takes in the Dal lake consists of one fixed pumping station and another floating pump barge. There are no arrangements for measuring the actual rates of pumping at both the pumping stations.

In plant No. 3, a Venturi flume is provided in the raw water channel to the flash mixer. The flow indicator installed over the flume is not reliable as its maximum capacity is 2.88 mld whereas the plant capacity is 18 mld.

The main deficiency in the existing intake and raw water conveyance arrangements is that there is no way of estimating the supply drawn from the different sources serving the Nishat Water Works.

Pre-treatment

Only part of the raw water flow to the Nishat Water Works is pre-treated by down- flow roughing filtration through beds of pebbles of 75 mm size.

In view of the good quality of raw water from Harwan Reservoir and Dal lake, the pre-treatment, provided is redundant while the S.K. canal water which often is turbid and carries silt is pre-treated only in part. It is desirable that the pre-treatment facilities and the arrangement of sources to serve the different plants of Nishat are reorganised.

Filter alum is used for chemical coagulation. Two high level alum solutionising-cum-solution storage tanks each of 2.5m^3 capacity have been provided in the chemical house. Each tank has a motorised stirrer. A constant head box has been provided for feeding the alum solution.

The alum solution tanks, the motorised stirrers and the pipings are in good condition. The solution storage capacity of 2.5 m^3 in each tank is found to be just sufficient (assuming a peak alum dose of 30 ppm and 7.5 per cent strength of alum solution). Alum dosage rate at the plant is fixed not based on any jar test but only by trial and error. Alum blocks were also added directly to the raw water channel in addition to alum solution dosing. The float control device was not being maintained at constant level which is necessary for ensuring constant hydraulic rate of dosing.

A flash mixer of 2 HP has been provided in a mixing chamber which is worked only 'off' and 'on'. The alum solution is added upstream of the throat of the Venturi flume. Adequate mixing is achieved by the hydraulic jump at the Venturi flume.

A clariflocculator has been provided with overall size of 28 m dia. x 3.84 m SWD with flocculator zone of 12.4 m dia. The detention periods in the floccculator zone and the settling zone as also the surface loading rate in the settling zone are satisfactory for the design flow. The flocculator paddles were not being worked all the time. The clarifier scraper bridge was also not being operated all the time though sludge bleeding was continuous. During the time of study the clariflocculator was overloaded as could be seen from the weirs in the effluent launder which were completely flooded.

Filtration

The design filtration rate being only 6 m/hr is satisfactory. The rate of flow controllers and rate indicators in none of the filters were working. However, the headloss gauges were functioning properly. The filter sand was not properly graded and the depth of supporting gravel (25 cm) was found inadequate. The filter washing was not satisfactory; air and washwater distribution was not uniform. Filter sand was also being carried over into wash water gutters. Considerable mounding of the sand surfaces and filter cracks were observed at various places in the filter bed. The filters have clogged upto a great extent (as observed from the high initial headloss) and are not able to deliver the design output. The filter output actually measured on three different dates was only about 60 per cent of the design value. Overall, the filter performance was far from satisfactory.

Disinfection

Bleaching powder is used for disinfection. The chemical is dissolved in water in a tank provided with a motorised stirrer. From the tank, the solution is drawn to a constant head box from where it is added to the water.

The bleaching powder dosage is not fixed based on chlorine demand test but by trial and error. As there is only one solution tank, the solution can not be settled before dosing is started. A constant level is not maintained in the dosing box.

Laboratory facilities

At present, no testing facilities are available at the plant except for residual chlorine. No records are maintained for the residual chlorine tests.

RECOMMENDATIONS

* Because of frequent and sudden increase in turbidity in the Sharaf Khul Canal leading to treatment problems, the drawal from the canal may be dispensed with or restricted to fair weather season in favour of Dachigam stream and Harwan reservoir.

* Considering the multiplicity of sources serving the Nishat water works and their varying qualities, the pre-treatment facilities and the arrangement of sources at Nishat be reorganised to minimise treatment needs.

* Adequate arrangements for raw water flow measurement and regulation need to be provided for effective operation and control of water treatment units.

* The chemical dosing step should be properly supervised as it is a critical step in water treatment. Alum dosage should be fixed by jar tests and the quantity added should be regulated by weight and not by number of blocks. Log books should be maintained for this unit process.

* The flocculators and the sludge scraper bridge should be operated continuously.

* All the filter beds require complete overhauling as the filter media is almost completely caked up, sand and gravel have mixed up the underdrain pipes appear to have broken/eroded at the perforations.

* The filter outlet controls which are now not working may be dispensed with and filters may be worked on declining rate filtration.

* Adequate laboratory facilities and trained staff should be provided to perform the usual plant control tests, viz.- jar test, chlorine demand test and tests for residual chlorine, pH and turbidity and, if possible, routine bacteriological analysis.

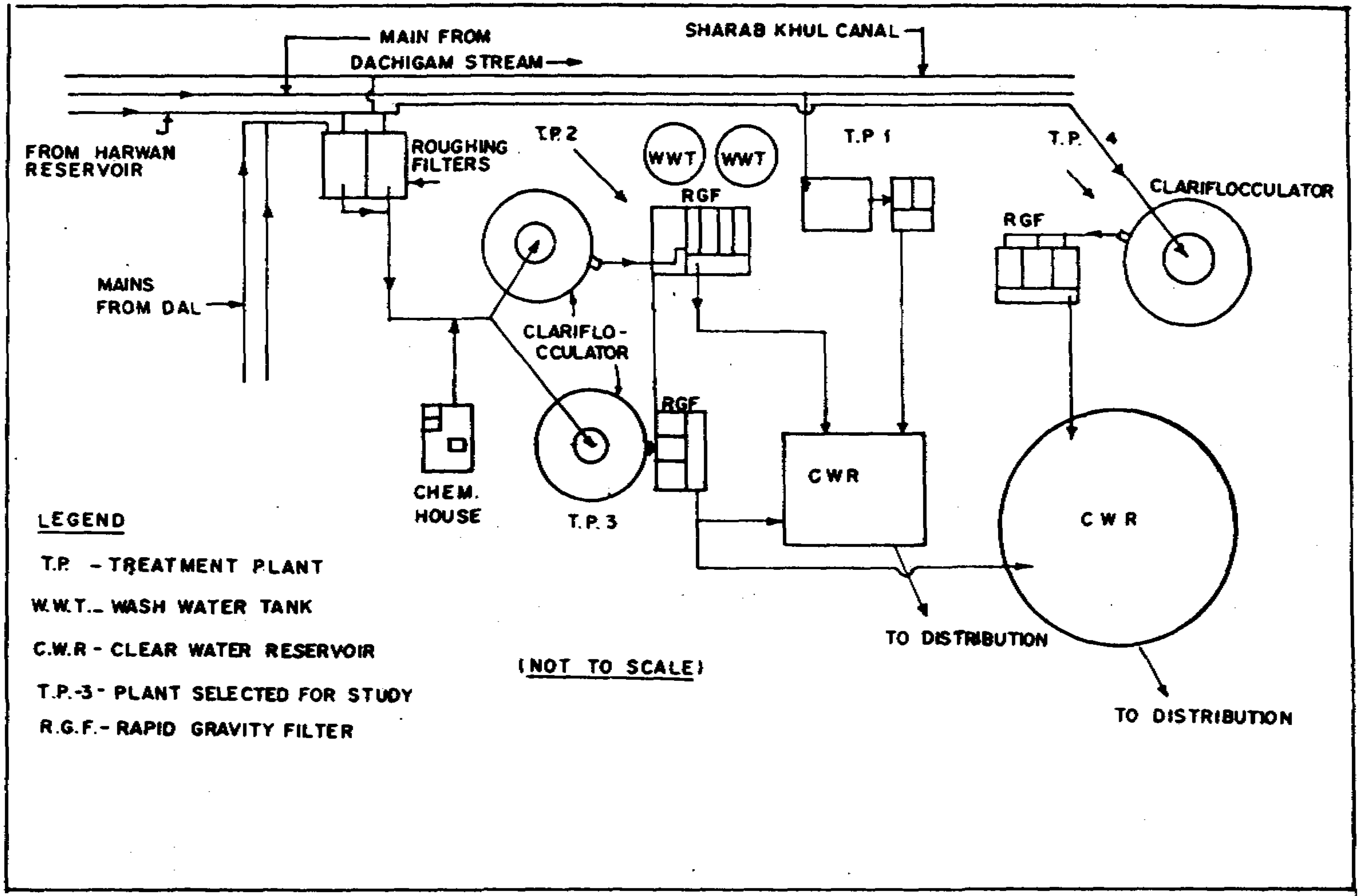


FIG 10.2 LAYOUT PLAN OF NISHAT WATER WORKS, SRINAGAR

TABLE 10.4

PLANT SUMMARY DATA - SRINAGAR

GENERAL	
Name and location	: Nishat Water Works No.3 Srinagar, J&K State
Year of construction	: 1979
Design capacity	: 18 mld
O & M Agency	: Public Health Engineering Department, Kashmir
Raw water source	: i) Dachigam Stream ii) Saraf khul canal iii) Harwan Reservoir iv) Dal lake
Treatment flowsheet	: Conventional with rapid sand filters
ENGINEERING	
Raw water pumping	: - Dal lake fixed pumping station :- 3 nos., 300 mm dia pumping main, 77 m static head. - Dal lake floating pump barge :- 4 nos., 600 mm dia pumping main, 81 m static head
Raw water flow measurement	: Venturi flume
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Mechanical, motor driven with details stirrer, 2 HP, 35 sec detention time
Flocculation	
- Method / Type of unit	: Mechanical Clariflocculator
- No. & Dimensions	: 1 no., 12.4 m dia, speed 4 rpm, 3.8 m SWD
- Detention time	: 37 minutes

Sedimentation

- Type of unit(s)	: Clarifier
- No. & size of unit(s)	: 1 no., 28 m dia, 3.8 m SWD
- Surface Overflow Rate	: 36 m^3/m^2/day
- Detention time	: 2 hr 30 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 3 nos., (twin beds) each 8.4 m x 5.6 m
- Rate of filtration	: 5.75 m^3/m^2/hr
- Filter media	
. Sand size	: E.S.-0.7 mm, U.C.-1.66
. Depth of sand	: 75 cm
. Gravel size	: 3 layers, 6-12 mm, 25-37 mm, 25-50 mm
Depth of each layer	: 5 cm, 7.5 cm, 7.5 cm respectively
- Backwash arrangements	
. Method	: Air scour followed by water wash
. Wash water tank cap.	: 227 m^3

Disinfection

- Chemicals used	: Bleaching powder

TABLE 10.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

NISHAT WATER WORKS - SRINAGAR

PARAMETERS	RAW	FINISHED
Physico-chemical		
Turbidity (NTU)	7.3	5.6
pH	7.9	7.7
Total Alkalinity ($CaCO_3$)	48	-
Conductivity (µS/cm)	128	-
Hardness ($CaCO_3$)		
Total	42	-
Carbonate	42	-
Non Carbonate	0	-
Calcium (Ca)	14	-
Magnesium (Mg)	2	-
Chlorides (Cl)	2	-
Sulphates (SO_4)	2	-
Iron (Fe)	0.45	-
Fluoride (F)	0.3	-
Nitrates (NO_3)	Tr.	-
Bacteriological (MPN/100 ML)		
Total coliform	14	0
Fecal coliform	8	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l.

TABLE 10.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

NISHAT WATER WORKS - SRINAGAR

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	7.3	4.3	2.8	5.6
T. Coliform (MPN/100 ML)	14	8.0	2.0	0

BELGAUM WATER WORKS - BELGAUM

INTRODUCTION

Belgaum, one of the largest cities in northern Karnataka, has a population of 3 lakhs (1981 census) including that of the cantonment area. The city draws its water supply from Rakaskop lake, which is an impoundment formed by a dam constructed across the river Markandeya. Raw water from Rakaskop flows by gravity over a distance of 5 km to Hindalga from where it is pumped to treatment plants located at Laxmitek 3 km from Rakaskop. There are two treatment plants at Laxmitek having capacities of 27.2 mld and 13.6 mld. The plant of 27.2 mld constructed in the year 1962 has been selected for evaluation. The treatment consists of aeration, alum addition, flash mixing, flocculation, sedimentation, filtration and post chlorination. The plant layout is shown in Fig. 11.1 and summary data is presented in Table 11.1. The plant is maintained by Karnataka Urban Water Supply and Drainage Board.

PLANT APPRAISAL

Raw water quality and flow measurement

Since Hindalga is located on the bank of river Markandeya, provision for drawing water, also from the river has been made. In order to conserve water in the lake, river water is pumped during rainy season when the turbidity of raw water is reported to be high. During the study period, the turbidity of raw water was in the range of 3-8 NTU with a coliform MPN of 23-1100 per 100 ml (Table 11.2). The plant inflow was measured based on the head over a pre-calibrated weir provided in the raw water channel varied from 10 mld to 26.6 mld as against the design value of 27.2 mld. Part of the flow was diverted to the new plant for trial runs. During all the three visits, the plant was underloaded.

Pre-treatment

A cascade type aerator with five concentric trays has been provided for aeration. Alum solution for coagulation is applied in the raw water channel leading to flash mixer. During the visits the applied dose of alum was found to be 4 mg/l. The pre-treatment units were in good working condition. The settled water turbidity was in the range of 2 to 4.5 NTU. Considerable reduction in coliform was also observed due to sedimentation (Table 11.3).

Filtration

The performance of filters was satisfactory and the filtered water turbidity was in the range of 0.4 to 1 NTU. The depth of sand in the filters was 84 cm with an E.S of 0.63 mm and U.C 1.65. The filter run during low turbidity period was reported to be 2-3 days. There is no provision for air scour and only water is used for backwashing.

Disinfection

Chlorine gas is used for disinfection. Many a time when the chlorinator is out of order, chlorine gas is directly fed to filtered water or bleaching powder is used. The finished water had a residual chlorine of 0.5 mg/l and was free from coliform as well as E.coli.

Laboratory facilities

A laboratory with necessary facilities to carry out physico-chemical as well as bacteriological analysis of water has been provided at the plant. The laboratory is well-equipped and neatly maintained.

RECOMMENDATION

* The laboratory should be equipped with a jar testing machine.

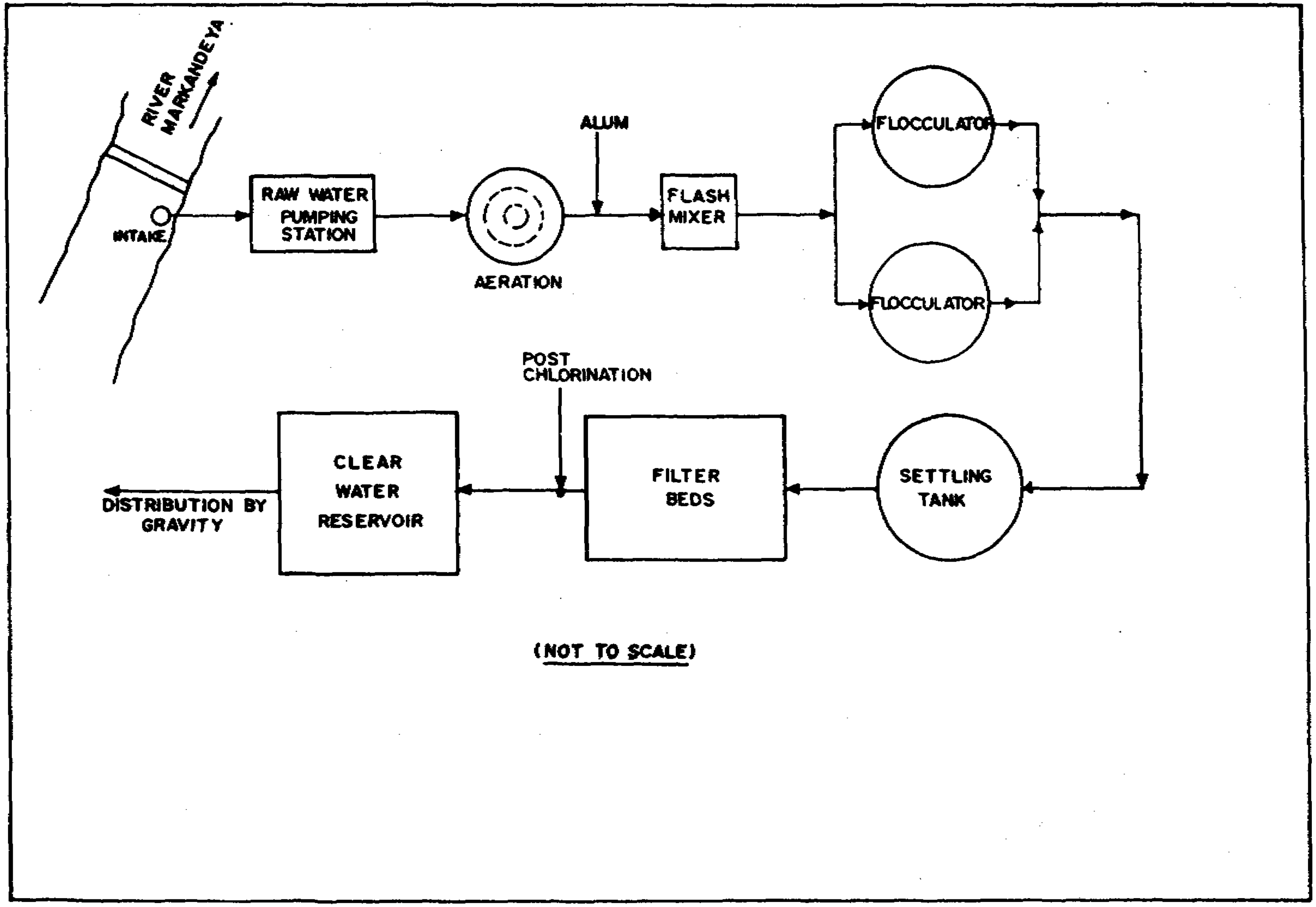


FIG 11.1 LAYOUT PLAN OF BELGAUM WATER TREATMENT PLANT

TABLE 11.1

PLANT SUMMARY DATA - BELGAUM

GENERAL		
Name and location	:	Belgaum Water Treatment Plant, Belgaum
Year of construction	:	1962
Design capacity	:	27.2 mld
O & M Agency	:	Karnataka Urban Water Supply and Drainage Board
Raw water source	:	Rakaskop lake across river Markandaya
Treatment flowsheet	:	Conventional with rapid sand filters
ENGINEERING		
Raw water pumping	:	5 nos,(one standby) 3 nos,200 HP, 250 m^3 /hr each, 2 nos,250 HP, 340 m^3 /hr each.
- Rising main diameter	:	525 mm
Raw water flow measurement	:	Rectangular sharp edged weir 1.22 m wide
Pre-treatment		
Aeration	:	Cascade aerator
Coagulation		
- Chemicals used	:	Alum solution
- Type of mixing	:	Mechanical, flash mixer
- Detention time	:	38 sec
Flocculation		
- Method/Type of unit	:	Mechanical flocculators
- No. & Dimensions	:	2 nos, each vol.of 252 m^3
- Detention time	:	30 minutes

Sedimentation

- Type of unit(s)	:	Radial flow type clarifier
- No. & size of unit(s)	:	One, 30.5 m dia, 3.66 m SWD
- Surface Overflow Rate	:	1.55 m/hr
- Detention time	:	2 hrs 20 minutes

Filtration

- Type of unit(s)	:	Rapid sand filters
- No. & size of unit(s)	:	6 nos, each 10 m x 5.8 m
- Rate of filtration	:	3.3 m/hr
- Filter media		
. Depth of sand	:	70 cm
. Gravel size	:	6 mm-1.3 cm, 3 cm-3.8 cm, 3.8 cm-5 cm
. Depth of each layer	:	7.5 cm
- Backwash arrangements		
. Method	:	Water wash only
. Wash water tank cap.	:	227 m^3

Disinfection

- Chemicals used	:	Chlorine gas
- Type of feed	:	Solution
- Chlorinator Details	:	Pressure type chlorinator

Clear Water Reservoir

- Type, No. & Capacity	:	RCC, two nos, 4540 m^3 and 11350 m^3
- Pump details	:	Distribution by gravity

TABLE 11.2

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

BELGAUM WATER WORKS - BELGAUM

PARAMERERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	3.4	1.0	7.8	0.4	6.5	1.5
pH	6.5	6.2	6.9	6.8	7.8	7.5
Total Alkalinity ($CaCO_3$)	30	26	22	21	28	28
Conductivity (µS/cm)	173	354	88	75	92	88
Hardness ($CaCO_3$)						
Total	20	22	14	14	28	28
Carbonate	20	22	14	14	28	28
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	-	-	3	3	9	9
Magnesium (Mg)	-	-	1	1	1	1
Chlorides (Cl)	9	11	5	5	4	4
Sulphates (SO_4)	10	10	3	3	23	30
Iron (Fe)	ND	ND	ND	ND	0.1	ND
Fluoride (F)	0.8	0.8	0.6	0.6	0.5	0.4
Bacteriological (MPN/100 ml)						
Total coliform	1100	0	23	0	240	0
Fecal coliform	23	0	23	0	15	0
E.coli	9	0	23	0	7	0
Fecal streptococci	240	0	43	0	23	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l
N.D.- Not detectable

TABLE 11.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

BELGAUM WATER WORKS - BELGAUM

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	3.4	2.6	0.5	1.0
	II	7.8	2.0	0.3	0.4
	III	6.5	4.5	1.0	1.5
T.Coliform (MPN/100 ml)	I	1100	43	4	0
	II	23	23	0	0
	III	240	7	4	0
E.Coli (MPN/100 ml)	I	9	0	0	0
	II	9	9	0	0
	III	7	0	0	0

BIJAPUR WATER WORKS - BIJAPUR

INTRODUCTION

Bijapur town with a population of 1.43 lakhs (1981 census) receives its water supply from two major sources viz. river Krishna and Bhutanal tank. Raw water from each source is treated separately at a plant of 10 mld capacity before supply to the city. For performance evaluation the 10 mld plant receiving raw water from Bhutanal tank was selected. This plant located at a distance of 10 km from Bijapur was originally designed in 1910 by Er. Visvesvaraya for a population of 30000 adopting slow sand filtration. Later on in the year 1976 these filters were replaced by rapid gravity filter system designed to serve the population of 1 lakh. The schematic flow sheet of the plant is shown in Fig. 11.2 and the plant summary data is presented in Table 11.4. The plant is maintained by city Municipal Council.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Bhutanal tank is drawn by gravity through an intake tower provided with inlet ports at three different levels. The bell mouthed inlets have been provided with screens to arrest floating matter.

During the evaluation study, the turbidity of raw water was in the range of 7.0-12.5 NTU and total coliform MPN in the range of 43-210 per 100 ml (Table 11.5). It was reported that the turbidity of raw water in the tank goes upto 250 NTU during rainy season.

During the study period, raw water inflow was 7.3 and 5.9 mld during first and second visit respectively. Thus, the plant was underloaded to the extent of 25-40 %. From time to time the seepage through the bunds of Bhutanal tank is collected in a well and is pumped to the sedimentation tank using 10 HP pump. During such pumping, raw water drawal from Bhutanal tank is stopped.

Pre-treatment

Raw water from Bhutanal tank is drawn by gravity into a receiving tank at the plant site where alum solution is applied. Raw water is also chlorinated using bleaching powder solution. A heavy chlorine dose of 3 to 5 mg/l is applied at the receiving tank so as to leave a residual chlorine of 0.8 mg/l in the filtered water. The previous practice of post-chlorination has been discontinued and only pre-chlorination is done.

A mechanical flash mixer has been provided at the plant with the mixing paddles directly connected to a 5 HP motor with a speed of 1440 rpm. No provision for flocculation has been made at the plant. Due to inadequate flocculation, carry over of flocs to the filters especially during high turbidity period was reported.

Four rectangular sedimentation tanks with a detention time of 3 hrs and SOR of 1.26 m/hr have been provided. No significant reduction in turbidity was observed after sedimentation (Table 11.6). Occasionally, the settled water turbidity was more than that of the raw water due to the addition of bleaching powder slurry for pre-chlorination and absence of effective flocculation.

Filtration

The filters were underloaded due to reduced plant inflow. During second visit only one filter was in operation and the other was under renovation. The depth of sand in the filters was 53 cm with an E.S of 1.07 mm and U.C of 2.3. Neither the depth nor the size of sand confirmed to CPHEEO recommendations. Since the filter media was oversized, the performance of the filters was not satisfactory (Table 11.6). The filters are backwashed routinely after 48 hours of run using water only for a duration of 10 minutes. The filter rate and headloss indicators were not in working condition.

Laboratory facilities

No laboratory facilities are available at the plant site for day-today control of plant operation.

RECOMMENDATIONS

* When seepage water is pumped to the plant for treatment, it should be admitted to the receiving tank where chemical dosing is practised. This will ensure proper treatment of water.

* The present practice of applying a heavy dose of chlorine to raw water only, is not desirable. Pre-chlorination, if necessary, and postchlorination should be practised separately to ensure effective disinfection.

* In the absence of flocculation facilities, the chemical addition and pre-treatment is ineffective. One of the existing settling tanks could be converted into a flocculator as per details supplied to the plant authorities.

* Since the filter sand is oversized, it should be replaced with sand having E.S of 0.5-0.7 mm and U.C 1.3-1.7. The minimun depth of sand should be 60 cm.

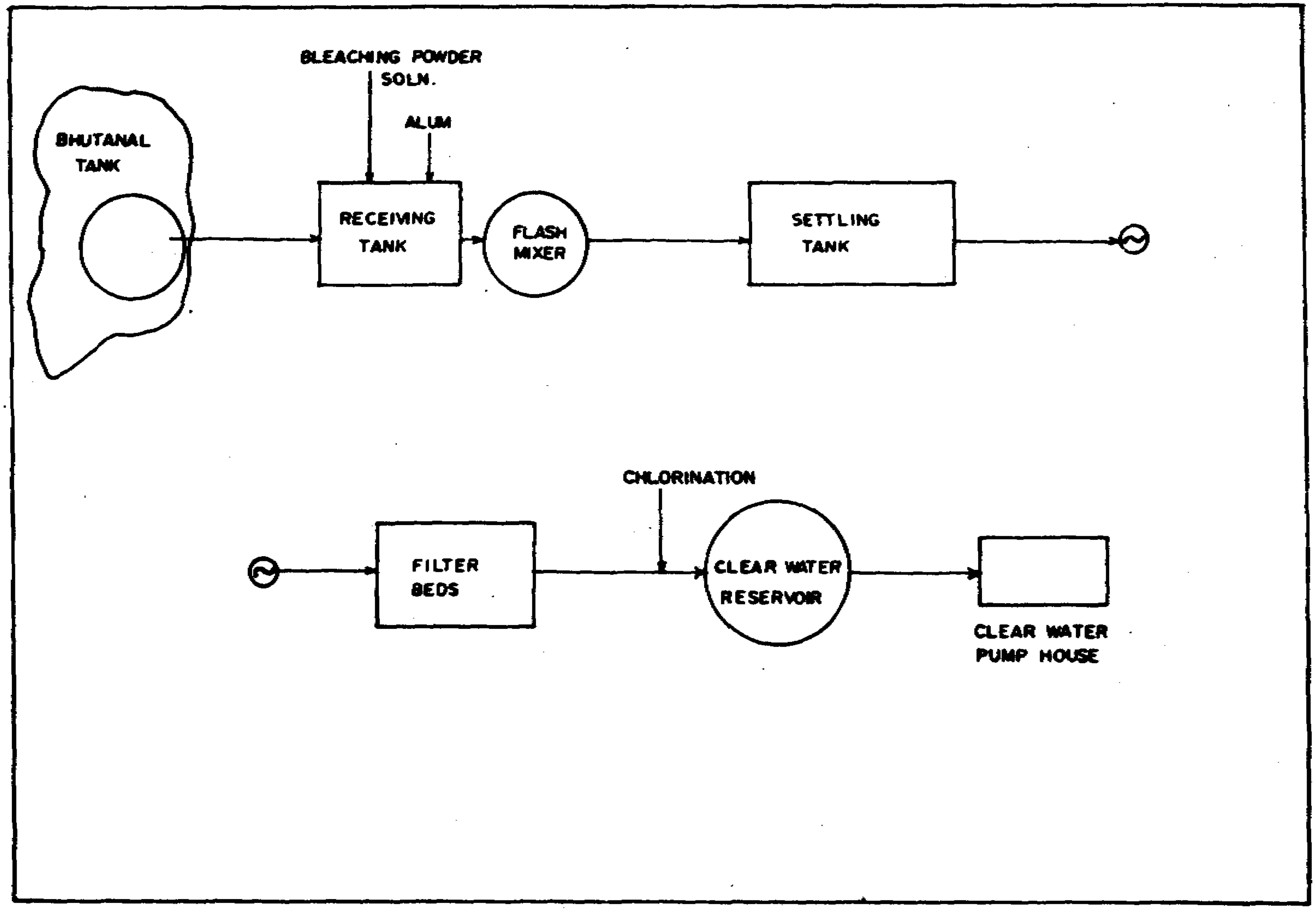


FIG 11.2 BIJAPUR WATER TREATMENT PLANT - SCHEMATIC

TABLE 11.4

PLANT SUMMARY DATA - BIJAPUR

GENERAL

Name and location	: Bijapur Water Works, Bijapur
Year of construction (Augmentation if any)	: 1976
Design capacity	: 10 mld
O & M Agency	: Municipal Council, Bijapur
Raw water source	: Bhutanal Tank
Treatment flowsheet	: Conventional with Rapid Sand Filters (with prechlorination)

ENGINEERING

Raw water pumping	: Flow by gravity

Pre-treatment

Coagulation

- Chemicals used	: Alum solution
- Type of mixing	: Mechanical Flash Mixer
- Detention time	: 34 sec

Flocculation

- Method / Type of unit	: Hydraulic channel with Baffles

Sedimentation

- Type of unit(s)	: Horizontal flow rectangular tanks
- No. & size of unit(s)	: 4 nos, 12.5 x 9.2 x 3.7 m - 2 units 9.2 x 5.5 x 3.7 m - 2 units
- Surface overflow rate	: 1.26 m/hr
- Detention time	: 2 hrs 56 minutes

Filtration

Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 2 nos, 7.6 m x 6.7 m each
- Rate of filtration	: 4.1 m/hr
- Filter media	
. Sand size	: E.S.- 1.07 mm, U.C.- 2.3
. Depth of sand	: 53 cm
- Backwash arrangements	
. Method	: Water wash only
. Wash water tank cap.	: 400 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Reservoir

- No. & Capacity	: One 1362 m^3
- Pump details	: 2 nos, 170 HP and 200 HP 5.45 mld and 6.54 mld capacity

TABLE 11.5

PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

BIJAPUR WATER WORKS - BIJAPUR

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	12.5	8.0	7.0	4.7	4.5	-
pH	7.8	7.4	7.7	7.3	7.5	7.2
Total Alkalinity ($CaCO_3$)	116	114	86	79	110	110
Conductivity (µS/cm)	1340	1061	340	337	493	544
Hardness($CaCO_3$)						
Total	124	126	112	112	123	118
Carbonate	116	114	86	79	110	110
Non Carbonate	8	12	36	33	13	8
Calcium (Ca)	18	21	26	25	34	33
Magnesium (Mg)	19	18	12	12	9	9
Chlorides (Cl)	34	45	13	13	15	15
Sulphates (SO_4)	19	-	30	33	33	35
Fluoride (F)	0.2	0.2	0.2	0.2	0.2	0.2
Bacteriological (MPN/100 ml)						
Total coliform	210	0	43	4	93	-
Fecal coliform	43	0	23	0	23	-
E.coli	15	0	23	0	23	-
Fecal streptococci	43	0	43	0	9	-

All values except pH ,Turbidity and Conductivity are expressed as mg/l

TABLE 11.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT
BIJAPUR WATER WORKS - BIJAPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	12.5	8.0	3.5	8.0
	II	7.0	6.5	4.2	4.7
	III	4.5	7.0	1.7	-
T.Coliform (MPN/100 ml)	I	210	240	93	0
	II	43	15	4	4
	III	93	4	0	-
E.Coli (MPN/100 ml)	I	15	15	23	0
	II	23	0	0	0
	III	23	0	0	-

VANI VILAS WATER WORKS - MYSORE

INTRODUCTION

The city of Mysore with a population of about 4.5 lakhs (1981 census) draws its water supply from the Krishnaraja Sagar dam constructed across the river Cauvery. Raw water from the dam flows by gravity through the right bank low level canal to the Vani Vilas treatment plant which is located at Hongally village 29 km from Mysore city. The plant of 40 mld capacity commissioned in the year 1979 provides for conventional treatment consisting of alum dosing, flash mixing, flocculation, sedimentation, rapid gravity filtration and disinfection. The schematic flow sheet of the plant is shown in Fig.11.3 and the plant summary data is given in Table 11.7.

While the treatment plant is maintained by Karnataka Water Supply & Drainage Board the distribution and revenue collection is by City Municipal Council.

PLANT APPRAISAL

Raw water quality and flow measurement

Due to impoundment at the Krishnaraja Sagar dam, the turbidity of raw water is low even during rainy season and the physico-chemical characteristics are fairly uniform throughout the year. The turbidity of raw water was less than 2 NTU during study period (Table 11.8). The raw water flow to the plant is measured in a Parshall flume fitted with a flow indicator and recorder which were in working condition. The plant inflow during study period was only 22 mld (underloaded by nearly 45 %) due to regulated water allocation because of drought.

Pre-treatment

Alum solution is used for coagulation and the dose is applied just prior to the Parshall flume. Due to low turbidity of raw water (less than 2 NTU) a nominal dose of 5 mg/l was applied. Two mechanical flash mixing units have been provided of which one is kept as a standby.

As the plant was underloaded, the detention time in flocculator and clarifier was found to be 53 min and 280 min respectively. The turbidity of settled water was in the range of 0.2-1.2 NTU (Table 11.9).

Filtration

The depth of sand in all the filters was around 60 cm. The headloss as well as rate of flow indicators of all the filters were not in working condition. Due to underloading, the rate of filtration was 2.3 m/hr only and filtrate turbidity was in the range of 0.2-0.5 NTU. The filters were backwashed once in 24 hours with water only for 15 minutes.

Disinfection

Filtered water is disinfected using chlorine gas and occasionally with bleaching powder.The chlorinator was not in working condition and the chlorine dose is manually regulated. The residual chlorine in the finished water was found to be 0.6 mg/l.

Laboratory facilities

Adequate laboratory facilities with necessary equipment and reagents required for physico-chemical as well as bacteriological analysis of water have been provided at the plant. Most of the instruments are not in working condition. The laboratory is manned by technical assistant (non-graduate) who has undergone training sponsored by CPHEEO.

RECOMMENDATIONS

* The filter appurtenances should be repaired and put into working order to facilitate proper operation and control.

* The instruments in the laboratory should be repaired and a trained chemist with supporting staff should be appointed for proper control and monitoring of the plant performance.

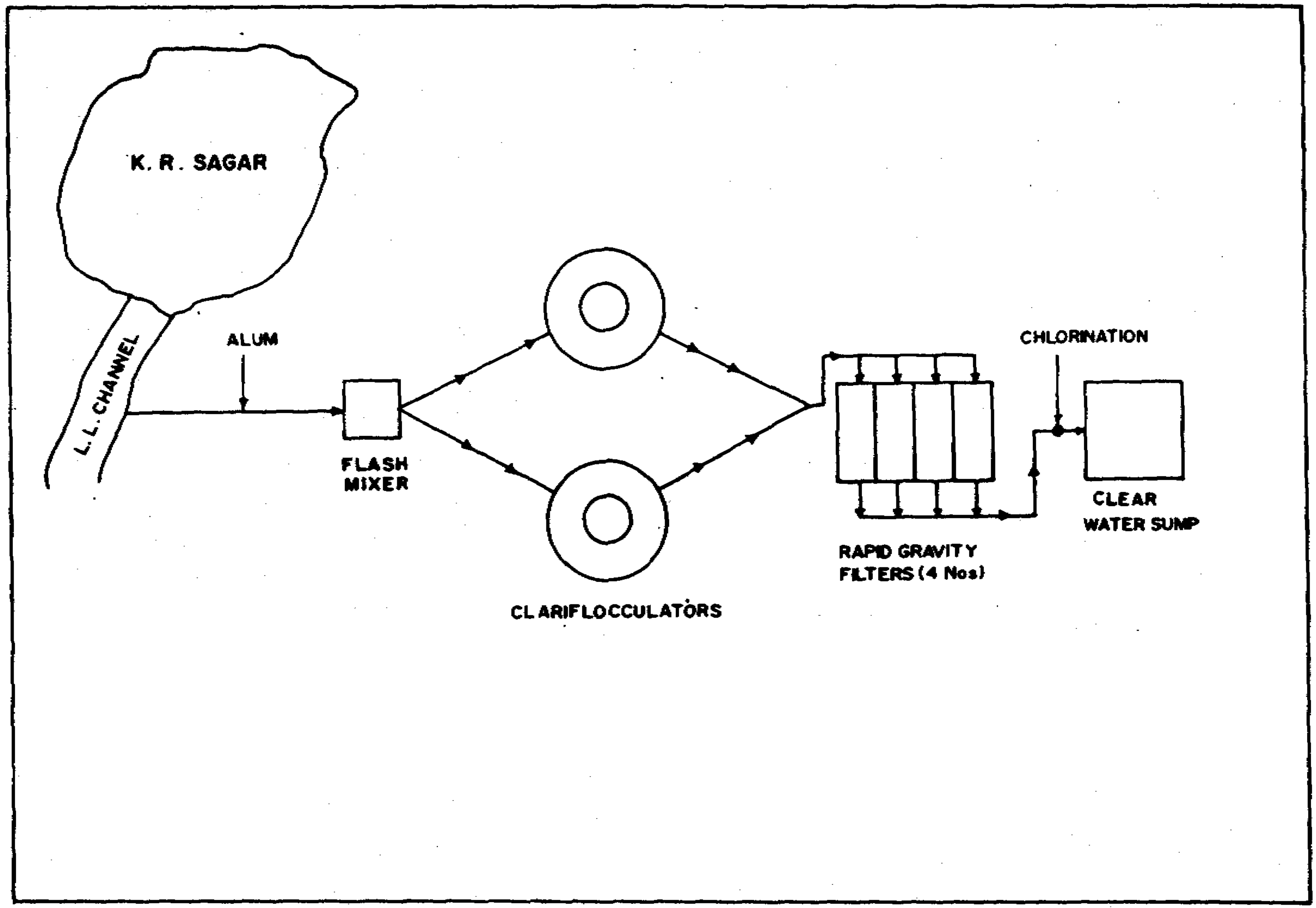


FIG 11.3 MYSORE WATER TREATMENT PLANT - SCHEMATIC

TABLE 11.7

PLANT SUMMARY DATA - MYSORE

GENERAL	
Name and location	: Vani Vilas Water Works, Mysore
Year of construction	: 1979
Design capacity	: 40 mld
O & M Agency	: Karnataka Urban Water Supply and Drainage Board
Raw water source	: Krishna Raja Sagar Dam
Treatment flowsheet	: Conventional with Rapid sand filters
ENGINEERING	
Raw water pumping	: Flow by gravity
Raw water flow measurement	: Crystal Dial type flowmeter
Pre-treatment	
Coagulation	
- Chemicals used	: Alum (Solution)
- Type of mixing	: Flash mixer, 2 nos, (One standby)
- Detention time	: 1 minute
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 nos, 13.1 m dia, 3.5 SWD
- Detention time	: 34 minutes

Sedimentation

- Type of unit(s)	: Radial flow Clariflocculator
- No. & size of unit(s)	: 2 nos, 32.9 m dia.,3.5 m SWD
- Surface Overflow Rate	: 1.16 m/hr
- Detention time	: 180 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 4 nos, 10.3 x 9.7 m each
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.64 mm, U.C.-1.64
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Water wash only
. Wash water tank cap.	: 4 lakh litres

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed

Clear Water Reservoir

- Type, No. & size	: RCC, one, rectangular 30 x 20 x 3.5 m
- Pump details	: 2 nos, centrifugal (one standby),100 HP each

TABLE 11.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

VANI VILAS WATER WORKS - MYSORE

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	0.5	0.3	1.0	1.5	1.7	0.7
pH	7.2	7.1	7.2	7.2	7.6	7.5
Total Alkalinity ($CaCO_3$)	122	128	80	80	114	112
Conductivity (µS/cm)	979	734	1139	938	364	316
Hardness ($CaCO_3$) Total	64	64	66	65	47	45
Carbonate	64	64	66	65	47	45
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	11	12	14	14	13	12
Magnesium (Mg)	9	9	8	7	4	3
Chlorides (Cl)	14	14	20	20	6	6
Sulphates (SO_4)	ND	ND	1	1	2	3
Iron (Fe)	ND	ND	ND	ND	0.3	ND
Fluoride (F)	0.3	0.3	ND	ND	ND	ND
Bacteriological (MPN/100 ml)						
Total coliform	230	0	930	-	150	4
Fecal coliform	23	0	93	-	150	0
E.coli	23	0	15	-	93	0
Fecal streptococci	23	0	93	-	93	4

All values except pH ,Turbidity and Conductivity are expressed as mg/l

N.D.- Not detectable

TABLE 11.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

VANI VILAS WATER WORKS - MYSORE

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	0.5	0.3	0.25	0.25
	II	1.0	0.8	0.5	1.5
	III	1.7	1.2	0.4	0.7
T.Coliform (MPN/100 ml)	I	230	43	4	0
	II	930	240	93	-
	III	150	23	4	4
E.Coli (MPN/100 ml)	I	23	0	0	0
	II	15	4	0	-
	III	93	0	0	0

SHIMOGA WATER TREATMENT PLANT - SHIMOGA

INTRODUCTION

Shimoga town in Karnataka with a population of about 1.5 lakhs (1981 census) receives water from River Tunga after treatment at the Krishna Rajendra water works situated 4 km from the town on the bank of the river Tunga. The plant designed to treat 13.5 mld and commissioned in the year 1977 is maintained by the Shimoga Municipal Council. The treatment plant is of conventional type with provision for aeration, alum dosing, flash mixing, flocculation, sedimentation, rapid gravity filtration and disinfection. The schematic flow sheet is shown in Fig. 11.4 and the plant summary data is presented in Table 11.10.

PLANT APPRAISAL

Raw water quality

During the study period, raw water turbidity was in the range of 3.5-20 NTU with low chlorides, hardness and fluorides. However, turbidity of raw water in river Tunga was reported to be high during monsoon season. The iron content in the water varied from 0.45-0.84 mg/l. The coliform count in raw water was in the range of 240 -2400 MPN per 100 ml (Table 11.11).

Raw water from intake well (5.5 m dia & 13 m deep) is pumped to the head works through two pumps of 100 HP each (one standby). There is no pollution due to industrial or domestic discharges in a stretch of one km upstream of intake except washing and bathing by men and cattle

Pre-treatment

All the pre-treatment units have been designed for 27.3 mld while the filters are designed for 13.5 mld only. The cascade aerator provided at the plant reduces iron concentration in raw water by 50%.

The flow meter provided for measuring raw water inflow was not in working condition. Alum solution is used for coagulation. The dose is decided arbitarily and not based on regular jar tests. The quantity of alum used was reported to vary from 100 kg to 1500 kg per day depending upon the turbidity of raw water. Mixing devices provided in alum solutionising tanks were corroded and not in operation.

Flash mixing is carried out in a chamber of 3.5 m diameter through a 3 HP motor. It was observed that the flash mixer was not put into continuous operation. Lot of cracks were found in the flash mixing chamber walls.

Performance of the clarifier was satisfactory as observed from settled water turbidity (0.3-1.2 NTU). Considerable reduction was observed in the bacterial count following flocculation and sedimentation (Table 11.12).

Filtration

There are three rapid gravity filters each with a capacity of 4.5 mld. Normal filter runs were reported to be 24 hrs. Performance of the filters was satisfactory as observed from filtrate turbidity which was less than 2 NTU. The headloss indicators and rate of flow indicators provided for the filters were not in working condition. Only water is used for backwashing of the filters.

Disinfection

Chlorination is carried out using chlorine gas/bleaching powder. The vacuum type chlorinator installed at the plant was not in working condition. Chlorine demand of the filtered water was found to be 1.0 mg/l. While the residual chlorine in the finished water was 0.8 mg/l. The finished water was free from coliform. During one of the visits, when bleaching powder was used for disinfection, an increase in turbidity of finished water was observed.

Laboratory facilities

Adequate laboratory facilities with equipment like turbidimeter, residual chlorine kit, jar testing machine, oven and distillation still etc. have been provided at the plant. But most of the instruments were out of order and trained laboratory personnel were not available.

RECOMMENDATIONS

* Raw water flow meter needs immediate repairs to enable measurement of plant inflow and process control.

* Regular jar tests need to be conducted to determine the optimum alum dose requirement.

* Flash mixer should be used continuously for proper coagulation of water.

* Instruments in the laboratory should be repaired and trained chemist should be appointed for proper operation and control of the plant.

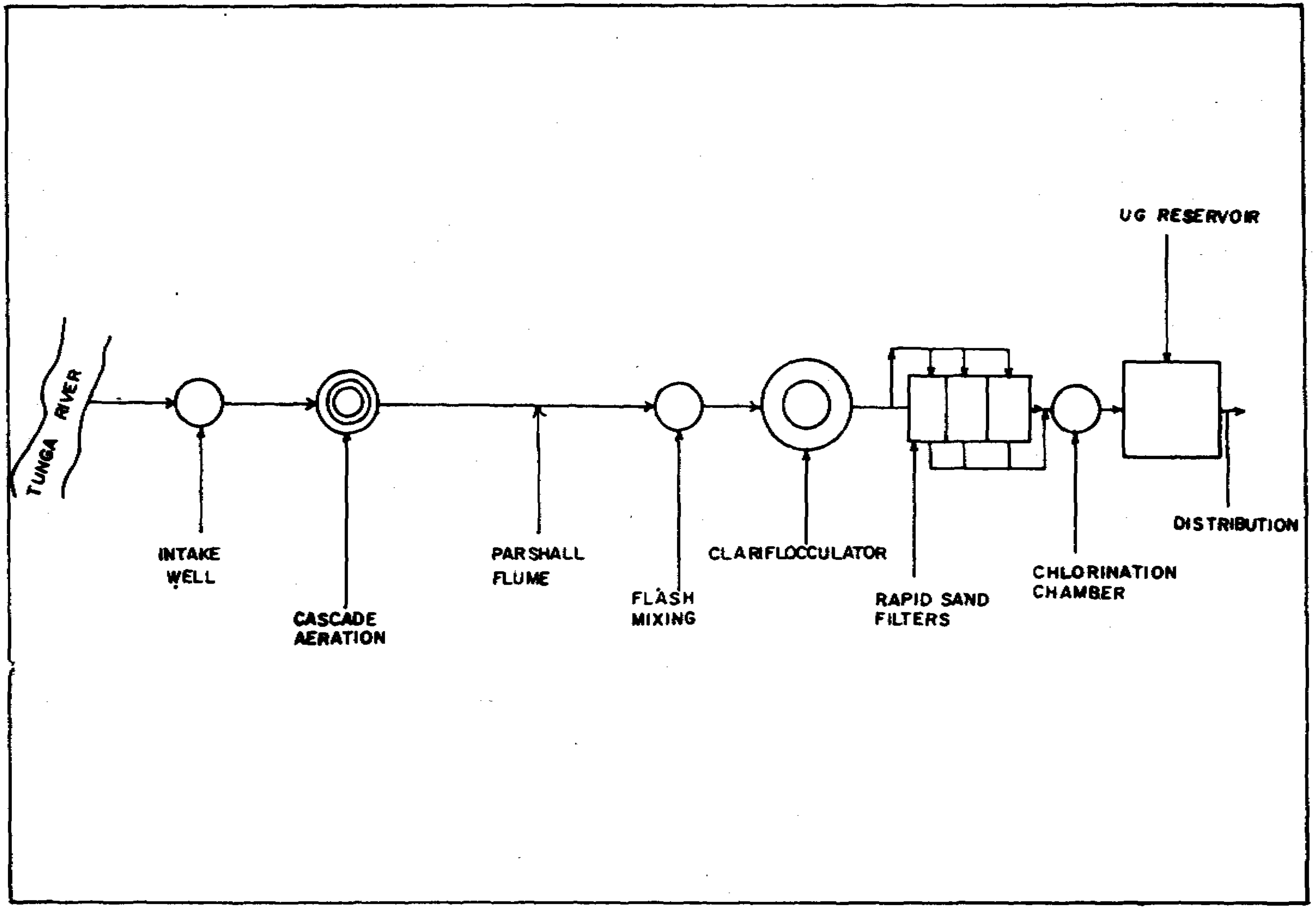


FIG 11.4 SRIKRISHNA RAJENDRA WATER TREATMENT PLANT - SHIMOGA

TABLE 11.10

PLANT SUMMARY DATA - SHIMOGA

GENERAL	
Name and location	: Shrikrishna Rajendra Water Works, Shimoga (Karnataka)
Year of construction	: 1977
Design capacity	: 13.5 mld
O & M Agency	: City Municipal Council, Shimoga
Raw water source	: River Tunga
Treatment flowsheet	: Conventional with Rapid Sand Filters
ENGINEERING	
Raw water pumping	: Two nos, (one standby), 100 HP each
-Rising main diameter	: 60 cm C.I.
Rawwater flow measurement	: Mahindra and Mahindra, capacity 1200 m^3/hr
Pre-treatment	
Aeration	: Cascade aerator (3 steps)
Coagulation	
- Chemicals used	: Alum (10% solution)
- Type of mixing	: Mechanical Flash Mixer, 3.5 m dia., 2.2 m depth
- Detention time	: 2 minutes
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: One, 14.8 m dia, 4.9 m SWD
- Detention time	: 80 minutes

Sedimentation

- Type of unit(s)	: Clariflocculator
- No. & size of unit(s)	: One, 34.6 m dia. and 4.9 m SWD
- Detention time	: 4 hrs (for 13.5 mld)

Filtration

- Type of unit(s)	: Rapid Gravity Filters
- No. & size of unit(s)	: 3 nos, 5.8 m x 5.8 m each
- Rate of filtration	: 5 m/hr
- Filter media	
. Sand size	: E.S.-0.45 mm, U.C.-1.4
. Depth of sand	: 70 cm
- Backwash arrangements	
. Method	: Water wash only
- Washwater tank cap.	: 136 m^3

Disinfection

- Chemicals used	: Chlorine gas, Bleaching powder
- Type of feed	: Solution feed
- Chlorinator Details	: Vacuum type,cap 960 gm/hr

Clear Water Reservoir

- Type, No.& Capacity	: RCC, one, 227 m^3
- Pumg details	: 2 nos, centrifugal, 250 HP each

TABLE 11.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

SHIMOGA WATER TREATMENT PLANT - SHIMOGA

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	3.5	5.2	8.6	2.5	20.0	2.2
pH	7.1	7.1	7.1	7.2	7.0	7.7
Total Alkalinity ($CaCO_3$)	52	50	64	60	26	24
Conductivity (μS/cm)	772	-	877	932	102	99
Hardness ($CaCO_3$)						
Total	16	24	36	34	24	24
Carbonate	16	24	36	34	24	24
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	5	6	9	8	6	6
Magnesium (Mg)	1	2	3	3	2	2
Chlorides (Cl)	18	16	22	22	9	9
Sulphates (SO_4)	4	2	8	13	6	6
Iron (Fe)	0.5	0.2	0.7	0.3	0.8	0.2
Fluoride (F)	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Bacteriological (MPN/100 ml)						
Total coliform	2400	0	240	0	240	0
Fecal coliform	430	0	23	0	93	0
E.coli	430	0	4	0	23	0
Fecal streptococci	23	0	9	3	23	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l

TABLE 11.12

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

SHIMOGA WATER TREATMENT PLANT - SHIMOGA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	3.5	2.5	2	5.2
	II	8.6	2.0	1.5	2.5
	III	20	8	2	2.2
	I	2400	460	0	0
T. Coliform (MPN/100 ml)	II	240	43	4	0
	III	240	43	43	0
	I	430	43	0	0
E. Coli (MPN/100ml)	II	4	0	0	0
	III	23	9	0	0

CALICUT WATER WORKS - MAVOOR

INTRODUCTION

Calicut town in Kerala draws its water supply from river Chaliyar. The water works designed to serve a population of 2.66 lakhs at the rate of 125 lpcd is located at Mavoor which is about 20 km from Calicut. The treatment plant commissioned in the year 1971 provides for conventional pre-treatment with alum followed by sedimentation, rapid sand filtration and chlorination. The schematic flow sheet is shown in Fig. 12.1 and the plant summary data is presented in Table 12.1. The plant is operated and maintained by the Kerala Water Authority.

PLANT APPRAISAL

Raw water quality and flow measurement

Though the Chaliyar river is perennial, the surface flow in the river gets considerably reduced during summer. During such periods, the flow is diverted to the intake point by constructing earthen bunds on the downstream side. No major source of pollution exists in the nearby vicinity of the intake. The chemical quality parameters of raw water are within the range (Table 12.2).

A Venturi flume has been provided at the inlet channel to measure the plant inflow. However, there was no flow indicating device. The plant inflow was actually measured at the time of the visit by installing a weir upstream of the flume and recording the head over the weir. The plant inflow was found to be 28.6 mld against the design value of 36 mld. A perusal of available records indicated that the plant had received 34 mld of raw water during the period 1979-80. The raw water pumps were operating at a decreased efficiency, it was noticed.

Pre-treatment

Alum and lime are added in sequence at the hydraulic jump in the raw water inlet channel. These chemicals, however, were added in an uncontrolled manner, without proper solution dosing system. The consumption of chemicals was reported to be of the order of 150 kg/day of alum and 100 kg/day of lime equivalent to a dose of 5 mg/l and 3 mg/l of alum and lime respectively for a raw water turbidity of 2 NTU. Adequate stock of chemicals was found at the plant. The flocculating paddles and sludge scrapers in both the clariflocculators were found in disuse. The poor operation of pre-treatment units was found to result in deterioration of settled water quality as evident from the turbidity which was 6 NTU as against a raw water turbidity of only 2 NTU (Table 12.3).

Filtration

The filter appurtenances such as the rate of flow controllers, the rate setters, headloss indicators etc. of all the four filters were non functional for one reason or another. In the absence of any reliable flow rate controlling system, all the four filters were operated at an arbitrarily adjusted filtration rates. The normal frequency of filter backwashing was reported to be once in 24 hours, irrespective of head loss or filtrate turbidity. Considerable quantity of sand was found lost from the filters due to defective backwashing. During the visit, the turbidity removal in the filters was only marginal as observed from the filtrate turbidity of 4 NTU while the influent turbidity was 6 NTU (Table 12.3).

Disinfection

Pressure type chlorinator has been installed at the water works. The dose of chlorine applied was found to be 1 mg/l which was found inadequate to ensure a minimum residual chlorine of 0.2 mg/l in the distribution system.

Laboratory facilities

Although laboratory equipment such as pH meter, turbidimeter and jar test apparatus etc. were available at the plant, these were not in good working condition and hence in disuse. No chemist has been posted at the plant and no regular monitoring of water quality at various stages of treatment is carried out.

Plant staff

The staff at the water works include Assistant Engineers (2 nos.), Work superintendent (3 nos.), Operators (12 nos.) Electricians and fitters. The filter operators have not received any formal training.

Financial aspects

The approximate annual expenditure towards operation and maintenance of the treatment plant was reported to be Rs.35 lakhs,while the annual revenue from the sale of water has been about Rs. 20 lakhs. The cost of treatment works out to about Rs. 0.75/m^3.

RECOMMENDATIONS

* The efficiency of raw water pumps has decreased by about 25 per cent. It is, therefore, necessary to repair/replace the pumps so as to ensure that their capacity matches with the rated capacity of the treatment plant.

* The existing raw water flow measuring device may be got either repaired or replaced with a new device of suitable capacity range.

* Simple, constant head chemical solution dosing systems should be installed for controlled dosing of alum and lime. Dosages of chemicals should be decided on the basis of jar tests to be conducted regularly.

* Equipment such as turbidimeter, jar test apparatus and pH meter etc., provided at the plant should be made operative and maintained in good working condition.

* All the mechanical equipment and appurtenances of clariflocculators and rapid gravity filters should be made operative and maintained properly.

* The plant operators need training for improved operation and maintenance.

* A qualified, trained chemist should be posted at the plant for routine water quality testing and process control.

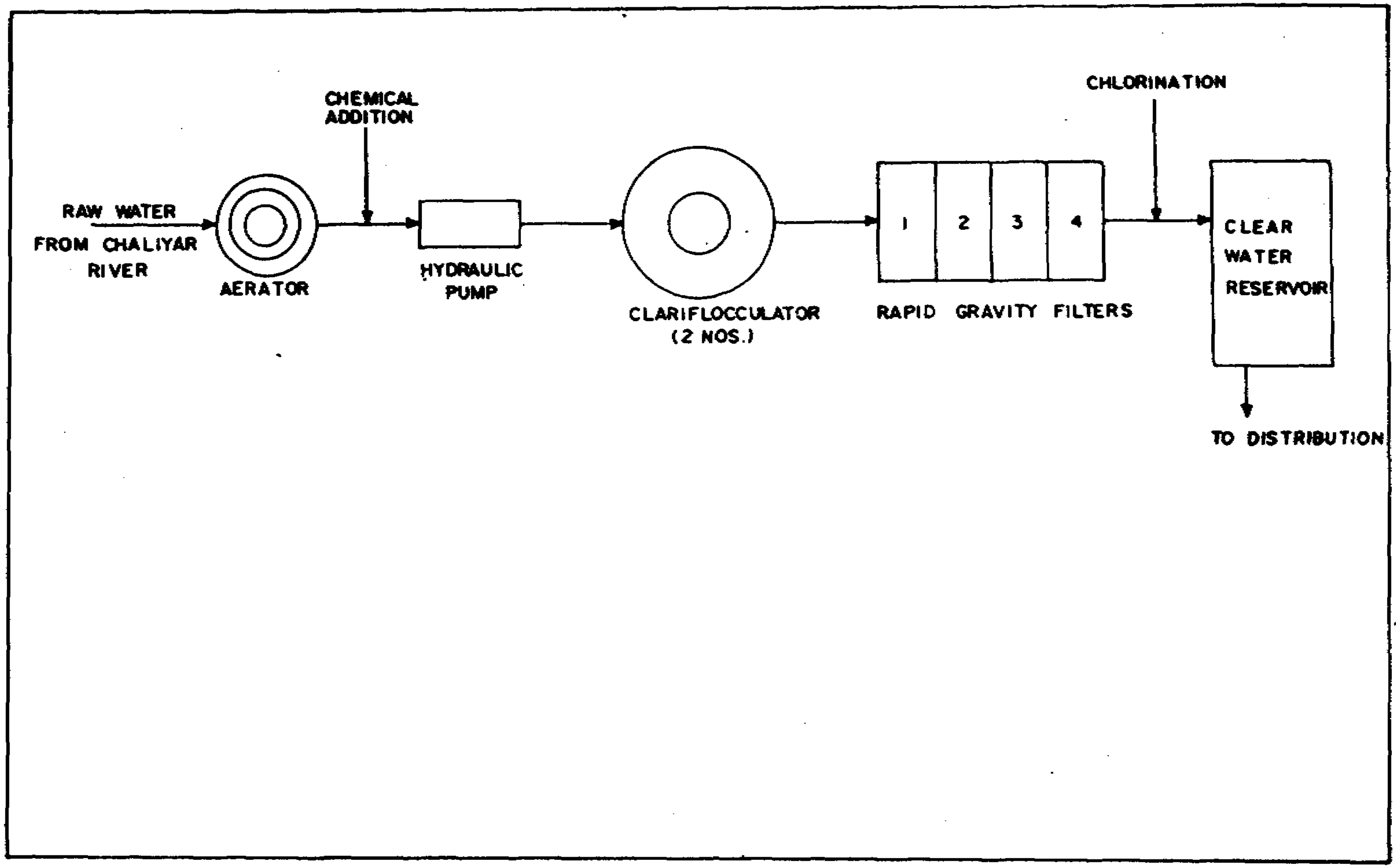


FIG 12.1 CALICUT WATER WORKS, MAVOOR - SCHEMATIC

TABLE 12.1

PLANT SUMMARY DATA - CALICUT

GENERAL

Name and location	: Calicut Water Works, Mavoor
Year of construction	: 1971
Design capacity	: 36 mld
O & M Agency	: Kerala Water Authority
Raw water source	: Chaliyar River
Treatment flowsheet	: Conventional with rapid sand sand filters

ENGINEERING

Raw Water Pumping	: 2 Nos., 250 HP each with discharge capacity of 315 lpm
- Rising main	: 600 mm dia. Cast Iron, 350 m length
Raw water flow measurement	: Venturi Flume
Pre-treatment	
Aeration	: Cascades, 5 Nos.
Coagulation	
- Chemicals used	: Alum & Lime
- Type of mixing	: Hydraulic
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos., each 11.0 m dia., 4.25 SWD
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 27.4 m dia. 3.4 m SWD
- Surface overflow rate	: 1.5 m/hr
- Detention time	: 2 hrs 10 minutes

Filtration

- Type of unit(s)	: Rapid gravity
- No. & size of unit(s)	: 4 Nos., (twin beds) each 9.10 x 8.50 m
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.6 mm, U.C.- 1.5
. Depth of sand	: 60 cm
. Supporting Gravel	: 50 cm.; 2.5 to 50 mm size
- Backwash arrangements	
. Method	: Air scour followed by water wash
. Wash water tank cap.	: 304 m^3

Disinfection

- Chlorine gas/Bl. powder	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: Pressure chlorinator of capacity 1.5 kg/hr

Clear Water Reservoir

- Type, No. & Capacity	: R.C.C., 1 No.,1800 m^3
- Pump details	: 4 Nos., 150 HP each.

TABLE 12.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

CALICUT WATER WORKS - MAVOOR

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	2	2	5	1
pH	7.3	7.1	6.8	-
Total Alkalinity ($CaCO_3$)	36	34	6	-
Hardness ($CaCO_3$)				
Total	16	16	20	-
Carbonate	16	16	6	-
Non Carbonate	NIL	NIL	14	-
Calcium (Ca)	5	5	-	-
Magnesium (Mg)	1	1	-	-
Chlorides (Cl)	720	750	12	-
Sulphates (SO_4)	2	3	Nil	-
Iron (Fe)	1.4	1.5	0.1	-
Bacteriological (MPN/100 ML)				
Total coliform	130	0	460	Nil

All the values except pH and turbidity are expressed as mg/l

TABLE 12.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

CALICUT WATER WORKS - MAVOOR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	2	6	4	2
	II	5	5	1	1
T. Coliform (MPN/100 ML)	I	130	47	33	NIL
	II	460	-	-	NIL

THIRUVALLA WATER WORKS - THIRUVALLA

INTRODUCTION

The water works at Thiruvalla with a capacity of 24 mld serves the water supply needs of Thriruvalla and Changanacherry towns and the municipal areas in and around Kuttanad with a population of 3.9 lakhs (1981 census). The plant, commissioned in the year 1977, draws raw water from river Manimalaion and provides for pre-treatment with alum coagulation followed by sedimentation, rapid sand filtration and chlorination. The plant layout is shown in Fig. 12.2 and plant summary data is presented in Table 12.4.

PLANT APPRAISAL

Raw water quality and flow measurement

River Manimalaion has low surface flow during the period May-June but no water scarcity has been experienced so far. However, due to change in the river flow regime during summer, raw water has to be diverted towards the intake point by constructing temporary earthen bunds. The source is not well protected and activities like washing of tractors, ferry boats etc. take place right near the intake on upstream side. The raw water has a low pH, low total dissolved solids and low alkalinity (Table 12.5).

A Parshall flume along with a flow indicator has been installed at the raw water inlet channel to measure the plant inflow. At the time of the visit, the recorded plant inflow was 1200 m^3/hr as against a design value of 1000 m^3/hr.

Pre-treatment

The cascade aerator provided at the treatment plant does not seem to serve any useful purpose other than improving the plant aesthetics. Lime is used as a coagulant aid in conjuction with alum. A fixed dose of alum and lime is applied irrespective of the changes in raw water quality. At the time of the visit, the actual dose of alum and lime as applied to the raw water of 12 NTU turbidity, was 10 and 15 mg/l respectively as against the corresponding jar test dose of 20 and 30 mg/l. The chemicals are added just upstream of the Parshall flume. The tanks provided for preparation of alum and lime solutions are not in use. The mechanical mixer in the flash mix unit was working satisfactorily while the flocculating paddles and sludge scrapers in both the clarifloc-culators were defunct for want of spares. Although the plant was overloaded and the chemical dosages were inadequate, still the settled water turbidity was low and within the acceptable limit because of low raw water turbidity (12 NTU).

Filtration

The rapid gravity filters were reported to have been overhauled in the year 1987 when the filter sand was replaced. However, the performance of the filters was not satisfactory as there was only a nominal reduction in turbidity due to filtration (Table 12.6). Though provision has been made for air scour, the filters were washed with water only as the air blower was down for repairs with the result the backwashing was ineffective. Cracks were observed on the sand surface in all the filters. The fitler appurtenances were also non-functional.

Disinfection

As the gas chlorinator was not in working order, disinfection was achieved using bleaching powder. The available chlorine in the bleaching powder used was found to be 32 per cent and the residual chlorine in the finished water was in the range of 0.4-0.8 mg/l.

Laboratory facilities

Laboratory facilities have been provided at the plant site. The available equipment includes turbidimeter, pH meter, jar testing machine, residual chlorine kit, and chemical balance. However, these were not being used as no chemist has been posted at the plant.

RECOMMENDATIONS

* Measures should be taken to prevent/restrict human activities near the intake to minimise the potential for pollution of raw water.

* Dosages of chemicals should be decided on the basis of jar test performed regularly.

* The sludge scraper mechanism for the clariflocculator should be got repaired and put into operation.

* In order to ensure clean filters and a filtrate of acceptable quality, effective back washing is a pre-requisite. The air blower should be got repaired immediately and put into operation to improve backwashing.

* A competent chemist with supporting staff should be posted at the plant for routine laboratory testing and plant control.

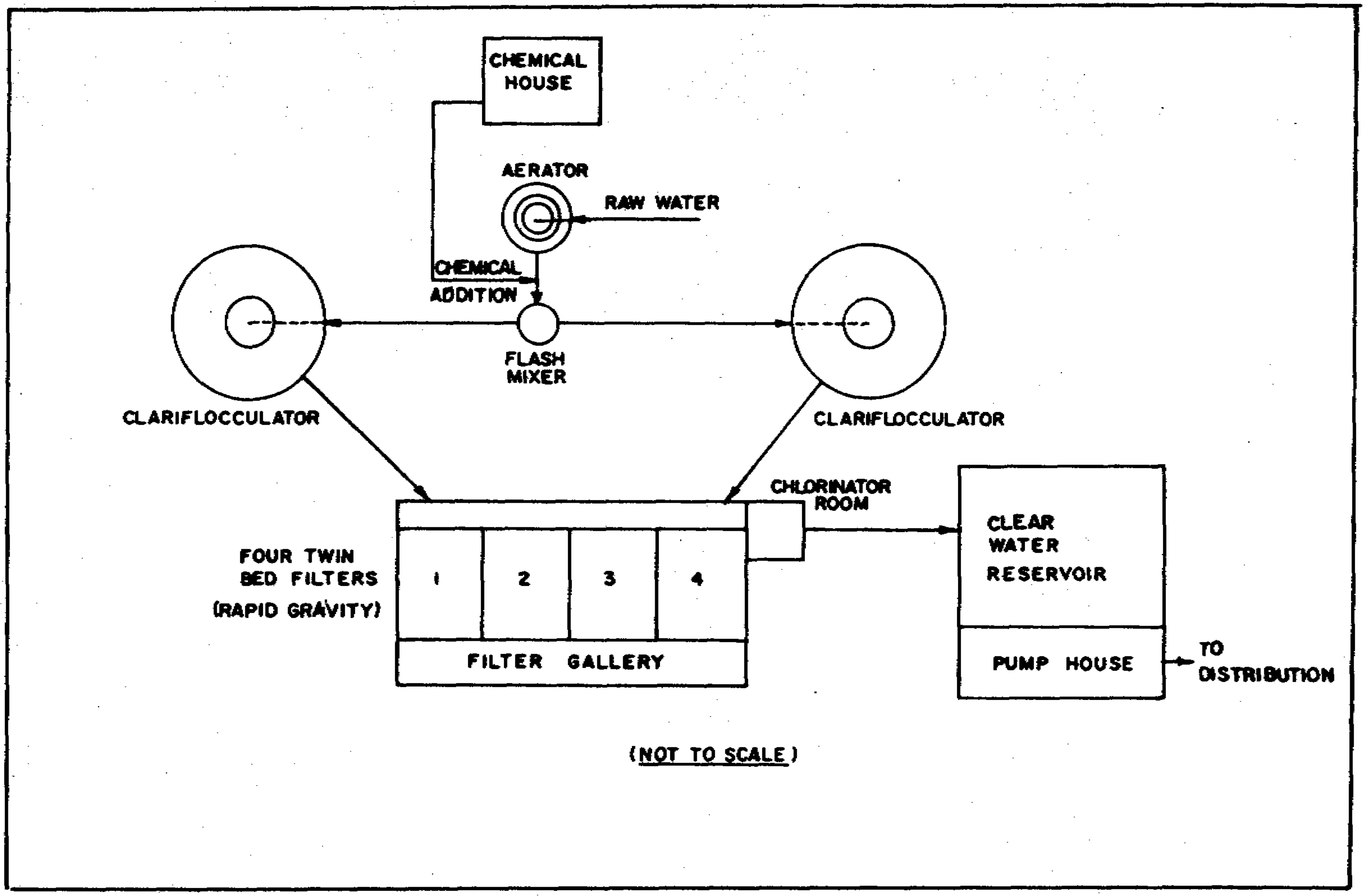


FIG 12.2 LAYOUT PLAN OF WATER TREATMENT PLANT, THIRUVALLA

TABLE 12.4

PLANT SUMMARY DATA - THIRUVALLA

GENERAL

Name and location	: Thiruvalla Water Treatment Plant, Thiruvalla
Year of construction	: 1977
Design capacity	: 24 mld
O & M Agency	: Kerala Water Authority
Raw water source	: River Manimalaion
Treatment flowsheet	: Conventional with rapid sand filters

ENGINEERING

Raw Water Pumping	: 4 Nos., each 175 HP with a discharge capacity of 9550 lpm
- Rising main diameter	: 700 mm C.I.
Raw water flow measurement	: Parshall flume with a flow indicator of capacity 0-2000 m^3/hr

Pre-treatment

Aeration	: Cascades, 4 Nos.
Coagulation	
- Chemicals used	: Alum & Lime
- Type of mixing with	: Mechanical mixer details 1 No, 2.7 m dia., 2.5 m SWD, 60 sec. detention time
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos., each 10 m dia. 4.2 m SWD
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 25 m dia. 3.3 m SWD
- Surface overflow rate	: 1.2 m/hr,
- Detention time	: 2 hr 40 minutes

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 4 Nos. (twin bed),each 6.9 x 8.25 m
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.45 mm, U.C.-1.3
. Depth of sand	: 75 cm
. Supporting Gravel	: 30 cm. depth
- Backwash arrangements	
. Method	: Air scour followed by water wash

Disinfection

- Bleaching powder/	: Chlorine gas & Bleaching Chlorine gas Powder
- Chlorinator Details	: Vacuum type 2 kg/hr capacity Clear Water Reservoir
- Type,No. & Capacity	: R.C.C., 1 No.,with two compartments, 1 million litres capacity
- Pump details	: 6 Nos., 60 HP each

TABLE 12.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

THIRUVALLA WATER WORKS - THIRUVALLA

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	5	3	12	3	50	5
pH	6.6	6.4	6.8	7.1	6.4	-
Total Alkalinity ($CaCO_3$)	30	24	8	6	12	-
Hardness ($CaCO_3$) Total	20	23	12	12	20	-
Carbonate	20	23	-	-	12	-
Non Carbonate	NIL	NIL	-	-	8	-
Calcium (Ca)	5.0	7	-	-	-	-
Magnesium (Mg)	2	1	-	-	-	-
Chlorides (Cl)	8	8	10	11	8	-
Sulphates (SO_4)	2	2	3	3	Nil	-
Iron (Fe)	0.2	0.3	-	-	Nil	-
Bacteriological (MPN/100 ML)						
Total coliform	NIL	NIL	-	-	170	Nil

All the values except pH and turbidity are expressed as mg/l

TABLE 12.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

THIRUVALLA WATER WORKS - THIRUVALLA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	5.0	5.0	3.0	3.0
	II	12.0	5.0	4.0	3.0
	III	50	25	6	5
T. Coliform (MPN/100 ML)	I	NIL	NIL	NIL	NIL
	II	1600	540	170	NIL
	III	170	-	-	NIL
E. Coli (MPN/100 ML)	I	23	5	2	NIL
	II	0	0	0	0
	III	——	Not Tested		——

TRICHUR WATER WORKS - PEECHI

INTRODUCTION

Trichur water works which is located at Peechi reservoir has been designed to supply water to a population about 1.0 million (1981 census) of Trichur and the adjoining Panchayats of Kurkancherry, Ayyanthole and Nadathava. The source of supply is Peechi irrigation reservoir formed by constructing a dam across the river Manali. Water is drawn by gravity to the treatment works which provides for chemical pre-treatment with alum followed by sedimentation, rapid sand filtration and chlorination. The schematic flow sheet is given in Fig. 12.3 and the plant summary data is presented in Table 12.7. The responsibility for plant operation and maintenance rests with the Kerala Water Authority.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water is drawn from near the surface of the reservoir. The problem of odour in raw water has been reported particularly during the months of November and December. The raw water is soft and corrosive as shown by low pH value, low total dissolved solids and low alkalinity (Table 12.8). It is reported that the dissolved oxygen content of raw water, at times, goes below 1 mg/l.

The flow indicator installed at the Parshall flume to measure the plant inflow was found working satisfactorily. During the visit, the flow recorded was 12.7 mld as against the design value of 14.5 mld.

Pre-treatment

The applied dose of alum and lime was found as 25 mg/l and 30 mg/l respectively for a raw water turbidity of 12 NTU. No proper system of chemical dosing and control has been provided at the plant. The dose, therefore, was found to vary from time to time and in every shift. The method of preparation of alum and lime solutions was also unscientific. The mechanical mixer and flocculating paddles were found in proper working condition. During the visit, the raw water turbidity itself was very low (3 NTU) and there was no significant improvement after sedimentation (Table 12.9).

Filtration

Three rapid gravity filters (twin bed) designed to operate at a filtration rate of 6.0 m/hr have been provided. The filter appurtenances viz. the rate setter, rate of flow controller, and the loss of head indicator in all the filters were not in working condition. Backwashing of filters is carried out once in 24 hours with air scour followed by water wash. Backwashing was found ineffective as seen from the mudball formation and filter cracks.

Disinfection

As the chlorinator installed at the water works was completely corroded and inoperative, bleaching powder solution was used for disinfection. The dose of bleaching powder was not properly regulated. The available chlorine in the bleaching powder used was found as 29 per cent while the residual chlorine in the finished water was 0.2 to 0.8 mg/l.

Laboratory facilities

No laboratory facility exists at the plant site.

Plant staff

The staff at the plant include Assistant Engineer 1 No.),Water Works Superintendant (1 No.),Operators (4 Nos.)and Cleaners (8 Nos.). The staff has not undergone any formal training in operation and control of water treatment plant.

Financial aspect

The annual expenditure on operation and maintenance of water treatment system was reported to be about Rs.11 lakhs. The cost of treatment works out to approx. Rs. 0.25/m^3.

RECOMMENDATIONS

* An appropriate chemical dosing system should be installed immediately for controlled addition of chemicals.

* All the filter appurtenances should be checked for their functionality and steps taken to repair/replace them.

* The filter backwashing should be improved by ensuring adequate duration of air scour followed by water wash.

* A new chlorinator should be installed in a properly designed chlorination room with necessary safety provisions. - Minimum laboratory equipment like pH meter, turbidimeter, jar test apparatus, residual chlorine kit etc. should be provided for day to-day monitoring and control of the treatment processes.

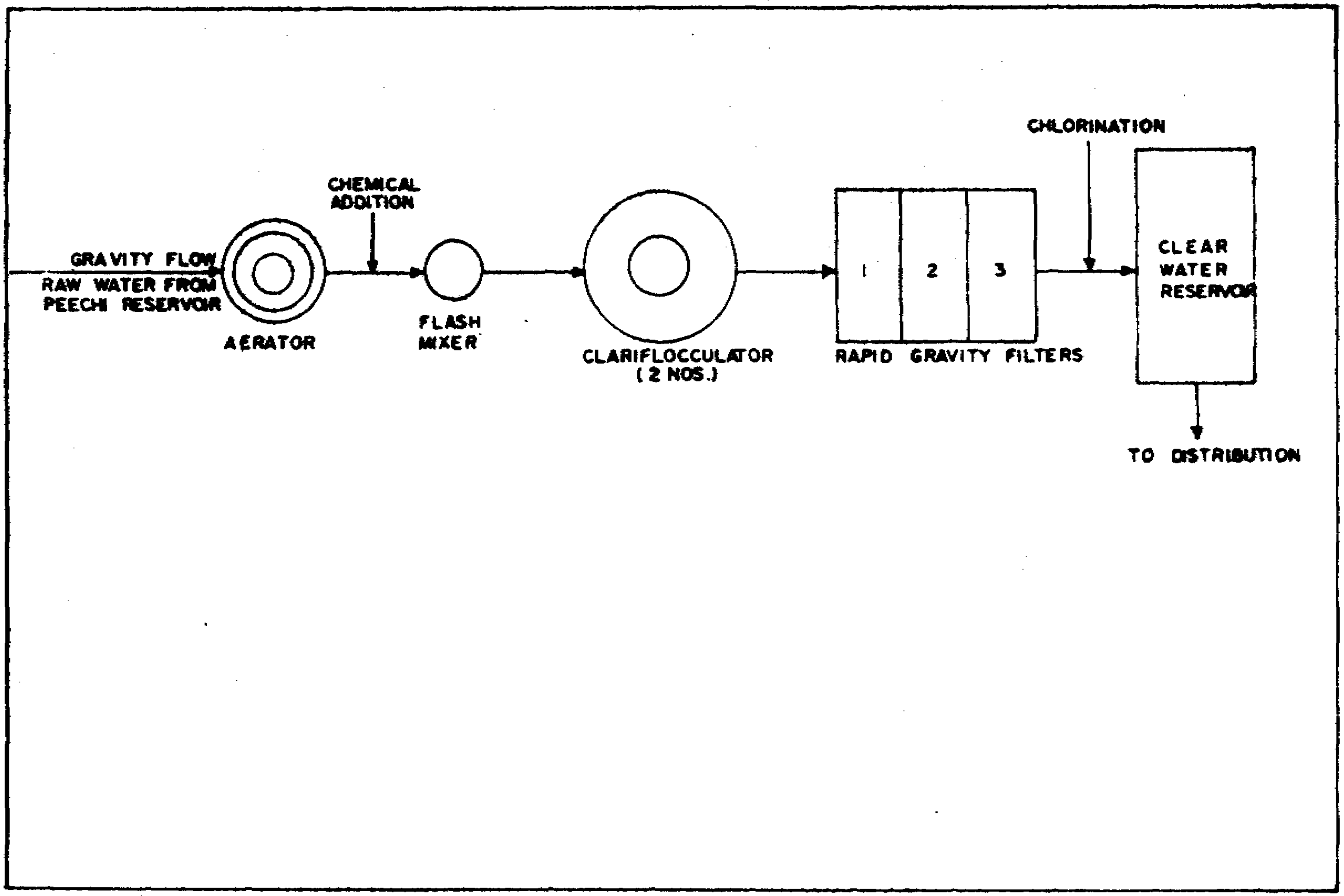


FIG 12.3 TRICHUR WATER WORKS, PEECHI - SCHEMATIC

TABLE 12.7

PLANT SUMMARY DATA - TRICHUR

GENERAL	
Name and location	: Trichur Water Works,Peechi
Year of construction	: 1961
Design capacity	: 14.5 mld
O & M Agency	: Kerala Water Authority
Raw water source	: Peechi Irrigation Reservoir
Treatment flowsheet	: Conventional with rapid sand filters
ENGINEERING	
Raw water gravity main	: 183 m long C.I. Pipe
- diameter	: 600 mm
Raw water flow measurement	: Parshall flume with flow indicating device.
Pre-treatment	
Aeration	: Cascades, 4 Nos.
Coagulation	
- Chemicals used	: Alum & Lime
- Type of mixing with	: Mechanical mixing details 1 No, 3.65 m dia. 1.8 SWD, 40 sec. detention time
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos, each 7.3 m dia. 3.95 m SWD
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., each 24.4 m dia.
- Surface overflow rate	: 1.8m/ hr

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 3 Nos., each 4.25 x 5.5 m
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.-0.45 mm, U.C.-1.3
. Depth of sand	: 75 cm
. Supporting Gravel	: 40 cm. depth
- Backwash arrangements	
. Method	: Air scour followed by water wash

Disinfection

- Bleaching powder/ Chlorine gas	: Chlorine gas
- Chlorinator Details	: Vacuum type; capacity 5 kg/hr.

Clear Water Reservoir

- Type,No. & Capacity	: R.C.C., 1 No.,with four compartments, 0.85 million litres capacity
- Distribution	: By gravity

TABLE 12.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

TRICHUR WATER WORKS - PEECHI

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	3	2	12	-	10	3
pH	6.5	6.5	6.8	-	7.6	-
Total Alkalinity ($CaCO_3$)	28	30	12	-	8	-
Hardness ($CaCO_3$)						
Total	12	28	16	-	16	-
Carbonate	12	28	-	-	8	-
Non Carbonate	NIL	NIL	-	-	8	-
Calcium (Ca)	3	9	-	-	-	-
Magnesium (Mg)	1	2	-	-	-	-
Chlorides (Cl)	3	5	5	-	6	-
Sulphates (SO_4)	1	14	2	-	Nil	-
Iron (Fe)	1.3	1.5	2	-	Nil	-
Bacteriological (MPN/100 ML)						
Total coliform	79	0	-	-	240	Nil

All the values except pH and turbidity are expressed as mg/l

TABLE 12.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

TRICHUR WATER WORKS - PEECHI

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	3	4	1	2
	II	10	10	5	3
T. Coliform (MPN/100 ML)	I	920	350	130	NIL
	II	240	-	-	NIL
E. Coli (MPN/100 ML)	I	23	21	13	0
	II	——	Not Tested		——

ARUVIKKARA WATER WORKS - TRIVANDRUM

INTRODUCTION

Trivandrum, the capital city of Kerala has its water works located at Aruvikkara which is about 22 km from the city. The treatment plant with a design capacity of 50 mld was commissioned in the year 1973 and the capacity was augmented by 25 mld in the year 1987. The 50 mld plant with conventional pre-treatment using alum coagulation and sedimentation followed by rapid sand filtration was selected for evaluation. The plant layout and summary data are given in Fig.12.4 and Table 12.10 respectively. The water works is maintained by the Kerala Water Authority, Trivandrum.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water source is Aruvikkara reservoir which is an impoundment formed by a dam constructed across the Karamana river. The storage capacity of the reservoir is 628.26 million litres and there has been no scarcity of water even during summer. Adequate measures have been taken for protection of the source in the vicinity of the intake. The chemical quality of raw water (Table 12.11) is within the limits recommended by CPHEEO. The raw water turbidity is reported to be generally low throughout the year.

Raw water is pumped to the treatment plant through a 700 mm dia. rising main. A flow indicator along with an integrator installed in the raw water inlet channel near the flume was non-functional. The plant inflow as measured by noting the head over the weirs in the filter outlet chambers was found to be 67.85 mld as against the design value of 50 mld. The reason for overloading (about 35 per cent) is attributed to the difficulties in regulating the raw water control valves at the pump house in the absence of flow indicating devices.

Pre-treatment

Alum and lime are used for coagulation and the chemicals in solution form are added near the flume at the raw water inlet channel. Pre-chlorination using bleaching powder is also practised occasionally for algae control. No proper system of dose regulation has been provided, and a fixed quantity of 350 kg/day of alum and 300 kg/day of lime are added during the fair season. During monsoon when the raw water turbidity is high, the alum dose is reported to be increased to threefold. Overloading of the units coupled with incorrect and unregulated dose of chemicals, non-functioning of mechanical mixers, and flocculators were found to result in poor pre-treatment. This is evident from the settled water turbidity of 6 NTU and 8 NTU as compared to the raw water turbidity of 8 NTU (Table 12.12).

Filtration

All the filters were reported to have been overhauled during May-June, 1987 when the filter media including the underdrain plastic nozzles were replaced. The filter appurtenances were found non-functional. The frequency of filter backwashing was once in 16 to 24 hours due to overloading. Since the air blower was under repair, only water wash was given which was found ineffective. Filter cracks and mudballs were observed in all the filters. In general, the performance of the filters was unsatisfactory and during one of the visits, the turbidity of the settled water and the filtrate was the same at 9 NTU (Table 12.12).

Disinfection

Filtered water is disinfected using chlorine gas. The dose applied was 1.5mg/l which was adequate to provide a residual chlorine of 0.5 mg/l in the finished water.

Laboratory facilities

A fairly well equipped laboratory with essential instruments/equipment and other infrastructural facilities is available at the plant for routine control tests. The available equipment includes pH meter, turbidimeter, jar test apparatus and residual chlorine kit. These facilities have been established at the time of the augmentation of the plant capacity in the year 1987. A qualified chemist and a laboratory assistant have been posted for water quality testing and plant control. However, the facilities are not being utilised fully to improve the plant performance.

Plant staff

In addition to the laboratory staff, filter operators (7 nos), fitters (6 nos.), and pump operators (12 nos.) have been posted at the water works under the direct supervision of one Assistant Engineer. The staff has not undergone any formal training in the operation and control of water treatment plant.

RECOMMENDATIONS

* Immediate steps should be taken to install the flow indicating devices for proper division and control of plant inflow between the two treatment plants. Proper regulation of flow through the rising mains should be ensured so that the plant overloading is within the design limits.

* The dose of chemicals should be fixed on the basis of raw water quality and tretability studies. For this purpose the available laboratory facilities should

be fully utilised. This would help improving the plant performance and also effect economy in operation.

* Proper maintenance of mechanical mixer, flocculating paddles, sludge scrapers and filter appurtenances is necessary to improve the functionality of the treatment system.

* The present practice of backwashing the filters without air scour is found inadequate resulting in formation of mudballs and short filter runs. Auxiliary air scour prior to water wash should be practised.

* The plant staff should be deputed to undergo formal training in water works operation and maintenance.

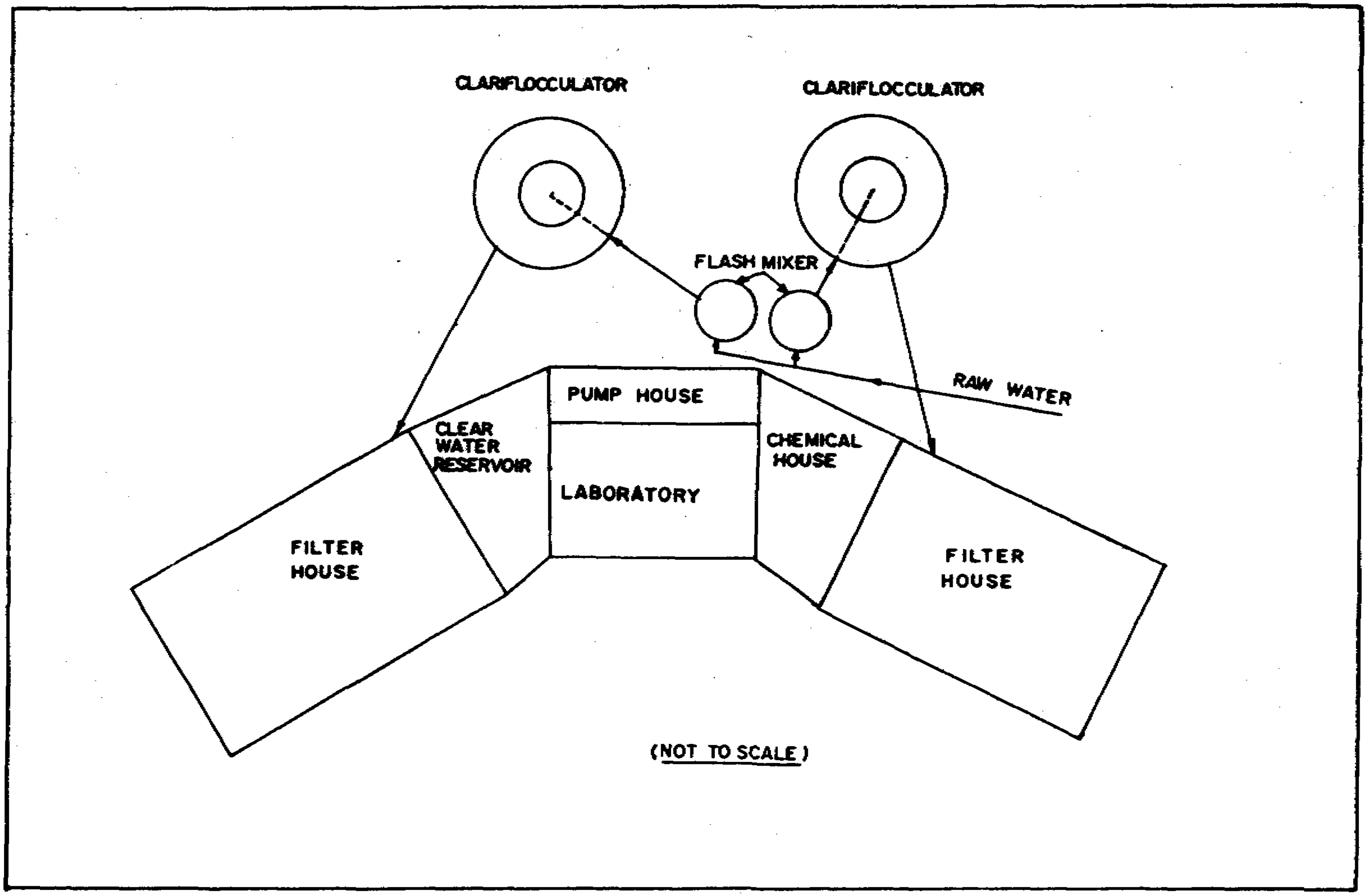


FIG 12.4 LAYOUT PLAN OF TRIVANDRUM WATER TREATMENT PLANT - ARUVIKKARA

TABLE 12.10

PLANT SUMMARY DATA - TRIVANDRUM

GENERAL	
Name and location	: Aruvikkara Water Works, Trivandrum
Year of construction	: 1973
Design capacity	: 50 mld
O & M Agency	: Kerala Water Authority
Raw water source	: Aruvikkara Reservoir
Treatment flowsheet	: Conventional with rapid sand filters
ENGINEERING	
Raw Water Pumping	: 6 Nos., each 170 HP with a discharge capacity of 303 lps
- Rising main	: 500 m length, C.I.,700 mm dia.
Raw water flow measurement	: Parshall flume with flow indicating device
Pre-treatment	
Coagulation	
- Chemicals used	: Alum & Lime
- Type of mixing with	: Mechanical mixer, 2.1 m dia, details 4.5 m. SWD
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 Nos., each 12.2 m dia.

Sedimentation

- Type of unit(s)	: Radial flow
- No. & size of unit(s)	: 2 Nos., 34.20 m dia. 3 m SWD

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 6 Nos., (twin bed) each 10.3 m x 6.6 m
- Rate of filtration	: 4.8 m/hr
- Backwash arrangements	
. Method	: Air scour and water wash
. Washwater tank cap.	: 70 m^3

Disinfection

- Chemicals used	: Chlorine gas, Bleaching powder for pre-chlorination
- Chlorinator Details	: Chlorinator with 3.5 kg/hr capacity Clear Water Reservoir
- Type,No. & Capacity	: R.C.C., 1 No.,two compartments 680 m^3 capacity
- Pump details	: 6 Nos, 150 HP each.

TABLE 12.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

ARUVIKKARA WATER WORKS - TRIVANDRUM

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	8	3	8	6	50	10
pH	6.8	6.9	6.8	6.7	7.2	-
Total Alkalinity ($CaCO_3$)	20	25	12	21	14	-
Hardness ($CaCO_3$)						
Total	10	20	4	12	28	-
Carbonate	10	20	-	-	14	-
Non Carbonate	NIL	NIL	-	-	14	-
Calcium (Ca)	2	3	-	-	-	-
Magnesium (Mg)	1	2	-	-	-	-
Chlorides (Cl)	3	5	6	8	5	-
Sulphates (SO_4)	2	5	NIL	NIL	NIL	-
Iron (Fe)	0.4	0.5	-	-	0.1	-
Bacteriological (MPN/100 ML)						
Total coliform	5400	0	5400	NIL	350	NIL
Fecal streptococci	340	-	340	NIL	< 50	NIL

All the values except pH and turbidity are expressed as mg/l

TABLE 12.12

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

ARUVIKKARA WATER WORKS - TRIVANDRUM

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	8	6	3	3
	II	8	9	9	6
	III	50	50	20	10
T.Coli (MPN/100 ML)	I	5400	2400	330	Nil
E.Coli (MPN/100 ML)	I	490	230	4	Nil

LAXMINARAYANGIRI WATER TREATMENT PLANT BHOPAL

INTRODUCTION

Bhopal, the capital city of Madhya Pradesh has a population of about 8.5 lacs. The main source of water supply to the city is Upper Lake, Bhopal. The treatment plant with a design capacity of 22.7 mld and located at Laxminarayangiri hills is maintained by PHED, Bhopal. The schematic flow sheet is shown in Fig. 13.1 and the plant summary data is presented in Table 13.1.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water pump house, which is on the bank of the lake, is located below the MWL of the lake with the result the raw water pumps work under positive suction most of the time. No separate intake well has been provided at the headworks and raw water is directly pumped from the lake through the suction pipe and foot valves. All raw water pumps (5 nos) including the standby units (2 nos) were found in working condition. The head works is 4.7 km away from treatment plant.

The Upper Lake receives domestic sewage discharge, though not in the immediate vicinity of the intake. Bathing and washing of clothes was observed near the headworks. Increase in color and turbidity of raw water was reported during Ganesh festival due to immersion of idols in the lake.

A Venturi flume has been provided to measure the plant inflow. Though the flow indicating device installed at the flume was found in working condition, the flow recorder and integrator were not working. During one of the visits, the raw water inflow to the plant was 32.5 mld indicating overloading to the extent of 44 per cent. This was due to the inflow of 136 m^3/hr of raw water pumped into the plant from the rising main of BHEL treatment plant. During the next visit, due to failure of monsoon, drawal of water from the lake was reduced to 17.7 mld to conserve the supply for summer, so the plant was underloaded to the extent of 22 per cent.

Samples of raw and finished water were collected and analysed for physico-chemical parameters (Table 13.2).It can be seen from the results that all the parameters are found to be within the recommended limits for potable purposes.

Pre-treatment

The hydraulic impingement (jet)type flash mixer provided at the plant was in disuse. The alum solution wasadded in the flash mixing chamber. The constant head alum dosing device was not functioning and hence the dose was controlled manually.

The reported concentration of alum solution and the dose of alum applied were significantly different from the actual values.

Pre-chlorination using chlorine gas is carried out at the water works round the year with a view to improving coagulation and reducing algal growth in the treatment units. Only one chlorinator has been provided for pre as well as post-chlorination.

During the visit,one of the two flocculators was empty for repair of leaks and replacement of corroded flocculator paddles and the flow was bypassed to sedimentation tanks. During the next visit, both the flocculators were in operation and floc formation was found to be good.

Horizontal flow rectangular settling tanks have been provided and the tanks are cleaned once a year. Settled water turbidity was less than 8 NTU (Table 13.3) even when the plant was overloaded thereby indicating the high efficiency of the settling tanks.

Filtration

Filter appurtenances such as rate setters, rate controllers and headloss indicators of all the filters were found in disuse. Filters were backwashed once in 24 hours using air scour and water; however, when underloaded they were backwashed once in 48 hrs. The backwashing operation was observed to be satisfactory. Though the filter beds were clean, the sand depth in the filters was about 45-50 cm which is less than the minimum desired value of 60-75 cm (E.S - 0.50 mm, U.C-1.64). According to the plant chemist, sand & gravel are replaced after every 5-6 years of use. The sludge from sedimentation basin and spent backwash water from the filters are discharged into a nearby nullah and is utilised for watering the PWD garden.

Filtrate turbidity was always less than 2 NTU (Table 13.3) even when the filters were overloaded. During the first visit the filtered water was free from coliform bacteria indicating good performance of the filters.

Disinfection

Post chlorination is done using vacuum type chlorinator with chlorine gas. The chlorine solution is injected into the pipeline carrying filtered water to the reservoirs. Only one chlorinator is used for pre and post chlorination. The total chlorine dose was 4 kg/hr and the residual chlorine in the tap water at the plant was more than 1 mg/l.

Laboratory facilities

A small laboratory with a trained chemist is provided at the plant with necessary facilities and equipment like pH meter, turbidimeter, jar testing machine, distilled water still, refrigerator etc. Most of the instruments except jar testing machine were found in working condition. In addition to this laboratory, there is a central laboratory at Bhopal with all the facilities required for complete water analysis. Plant operation and maintenance records are maintained properly. None of the filter operators had undergone any formal training.

RECOMMENDATIONS

* In view of the discharge of domestic sewage and anthropogenic activities at the Upper Lake,the raw water quality should be monitored regularly to facilitate preventive and corrective measures.

* The flash mixer should be put into commission so as to ensure proper mixing of chemicals and formation of microflocs.

* The mixers in the alum solutionising tanks should be put into regular operation for complete dissolution of alum slabs and to maintain a solution of uniform strength.

* The filter appurtenances such as rate setters, rate controllers and head loss indicators should be got repaired for effective operation and maintenance of the plant

* During scarcity periods, the feasibility of recycling filter backwash water after sedimentation can be explored. This also can improve the efficiency of settling and filtration by providing nucleii for the formation of flocs when raw water is difficult to coagulate.

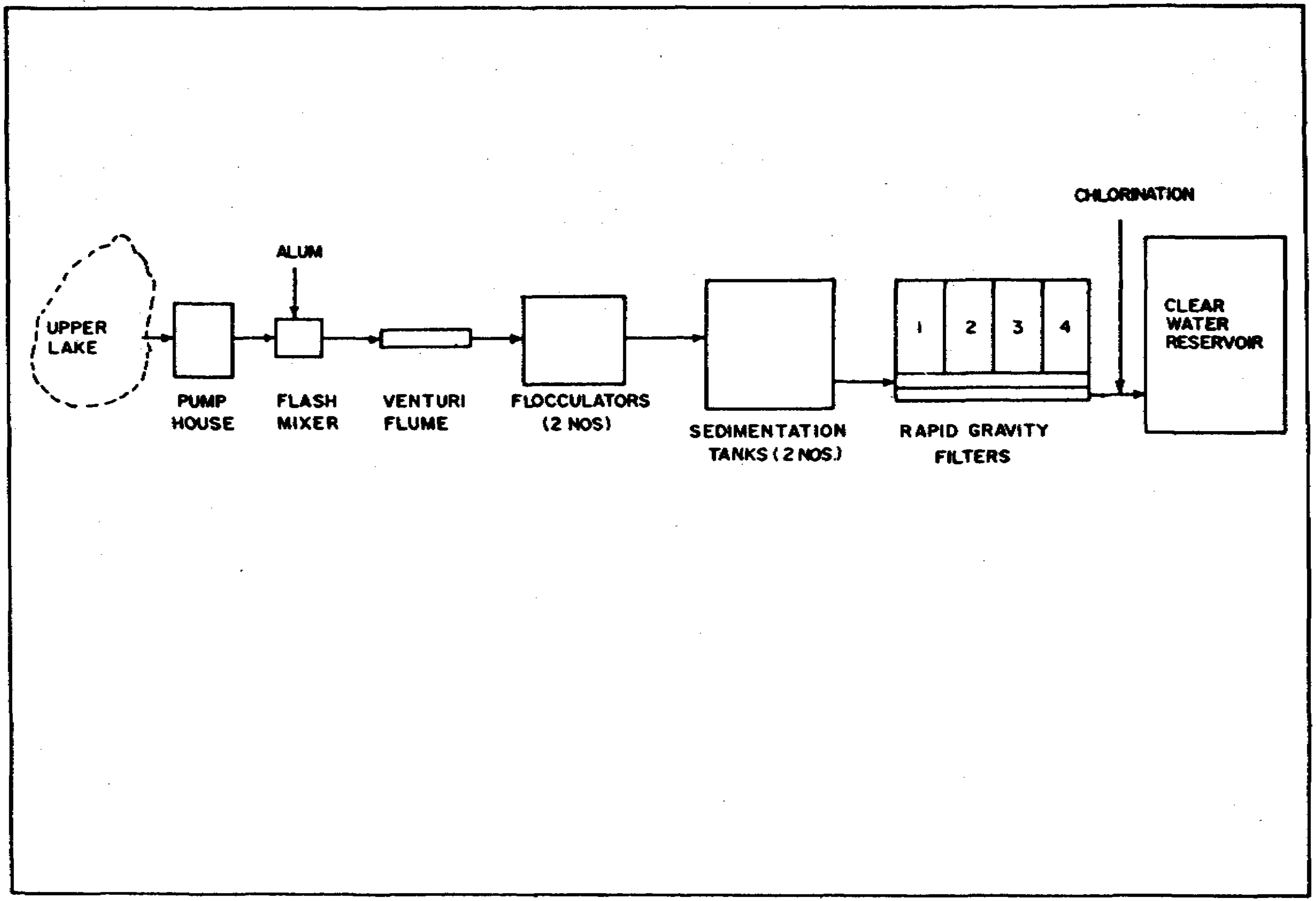


FIG 13.1 LAXMINARAYANGIRI WATER TREATMENT PLANT (SCHEMATIC) - BHOPAL

TABLE 13.1

PLANT SUMMARY DATA - BHOPAL

GENERAL

Name and location	: Laxminarayangiri water treatment plant (Bhopal)
Year of construction	: 1964
Design capacity	: 22.7 MLD
O & M Agency	: Public Health Engineering Department, Bhopal
Raw water source	: Upper Lake, Bhopal
Treatment flowsheet	: Conventional with rapid sand filters (with pre-chlorination)

ENGINEERING

Raw water pumping	: Centrifugal pumps-5 nos; 300 HP x 2 nos, 220 HP x 2 nos,200 HP (2 pumps connected in series),standby - 2 nos.
-Rising main diameter	: 530 mm
Raw water flow measurement	: Venturi flume

Pre-treatment

Coagulation

- Chemicals used	: Alum
- Method of mixing	: Mechanical (Jet type)
- Detention time	: 2 minutes

Flocculation

- Method / Type of unit	: Mechanical
- No. & size of unit(s)	: 2 nos,each 7.5 m x 7.5 m x 4.35 m SWD
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Rectangular, Horizontal flow
- No. & size of unit(s)	: 2 nos, each 30 m x 10.5 m x 3.3 m SWD
- Surface over flow rate	: 1.5 m/hr
- Detention time	: 2 hr 30 minutes

Filtration

- Type of unit(s)	: Rapid sand filters (open to sky)
- No. & size of unit(s)	: 4 nos,(twin beds), each 8.5 m x 7.6 m
- Rate of filtration	: 4.8 m/ hr
- Filter media	
. Depth of sand	: 0.75 m
. Gravel size & depth	: 4.5 mm - 0.076 m 15 mm - 0.076 m 25 mm - 0.15 m
- Backwash arrangements	
. Method	: Air scour, water wash
. Wash water tank cap.	: 227 m^3

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: Vacuum type

Clear Water Reservoir

- No. & Capacity	: 3 nos, each 6800 m^3
- Pump details	: By gravity

TABLE 13.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

LAXMINARAYANGIRI WATER TREATMENT PLANT - BHOPAL

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	5.0	1.5	19	2.0
pH	7.9	7.8	8.1	7.9
Total Alkalinity ($CaCO_3$)	89	92	66	49
Conductivity (µS/cm)	166	166	156	156
Hardness ($CaCO_3$)				
Total	95	90	55	55
Carbonate	89	90	55	49
Non Carbonate	6	0	0	6
Calcium (Ca)	34	34	15	14
Magnesium (Mg)	3	1	4	5
Chlorides (Cl)	3	7	6	12
Sulphates (SO_4)	1	1	N.D.	8
Iron (Fe)	0.2	0.2	0.8	N.D.
Fluoride (F)	0.1	0.1	0.2	0.1
Nitrates (NO_3)	5	4	7	3
Bacteriological (MPN/100 ML)				
Total coliform	93	0	1600	0
E.coli	23	0	1600	0
Fecal streptococci	7	0	6	0

All values except pH, Turbidity and Conductivity are expressed as mg/l

N.D. - Not detectable

TABLE 13.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

LAXMINARAYANGIRI WATER TREATMENT PLANT - BHOPAL

PARAMETERS	VISIT	RAW WATER	SETTLED WATER *	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	5.0	2.4	1.5	1.5
	II	19	8.0	2.0	2.0
T. Coliform (MPN/100 ML)	I	93	0	0	0
	II	1600	240	8	0
E. Coli MPN/100 ML	I	23	0	0	0
	II	1600	80	4	0

* Pre-chlorination is practised

LALPUR WATER TREATMENT PLANT - JABALPUR

INTRODUCTION

The water treatment plant at Lalpur (Jabalpur) was constructed in the year 1980 for a design population of 7,83,000 (1986) with river Narmada as the source of raw water. The plant located 8 km from Jabalpur city has a capacity of 42 mld and is maintained by PHED, Madhya Pradesh, which meets the salary of plant and laboratory staff and expenditure on operation and maintenance. However, the cost of power and chemicals, is met by the Jabalpur Municipal Corporation which also collects the water revenue. The treatment comprises chemical addition downstream of the Parshall flume in the raw water channel, flash mixing, flocculation and sedimentation in clariflocculators, rapid gravity filtration and chlorination. The schematic flow sheet is shown in Fig. 13.2 and the plant summary data is presented in Table 13.4. The plant is operated only for 16 hours/day because of inadequate storage capacity of overhead service reservoirs.

PLANT APPRAISAL

Raw water quality and flow measurement

The intake well on the river bank is provided with openings at different levels to facilitate drawal of water from different depths. The inlet ports are provided with screens to prevent entry of floating debris. The river water flows to a sump well through a tunnel of 1.5 m dia. and 185 m long. The problem of silt/sand entry into the sump has been reported during monsoon seasons. For periodic removal of silt/sand a grid of G.I. pipes fitted with nozzles and connected to an air compressor is laid in the tunnel and sump well. A bucket elevator with an endless chain and two pumps of 40 HP each are provided for the removal of silt/sand.

A bathing ghat known as Gwari ghat is located about 1 km upstream of the intake.

Raw water is pumped through 600 mm dia. C.I. rising main to the treatment plant located about 300 m away from the raw water sump. Adequate provision for standby pumps has been made.

A Parshall flume has been installed for raw water flow measurement. The float operated flow indicating device was in working condition but not the flow recorder and the integrator. Raw water inflow to the plant measured at site by lowering the water level in clariflocculator(s) and observing the rise in level for a known period of time, was found to be 39.2 mld thereby indicating that the plant was slightly underloaded. Physico-chemical quality parameters for raw and finished water (Table 13.5) are within the limits recommended by CPHEEO.

Pre-treatment

Alum and lime are used for coagulation. Lime addition is practised only during monsoon period and prior to alum addition. Lime and alum solution are conveyed in PVC pipes provided with C.I. sluice valves which are in good condition.

The strength of alum solution used and the dose of alum applied were reported much higher than actually found. The 5 % alum solution was found to be only of 1 % strength. Similarly the actual alum dose applied was only 16.4 mg/l as against the reported value of 39 mg/l. Provision has been made to store adequate quantity of chemicals. All chemicals like alum, lime and bleaching powder/chlorine are supplied by Municipal Corporation on requisition from PHED. The alum and lime dosing facilities were found in good working condition with the exception of a mixing paddle in one of the alum solutionising tanks. Flash mixing was found to be effective.

Mechanical gadgets such as flocculator paddles, sludge scraper bridge were found in working order. The sludge bleeding is done continuously. Performance of clariflocculator as observed from the settled water turbidity (3.5 NTU) was found to be satisfactory (Table 13.6). It was reported by the plant chemist that during fair season when the raw water turbidity is low and colloidal in nature, it is difficult to coagulate and that retention of a part of the sludge for longer period in the flocculator improves the efficiency of flocculation and sedimentation. This was also confirmed by actual laboratory tests.

Filtration

The rapid sand filters are open to sky and operated at a normal filtration rate of 4.5 m/hr. The filter appurtenances such as rate setters, rate controllers and headloss indicators of all the filters were not in working condition. The filtered water turbidity from all the filters was less than 1 NTU (Table 13.6).

Filters are backwashed once in 32 hrs with air scour (3-4 minutes) followed by water wash (5-6 minutes). The filters were in good condition and free from mud ball formation. The depth of sand in all the filters was found to be 70-75 cms with an E.S of 0.68 mm and U.C of 1.40. The sludge from the claifiers and filter backwash water are discharged into a Nullah which ultimately joins the river.

Disinfection

Chlorine gas is used for disinfection. As the chlorinator was not in working order, chlorine gas is fed into the filtered water channel leading to the clear water reservoir. The dose is fixed by trial and error by testing for the residual chlorine in the clear water reservoir outlet. The chlorine gas was found leaking, resulting in the corrosion of filter appurtenances. The contact period provided is 30 minutes. The finished water had a residual chlorine of 1.0 mg/l and was found free from coliforms.

Laboratory facilities

A small laboratory headed by a qualified chemist has been provided at the plant with necessary facilities and equipment like jar test machine, Aplab turbidimeter, microscope, chemical balance and necessary chemicals. None of the filter operators had undergone any formal training. Record keeping with respect to plant operation was most unsatisfactory and no log books were maintained.

RECOMMENDATIONS

* The raw water flow recorder and integrator should be repaired and reinstalled.

* The filter appurtenances such as rate setters, rate controllers, headloss gauges need to be repaired for effective operation and maintenance of the filters.

* The practice of direct application of chlorine gas in uncontrolled manner at the filtered water channel should be discontinued and measures be taken for repairing the chlorinator.

* The use of Aplab Turbidimeter should be discontinued and a new one which works on Nephelometric principle may be procured. Laboratory facilities at the plant should be augmented with pH meter, turbidimeter, magnetic stirrer etc. for effective control of treatment processes.

* The chemist and other operating staff be trained for proper operation, maintenance and control of the plant.

* Proper records for operation and maintenance of the plant should be maintained.

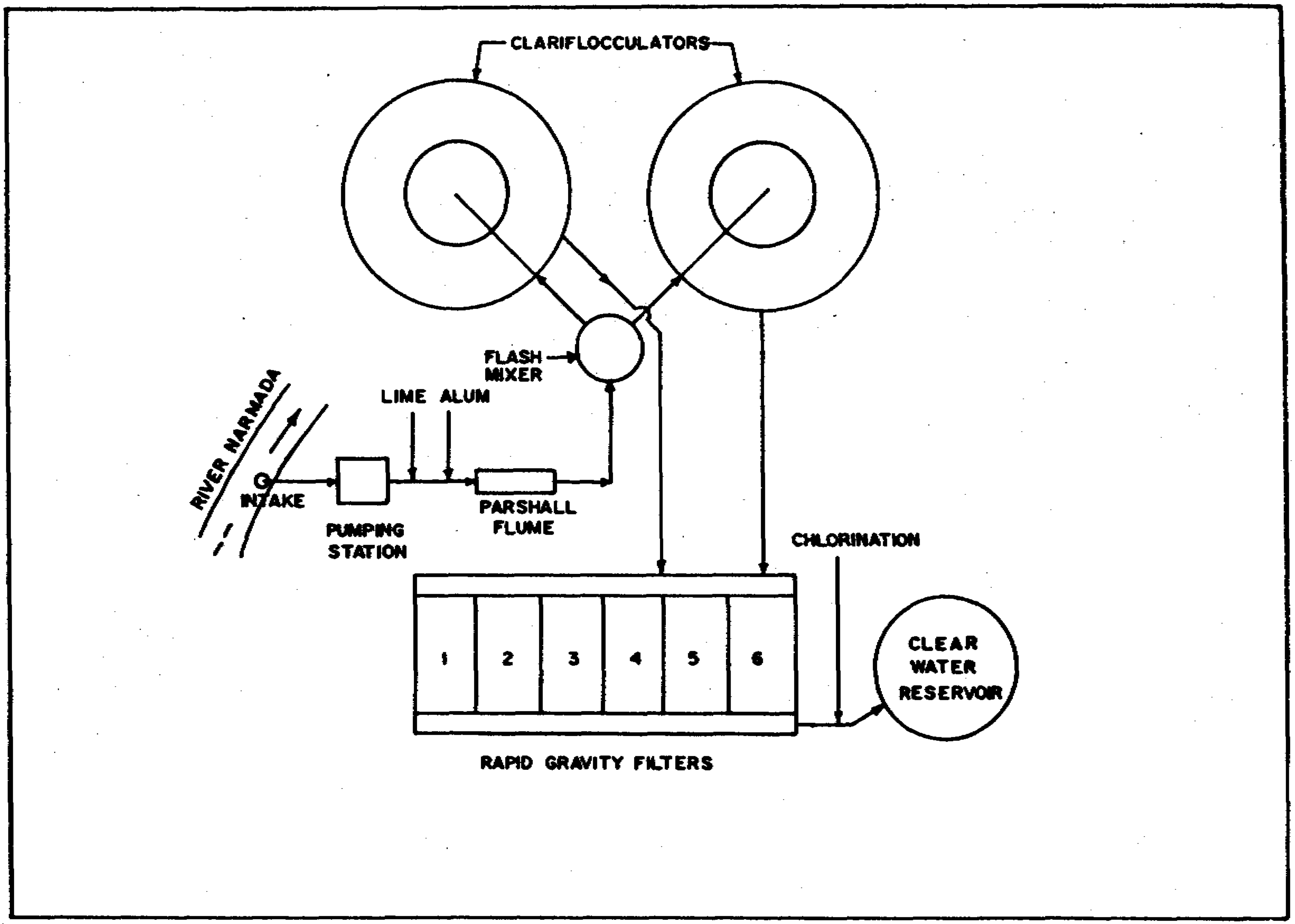


FIG 13.2 LALPUR WATER TREATMENT PLANT (SCHEMATIC) - JABALPUR

TABLE 13.4

PLANT SUMMARY DATA - JABALPUR

GENERAL	
Name and location	: Lalpur Water Treatment Plant, Jabalpur (M.P.)
Year of construction	: 1983
Design capacity	: 42 mld
O & M Agency	: Public Health Engineering Department, Jabalpur
Raw water source	: River Narmada
Treatment flowsheet	: Conventional with rapid gravity filters
ENGINEERING	
Raw water pumping	: Vertical turbine pumps 220 HP x 4 Nos, each 4.5 mgd standby 2 nos.
-Rising main diameter	: 600 mm
Raw water flow measurement	: Parshall flume
Pre-treatment	
Coagulation	
- Chemicals used	: Lime, Alum
- Type of mixing	: Mechanical
- Detention time	: 30 sec
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: 2 Nos, each 13.0 m dia x 3.15 m SWD
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Circular
- No. & size of unit(s)	: 2 Nos, each 19.85 m x 3.15 m SWD
- Surface overflow rate	: 1.25 m/hr
- Detention time	: 2 hr 30 min.

Filtration

- Type of unit(s)	: Rapid Sand Filters
- No. & size of unit(s)	: 6 Nos (twin beds) each 7.75 m x 8.92 m (open to sky)
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S-16/30 mesh(mm),U.C- 1.1 to 1.3
Depth of sand	: 0.68 m
. Gravel size & depth	: 57 x 37 mm - 75 mm 37 x 12 mm - 75 mm 12 x 6 mm - 75 mm 6 x 2.5mm - 150 mm
- Backwash arrangements	
. Method	: Air scour and water wash
. Washwater tank cap.	: 720 m^3

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: Pressure type

Clear Water Reservoir

- Type, No. & Capacity	: Circular
- Pump details	: Vertical turbine pumps 220 HP x 6 Nos (3 are standby)

TABLE 13.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

LALPUR WATER TREATMENT PLANT - JABALPUR

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	15	1.0	15	1.0
pH	7.8	7.5	8.4	7.5
Total Alkalinity ($CaCO_3$)	142	125	105	91
Conductivity (µS/cm)	290	290	160	165
Hardness(CaCO3) Total	130	130	86	86
Carbonate	130	125	86	86
Non Carbonate	0	5	0	0
Calcium (Ca)	32	32	23	23
Magnesium (Mg)	12	12	7	7
Chlorides (Cl)	4	6	3	6
Sulphates(SO_4)	Tr	15	1	7
Iron (Fe)	2.2	0.3	0.3	Tr
Fluoride (F)	0.2	0.2	0.2	0.2
Nitrates (NO_3)	2	2	1	2
Bacteriological (MPN/100ml)				
Total coliform	500	0	500	0
E.coli	8	0	27	0
Fecal streptococci	500	0	170	0

All values except pH,Turbidity and Conductivity are expressed as mg/l Tr- Traces

TABLE 13.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

LALPUR WATER TREATMENT PLANT - JABALPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	15	3.5	1.0	1.0
	II	15	3.5	1.0	1.0
T.Coliform (MPN/100ml)	I	500	27	8	0
	II	500	80	23	0
E.Coli (MPN/100ml)	I	8	4	0	0
	II	27	80	17	0

PHEROLE WATER WORKS - AURANGABAD

INTRODUCTION

The city of Aurangabad receives its water supply from Pherole water works located at village Pherole, 18 Km away from Aurangabad city. It serves a population of about 4 lakh persons. The plant with 27.6 mld capacity was commissioned in the year 1976 and has been augmented in the year 1984 with a 28 mld conventional water treatment plant. The total capacity of the plant is 55.6 mld. It receives raw water from Jayakwadi dam constructed across river Godavari. The treatment comprises aeration, pre-treatment with chemical coagulation followed by rapid sand filtration and post-chlorination. The schematic flow sheet is shown in Fig.14.1 and the plant summary data is presented in Table 14.1. The plant is operated and maintained by MWSSB.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Jayakwadi dam is pumped in two stages-first to a reservoir at village Dhorkin and then to Pherole water treatment plant. No potential source of pollution is observed near the intake which is provided with fixed screens to remove floating debris. Though adequate supply of raw water is available all through the year, contrary to expectations, the turbidity in raw water during summer is higher than that in winter. This is due to the shallow water depth and high wind velocities during summer resulting in the stirring up and suspension of bottom sediments near the intake. Algal growth was also observed in the impounded reservoir. Raw water quality was found to be fairly good (Table 14.2). The flow indicator and recorder installed at the plant are in working condition.

Pre-treatment

Raw water was pre-chlorinated using bleaching powder. Proper dosing of alum and bleaching powder was observed and floc formation in the flocculator was satisfactory. However, the clarifier scraper bridge was not found in working condition leading to problems in desludging.

Filtration

The filters were operated and maintained well. The filter rate controller and other appurtenances were all in good working condition. The filter performance was satisfactory and the filtrate quality was meeting the standards prescribed by CPHEEO. The overall performance of the various units was satisfactory.

Disinfection

Disinfection of filtered water is achieved using chlorine gas. Though a chlorination room has been provided, the chlorine cylinder was kept outside the room in the open. Residual chlorine was found to be in the range of 1.6 to 2.0 mg/l in the finished water.

Laboratory facilities

The water works is provided with essential laboratory facilities which include Aplab turbidimeter, chemical balance and residual chlorine comparator. Fortnightly water samples are sent to the state Public Health Laboratory at Aurangabad for physico-chemical and bacteriological analysis.

RECOMMENDATIONS

* The travelling bridge with sludge scraper arm should be put into working condition so as to facilitate efffective desludging of the clarifier and ensure its good performance.

* Formal training of the plant operators would help enhance their skill level leading to better performance of the plant.

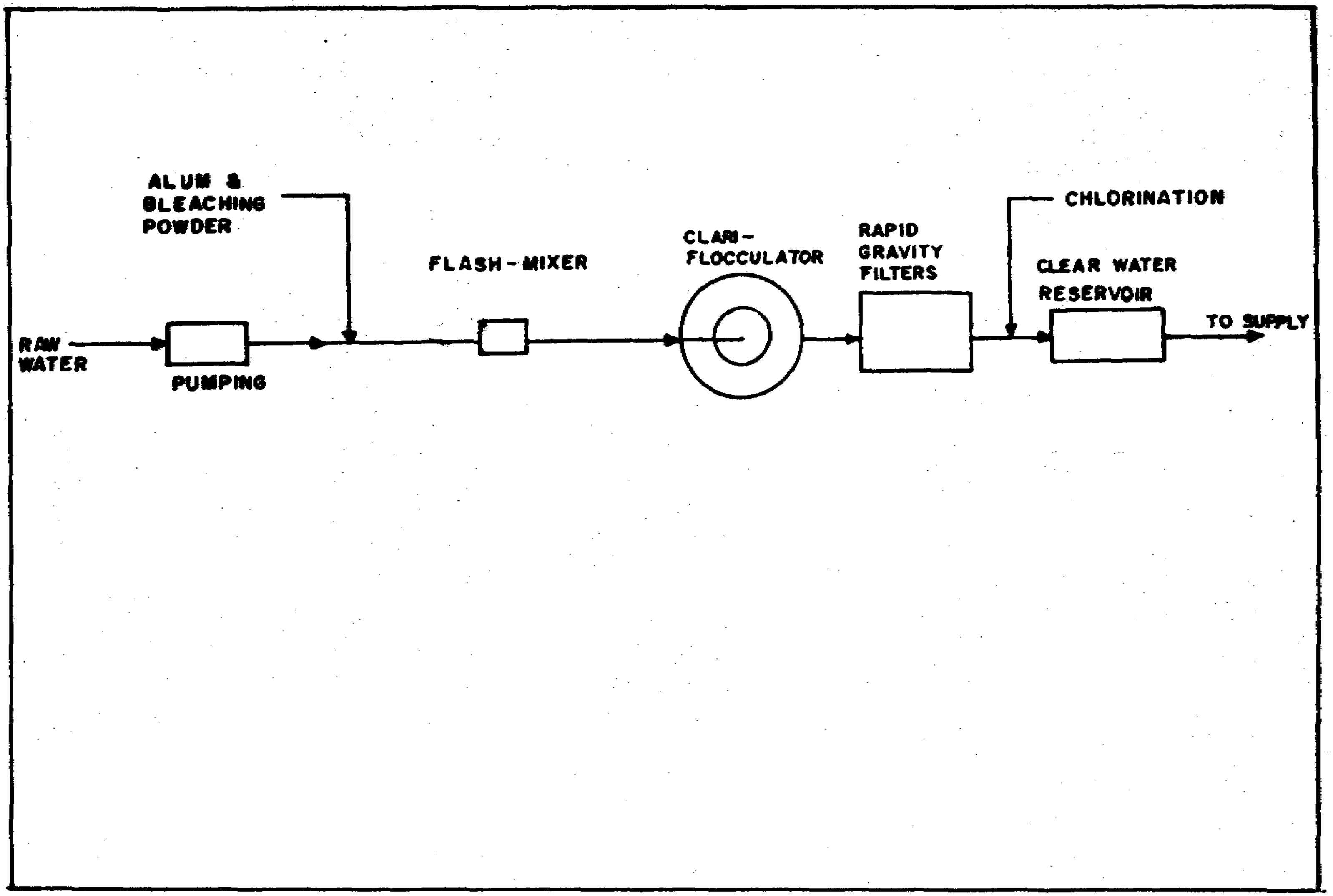


FIG 14.1 PHAROLE TREATMENT PLANT (SCHEMATIC), AURANGABAD

TABLE 14.1

PLANT SUMMARY DATA - AURANGABAD

GENERAL		
Name and location	:	Pherole Water Works, Aurangabad
Year of construction (Augmentation if any)	:	1976,(Augmentation in 1982)
Design capacity	:	55.6 mld
O & M Agency	:	Maharashtra Water Supply & Sewerage Board
Treatment flowsheet	:	Conventional with rapid gravity filters and prechlorination
ENGINEERING		
Raw water pumping	:	4 Nos., Vertical turbine, 400 HP, of which one is standby
- Rising main diameter	:	700 mm
Raw water flow measurement	:	Flow recorder provided.
Pre-treatment		
Aeration	:	Cascade type
Coagulation		
- Chemical used	:	Alum
- Method of Mixing	:	Mechanical
- Detention time	:	45 Sec
Flocculation		
- Method / Type of units	:	Mechanical(clariflocculators)
- No. & size of units	:	2 Nos., 12.8 m dia. each
- Detention time	:	30 minutes

Sedimentation

- Type of unit(s)	:	Circular clarifiers
- No. and size of unit(s)	:	2 Nos,36 m dia each and 4.5 m SWD
- Surface overflow rate	:	1.3 m/hr
- Detention time	:	3 hrs

Filtration

- Type of unit(s)	:	Rapid gravity filters
- No. & size of unit(s)	:	10 Nos, 11.25 m x 4 m each
- Rate of filtration	:	5 m/hr

Filter media

. Sand size	:	E.S.- 0.6 mm, U.C.- 1.5
. Gravel size	:	4.5 - 7.5 mm

Backwash arrangements

. Method	:	Air scour + water wash
. Washwater tank cap.	:	500 m^3

Disinfection

- Chemicals used	:	Chlorine gas/bleaching powder
- Type of feed	:	Solution feed
- Chlorinator Details	:	Pressure type
- Clear water Reservoir		
- No. & capacity	:	2 Nos of 1175 m^3 capacity each
- Pump details	:	3 Pumps, Centrifugal type, 475 HP

TABLE 14.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

PHEROLE WATER WORKS - AURANGABAD

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity(NTU)	6	0.5	27	0.8	27	0.7
pH	8.5	8.3	7.7	7.8	7.8	7.6
Total Alkalinity ($CaCO_3$)	110	110	120	120	130	130
Hardness ($CaCO_3$)						
Total	126	126	152	152	140	140
Carbonate	110	110	120	120	130	130
Non Carbonate	16	16	32	32	10	10
Calcium (Ca)	24	24	27	27	20	20
Magnesium (Mg)	16	16	20	20	22	22
Chlorides (Cl)	72	70	80	80	60	60
Sulphates (SO_4)	9	9	15	25	22	37
Iron (Fe)	0.3	-	0.1	-	0.5	-
Nitrates (NO_3)	Tr	Tr	Tr	Tr	Tr	Tr
Bacteriological (MPN/100 ML)						
Total coliform	-	-	15000	0	240	0
Fecal coliform	-	-	390	0	93	0
E.coli	-	-	-	-	9	0
Fecal streptococci	-	-	93	0	9	0

All values except pH and turbidity are expressed as mg/l
Tr - Traces

TABLE 14.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

PHEROLE WATER WORKS - AURANGABAD

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	6	4	-	0.5
	II	25	16	-	0.8
	III	27	7.5	-	0.7
T.Coliform (MPN/100 ML)	I	-	-	-	-
	II	15000	2400	240	0
	III	240	43	9	0
E.Coli (MPN/100 ML)	I	-	-	-	-
	II	-	-	-	-
	III	9	0	0	0

BAWDA WATER WORKS - KOLHAPUR

INTRODUCTION

The city of Kolhapur with a population of 3.4 lakhs (1981 census) draws its water supply from the river Panchaganga. The river water is treated at Bawda water works, situated about 4 km away from the city. The plant with a design capacity of 43 mld has been commissioned in the year 1978 and provides for pre-chlorination, followed by conventional treatment with rapid sand filtration and post-chlorination. The schematic flow sheet is shown in Fig 14.2 and the plant summary data is presented in Table 14.4.

PLANT APPRAISAL

Raw water quality and flow measurement

The raw water intake foı the water works is located upstream of a weir across the river constructed by the Irrigation Department. The intake well has been provided with fixed screens at three different levels to prevent entry of floating matter. Considerable human activity by way of bathing and washing is observed near the intake. The turbidity of raw water is reported to be very high during monsoon. A turbidity of 1500 NTU was observed during one of the visits. While the chemical parameters of raw water quality are within the limits prescribed by CPHEEO, the bacteriological analysis indicates high degree of pollution (Table 14.5).

The raw water flow indicator and recorder installed at the Parshall flume were not in working condition.

Pretreatment

Alum and bleaching powder are dosed at The flow measuring flume. The flash mixer installed at the plant was not working. The mechanical flocculators and the travelling bridge with sludge scrapers were also non-functional.

Filtration

Deep cracks, surface undulation and mudball formation were observed in the filters indicating ineffective backwashing and poor maintenance. Loss of head gauges and rate controllers were out of order and the filters were backwashed once in 24 hrs as a matter of routine. The E.S. of sand was observed to be much larger than the reported value indicating heavy coating of sand grains. The physico-chemical and bacteriological quality of filtrate was within the recommended limits of CPHEEO (Table 14.6).

Disinfection

Chlorine gas was directly bubbled into the clear water channel resulting in ineffective diffusion and corrosion of metal fixtures. A high residual chlorine was observed in the finished water. A new chlorination house with all safety measures is under construction.

Laboratory Facilities

The plant laboratory is equipped with turbidimeter (Aplab), residual chlorine test kit, weighing balance, glassware and reagents. While Jar test apparatus, pH meter etc. are not available. No chemist is posted at the plant and the water samples are sent to the state Public Health laboratory for analysis.

RECOMMENDATIONS

* The pollution of raw water due to human activities near the intake should be prevented/controlled

* Flow measuring devices, mechanical sludge scrapers of the clarifiers, loss of head gauges in the filters need to be repaired and kept in working condition

* Backwashing of the filters needs substantial improvement in order to avoid mud ball formation and filter cracks.

* Additional laboratory facilities should be provided and competent staff posted for effective monitoring and control of unit operations

* Formal training should be arranged for the plant staff to ensure better operation and maintenance of the plant.

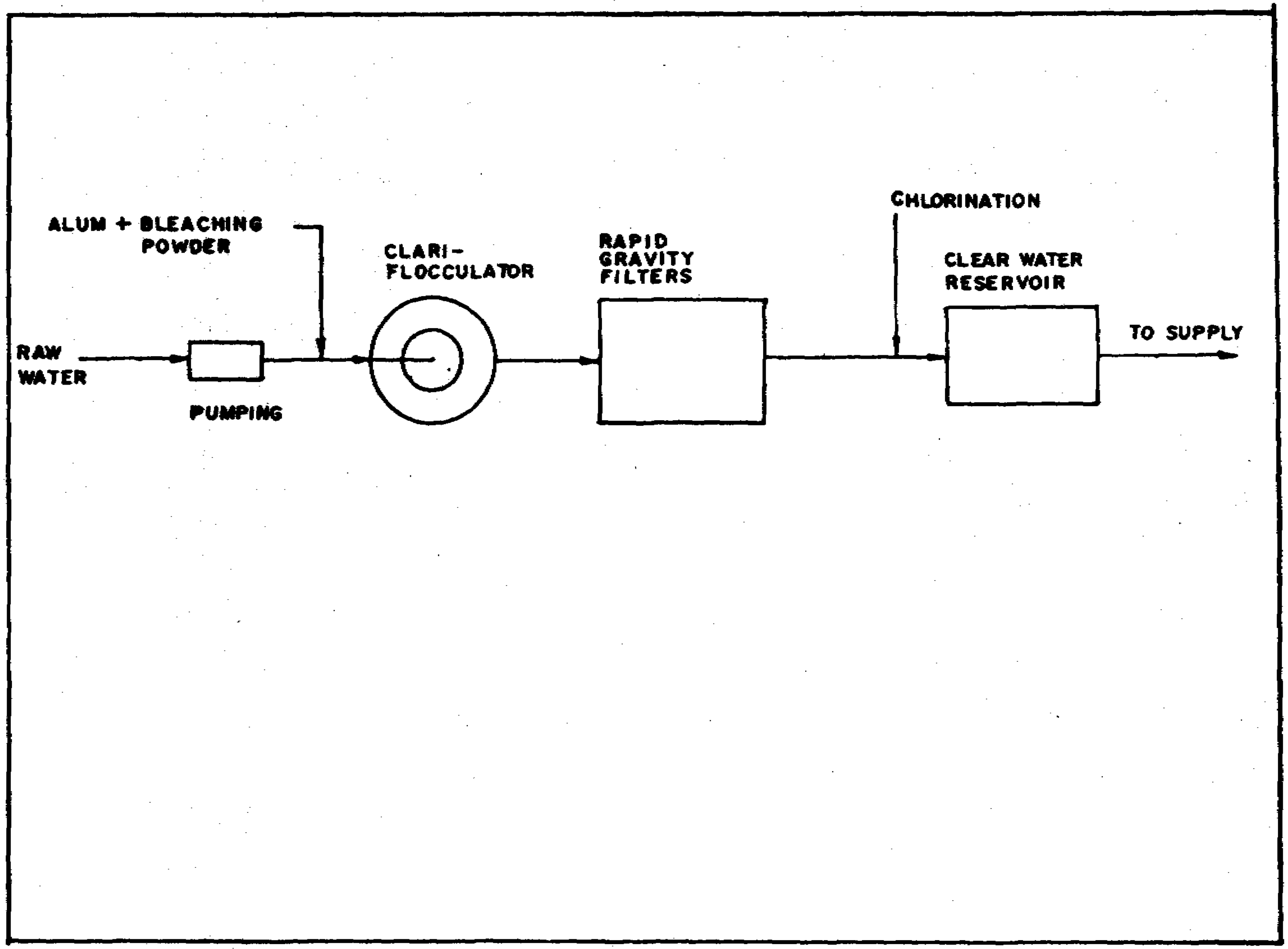


FIG 14.2 BAWDA WATER TREATMENT PLANT (SCHEMATIC), KOLHAPUR

TABLE 14.4

PLANT SUMMARY DATA - KOLHAPUR

GENERAL	
Name & Location	: Bawda water works, Kolhapur.
Year of construction	: 1978
Design Capacity	: 43 mld.
O & M Agency	: Maharashtra Water Supply and Sewerage Board
Raw water source	: River Panchaganga
Treatment flow sheet	: Pre-chlorination and Conventional treatment with rapid gravity filters
ENGINEERING	
Raw water Pumping	: 3 Nos., Vertical turbine, 250 HP,10.8 lakh lph capacity of which one is a standby
- Rising main Diameter	: 750 mm
Raw water flow measurement	: Parshall flume
Pre-treatment	
Aeration	: Cascade type
Coagulation	
- Chemicals used	: Alum, bleaching powder
- Type of mixing	: Mechanical
- Method of mixing	: Flash mixer, 3 m dia.
Flocculation	
- Method /type of unit	: Mechanical(clariflocculator)
- No. & size of unit(s)	: 2 Nos., 11.52 m dia. each
- Detention time	: 30 minutes

Sedimentation

- Type of unit	:	Circular clarifier
- No. & size of units	:	2 Nos., 32.92 m dia.each
- Surface overflow rate	:	1.22 m/hr
- Detention time	:	2 hrs 30 min.
Filtration		
- Type of unit(s)	:	Rapid gravity filters
- No. & size of unit(s)	:	4 Nos.; 94 m^2 area each
- Rate of filtration	:	5 m/hr
Filter media details		
. Sand size	:	E.S. - 0.55 to 0.6 mm U.C. - 1.55
. Depth of sand	:	64 cm
. Gravel size (mm)	:	38-50, 13-38, 6-13, 3-6
. Depth of each layer(cm)	:	7.6, 7.6, 10, 10
- Backwash arrangements		
. Method	:	Air scour + water wash
. Washwater tank cap.	:	227 m^3
Disinfection		
- Chemicals used	:	Chlorine gas
- Type of feed	:	Solution feed
- Chlorinator Details	:	3 No., Vacuum type
- Contact period	:	1 hour
Clear Water reservoir		
- Type, & capicity	:	Masonary of 2500 m^3
- Clear Water Pumping	:	2 Pumps., Centrifugal,325 H.P.

TABLE 14.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

BAWDA WATER WORKS PLANT - KOLHAPUR

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity(NTU)	12	1	30	5	1500	7.5
pH	8.2	8.0	7.4	7.7	7.6	7.1
Total Alkalinity ($CaCO_3$)	40	38	30	30	28	28
Hardness ($CaCO_3$)						
Total	52	52	50	50	50	50
Carbonate	40	38	30	30	28	28
Non Carbonate	12	14	20	20	22	22
Calcium (Ca)	11	11	17	17	14	14
Magnesium (Mg)	6	6	2	2	3	3
Chlorides (Cl)	28	28	16	16	26	26
Sulphates (SO_4)	Tr	Tr	10	6	2	2
Iron (Fe)	0.2	-	0.5	-	0.7	-
Nitrates (NO_3)	1.1	-	1.4	-	4.4	-
Bacteriological (MPN/100 ML)						
Total coliform	46000	Nil	46000	Nil	1.1x106	Nil
Fecal coliform	460	Nil	93	Nil	150	Nil
E.coli	-	-	23	Nil	11	Nil
Fecal streptococci	28	Nil	28	Nil	93	Nil

All values except pH and turbidity are expressed as mg/l

TABLE 14.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

BAWDA WATER WORKS PLANT - KOLHAPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	12	9	-	1
	II	30	20	-	5
	III	1500	60	-	7.5
T.Coliform (MPN/100 ML)	I	46000	150	Nil	Nil
	II	46000	150	21	Nil
	III	1.1x106	93	9	Nil
E.Coli (MPN/100 ML)	I	-	-	-	-
	II	23	Nil	Nil	Nil
	III	11	Nil	Nil	Nil

KANHAN WATER WORKS - NAGPUR

INTRODUCTION

Nagpur city, with an estimated (1986) population of 15 lakhs draws its water supply from three major sources viz. Pench canal (113.5 mld), river Kanhan (127 mld) and Gorewada lake (13.5 mld). In addition, Wunna water works, receiving raw water from Wunna irrigation canal supplies about 32 mld of treated water to the defence establishments and nearby villages.

The water works at Kanhan operated and maintained by the Nagpur Municipal Corporation has been selected for evaluation. The conventional treatment plant commissioned in the year 1942 was subsequently augmented to meet the increasing water needs of the city. The water works consists of two streams : (i) the old plant with a design capacity of 59 mld and (ii) the new plant with a design capacity of 68 mld. The new plant was evaluated for its performance. The schematic flow sheet is shown in Fig.14.3 and the plant summary data is given in Table 14.7.

PLANT APPRAISAL

Raw water quality and flow measurement

Adequate flow in the river is available to meet the needs throughout the year. However, in recent years the flow regime in summer gets shifted away from the intake wells. Temporary bunds of sand bags are erected every year to divert the flow to the intake wells. The river upstream is polluted occasionally due to disposal of fly ash from Koradi thermal power plant causing problems in treatment-high coagulant dose, short filter runs, coating of sand grains by oily substances etc.

For major part of the year, the physico-chemical quality of raw water is fairly uniform with a turbidity of less than 25 NTU (Table 14.8). During monsoon, the turbidity of river water goes very high (upto 1200 NTU) and considerable amount of sand and silt is drawn into the intake well causing problems in raw water pumping. During peak monsoon, heavy silt load from raw water is carried right upto the clarifiers, rendering the sludge scraper mechanism inoperative.

The raw water flow indicator provided near the aerator was not functioning and the rectangular flow measuring weir was in damaged condition. Actual flow measurements (by lowering the water level in the clariflocculator and noting the time taken to refill) indicated that the plant was underloaded to the extent of 37 to 52 per cent.

Pre-treatment

Filter alum is used as the coagulant. The mixing paddles in the alum solutionising tanks and the flash mixer were not functioning. During rainy season, alum slabs were added at the aerator to supplement the alum dose.

During one of the visits the actual alum dose applied to the raw water with a turbidity of 22 NTU was found to be 36 mg/l as against the reported value of 55 mg/l. The jar test dose to obtain a residual turbidity of less than 5 NTU, was found to be 20 mg/l, while the dose applied was much higher.

As the plant was underloaded, the detention time in the clarifier was much higher (6 hr 20 min to 8 hr) as against the design value of 3 hr. The SOR was in range of 0.56 - 0.71 m/hr as compared to the design value of 1.0 m/hr. The travelling bridge with sludge scraper mechanism was found working in only one of the two clariflocculators. The turbidity of settled water, however, was within the limits recommended by CPHEEO (Table 14.9).

Filtration

The filters were underloaded and the rate of filtration was 2.88 to 3.64 m/hr as against the design rate of 6.4 m/hr. The filter appurtenances such as rate controllers, rate of flow indicators and head loss gauges of all the filters were not in working condition. The sand used in the filters had an E.S of 0.7 mm and U.C of 1.3.

The filters were backwashed once in 24 hrs irrespective of the head loss or filtrate turbidity. The filters were maintained clean and no cracks or undulations were observed on the sand bed and the turbidity of finished water was within the limits prescribed by CPHEEO (Table 14.9)

Disinfection

During one of the visits the gas chlorinators were in operation; however, during the next visit, the chlorinators were under repair and direct feeding of chlorine gas was practised. The finished water had a residual chlorine of 1.2 mg/l and was free from coliforms.

Laboratory facilities

A well equipped laboratory has been provided at the plant for complete physico-chemical and bacteriological analysis. Turbidity and residual chlorine measurements are done regularly. A qualified chemist with supporting staff has been posted at the laboratory.

RECOMMENDATIONS

* Necessary steps should be taken to prevent occurence of pollution due to fly ash disposal from the thermal power plant upstream.

* Optimum alum dose as determined by jar test should be applied for effective coagulation, flocculation. The practice of dumping of alum slabs in raw water channel should be dispensed with.

* All mechanical gadgets in clariflocculators and filters should be got repaired and kept in good working condition for effective plant operation and control.

* The plant operators should be deputed for formal training courses to update their knowledge and skills. This will help improve the overall functioning of the plant.

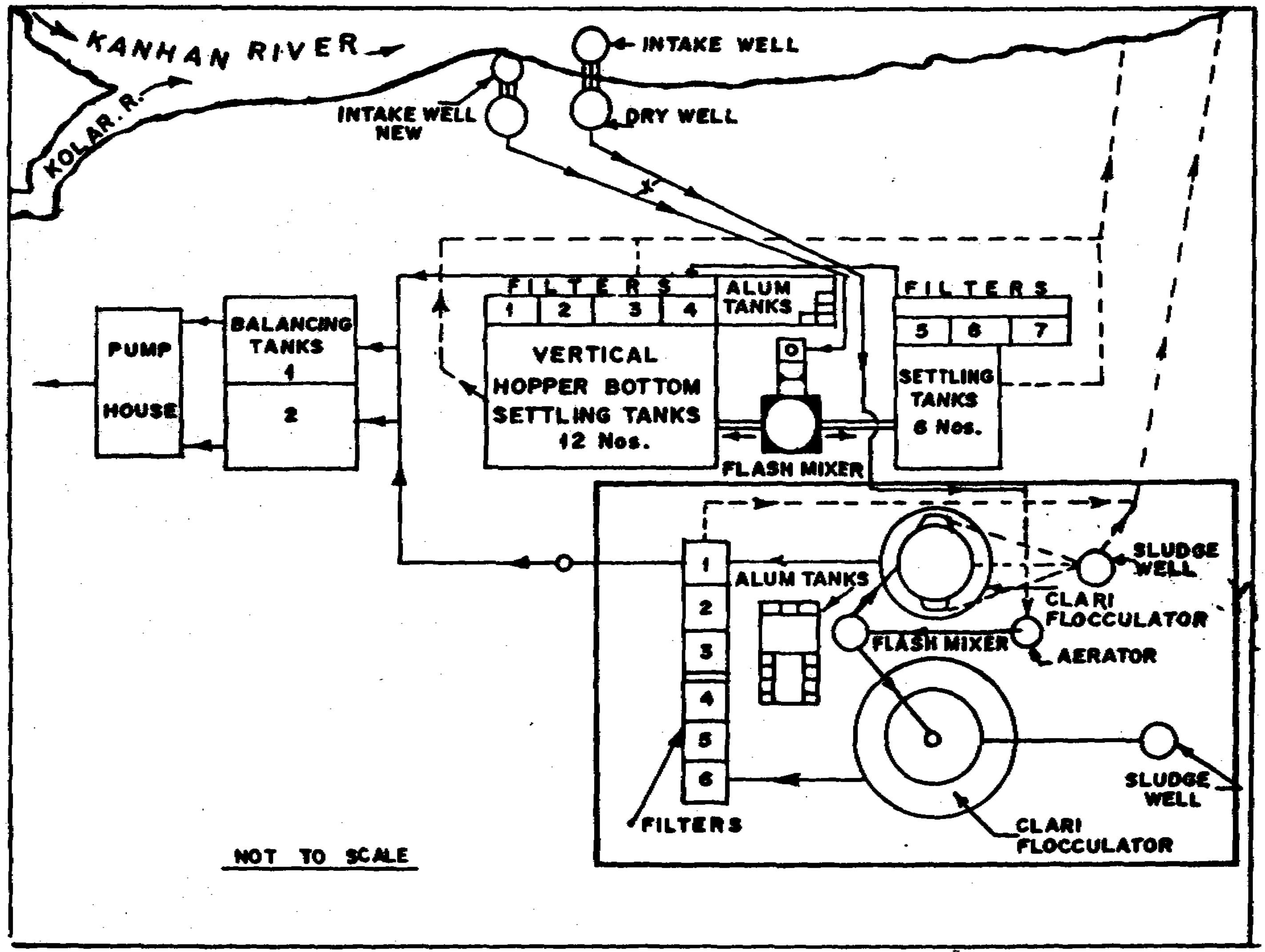


FIG 14.3 LAYOUT PLAN OF KANHAN WATER WORKS, NAGPUR

TABLE 14.7

PLANT SUMMARY DATA - NAGPUR

GENERAL	
Name and location	: Kanhan Water Works, Nagpur Maharashtra
Year of construction (Augmentation if any)	: 1965 (Augmented in 1971)
Design capacity	: 68.2 mld
O & M Agency	: Municipal Corporation of Nagpur
Raw water source	: River Kanhan
Treatment flowsheet	: Conventional with rapid sand filters
ENGINEERING	
Raw water pumping	: 3 Pumps of Horizontal Centrifugal, 1 pump of Vertical Centrifugal, of which 2 are standby
-Rising main diameter	: 690 mm
Raw water flow measurement	: A Rectangular weir & Mahindra Electroflow Float operated indicator
Pre-treatment	
Aeration	: Cascade aerator of 3.0 m dia
Coagulation	
- Chemicals used	: Alum solution
- Type of mixing	: Mechanical
- Method of mixing	: Flash mixer of 4.5 m dia with detention time of 2 minutes & 25 rpm speed.
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Size	: 2 Nos. (i) 13.4 m dia x 4.5 m SWD (ii) 16.8 m dia x 4.5 m SWD
- Detention time	: 34 minutes

Sedimentation

- Type of unit(s)	: Circular clarifiers
- No. & size of unit(s)	: 2 Nos. (i) 33.5 m dia x 4.5 m SWD (ii) 47.2 m dia x 4.5 m SWD
- Surface overflow rate	: 1 m/hr
- Detention time	: 3 hr

Filtration

- Type of unit(s)	: Rapid gravity
- No. & size of unit(s)	: 6 Nos.(twin bed) 9.7 m x 7.6 m each
- Rate of filtration	: 6.4 m/hr
- Filter media	
. Sand size & depth	: E.S - 0.7 mm, U.C. - 1.3, 60 cm depth
. Gravel size (mm)	: 50-37, 37-12, 12-6, 6-2.5
. Depth of each layer	: 10, 10, 10, 15 (cm)
- Backwash arrangement	
. Method	: Air scour + water wash
. Washwater tank cap.	: 1818 m^3

Disinfection

- Chemicals used	: Chlorine gas & Bl.powder in emergency
- Type of feed	: Solution feed
- Chlorinator Details	: Two Nos. Vacuum & Pressure type
- Contact period	: 30 minutes

Clear Water Reservoir

- Type, No. & Capacity	: Cement concrete, 3 Nos, 2 of 567 m^3 cap each and 1 of 1816 m^3 capacity

TABLE 14.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

KANHAN WATER WORKS - NAGPUR

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity(NTU)	17.0	0.5	22	1.0	210	0.9
pH	8.4	8.3	8.4	7.8	8.4	7.9
Total Alkalinity ($CaCO_3$)	163	158	164	152	189	176
Conductivity ($\mu S/cm$)	400	460	520	600	640	700
Hardness($CaCO_3$) Total	140	152	153	152	158	154
Carbonate	148	152	153	152	158	154
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	39	38	37	36	39	38
Magnesium (Mg)	12	14	15	15	15	14
Chlorides (Cl)	17	33	35	51	38	44
Sulphates (SO_4)	13	20	24	41	15	38
Iron (Fe)	0.2	ND	1.9	ND	0.2	ND
Fluoride (F)	0.4	0.7	0.8	1.1	0.8	0.6
Nitrates (NO_3)	Tr	Tr	Tr	Tr	Tr	Tr
Bacteriological (MPN/100 ML)						
Total coliform	9	0	240	0	540	0
E.coli	4	0	80	0	170	0
Fecal streptococci	21	0	50	0	170	0

All values except pH,turbidity and conductivity are expressed as mg/l

TABLE 14.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

KANHAN WATER WORKS - NAGPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	17	8	0.6	0.5
	II	22	10	1.1	1.0
	III	210	12	1.0	0.9
T. Coliform (MPN/100 ML)	I	9	27	30	0
	II	240	-	70	0
	III	540	350	49	0
E. Coli (MPN/100ML)	I	4	4	17	0
	II	80	-	23	0
	III	170	240	33	0

CANTONMENT WATER WORKS - PUNE

INTRODUCTION

The Cantonment water works Pune is a very old plant constructed in 1885 with slow sand filters. Subsequently, it was augmented by replacing slow sand filters with rapid gravity filter plants to the present capacity of 101 mld meeting the needs of about 5 lakh people. The source of raw water is the Right Bank canal fed from Khadakwasala dam constructed across the Mutha river. The plant provides for conventional treatment with rapid gravity filters. The treatment flow sheet is shown in Fig.14.4 and plant summary data is presented in Table 14.10. The plant is maintained by MWSSB.

PLANT APPRAISAL

Raw water quality and flow measurement

Due to natural impoundment at Khadakwasala dam and regular maintenance of the canal by the Irrigation Department, the raw water has a low turbidity. During monsoon visit a turbidity of 70 NTU was recorded. Adequate supply of raw water is available throughout the year to meet the needs. However, the canal water is subjected to pollution due to public use. The screens provided at the canal intake are damaged due to corrosion. The raw water flow recorder was found to be in working order, though its reliability was in doubt. The physico-chemical quality of raw water is fairly good (Table 14.11).

Pre-treatment

Facilities for controlled dosing and mixing of chemicals were found inadequate. Also the strength of alum solution was found to vary considerably. The alum dosed raw water was flowing through rectangular settling tanks without proper flocculation. The flow division between the tanks was also not equal. Reduction in turbidity due to sedimentation was not significant (Table 14.12). In the absence of mechanical sludge scraper arrangement the rectangular settling tanks were desludged once a year after emptying the tanks.

Filtration

A few of the rapid sand filters have been converted into dual media (sand-coconut shell) and declining rate filters. The filter appurtenances such as the rate of flow controllers, headloss gauges etc. were not in working condition. Undulations and cracks were observed in the filter beds indicating poor operation and maintenance and inadequate backwashing. The turbidity of filtered/ finished water was not meeting the standards prescribed by CPHEEO.

Disinfection

Filtered water is disinfected using chlorine gas/ bleaching powder. There is no provision for separate chlorination room. The product water was free from coliforms indicating that chlorination was effective.

Laboratory Facilities

The Public Health Laboratory of the state Government is located in the same campus. Water samples are sent to this laboratory for physico-chemical and bacteriological analysis. At the plant site, only residual chlorine and turbidity are tested. A Paterson type turbidimeter is used to measure turbidity.

RECOMMENDATIONS

* Alum dosing and flocculation equipment should be procured and installed for controlled chemical addition and effective flocculation.

* The optimum alum dose should be decided based on regular jar tests.

* The loss of head guages and rate of flow indicators should be got repaired to facilitate filter operation and control.

* Improvement in filter backwashing is necessary to avoid formation of mud balls, development of cracks, undulations etc. in the filter bed.

* The staff engaged in operation should be imparted formal training for better performance of the plant.

* A separate chlorination room with adequate safety arrangements should be provided.

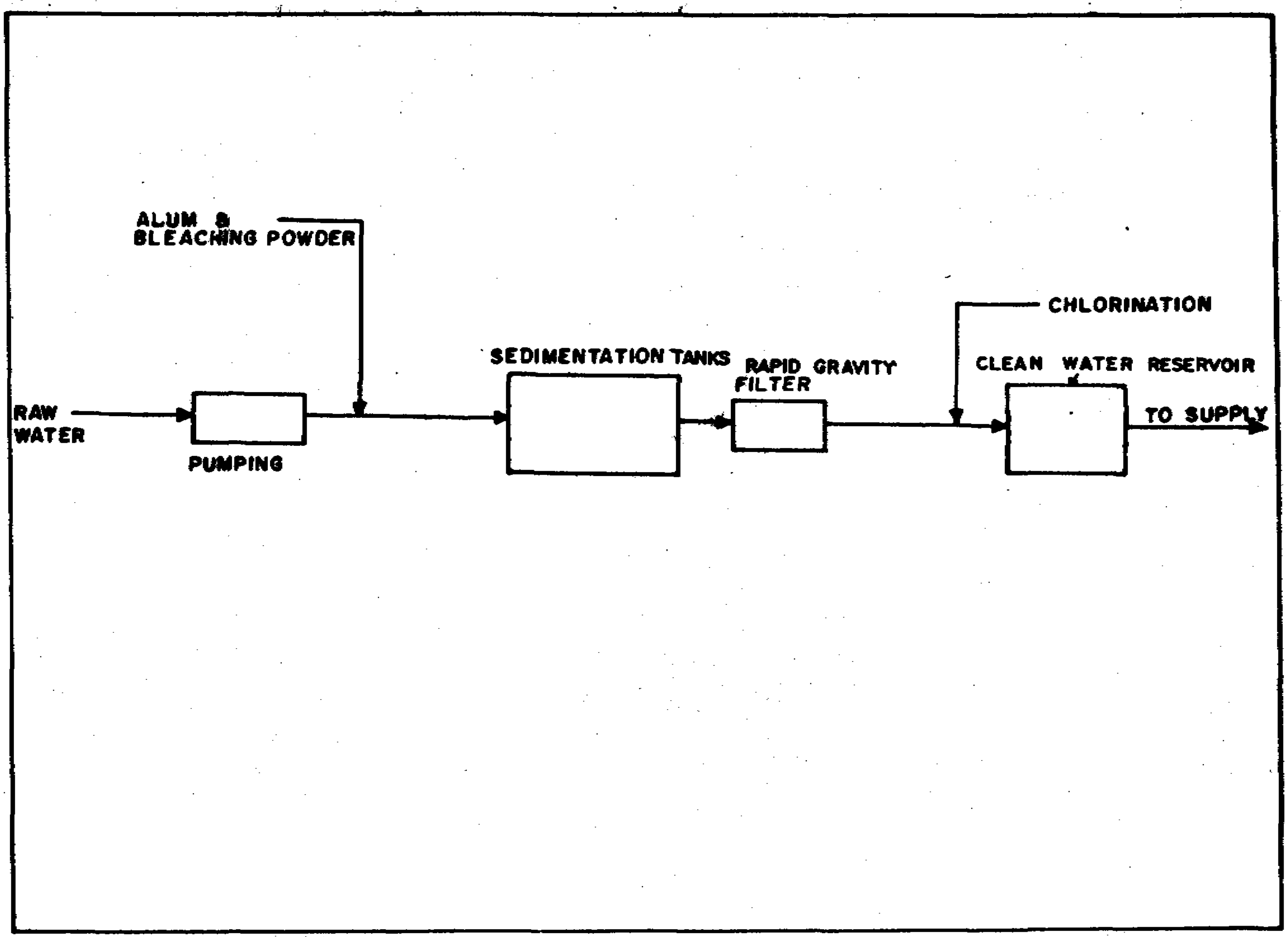


FIG 14.4 CANTONMENT WATER TREATMENT (SCHEMATIC), PUNE

TABLE 14.10

PLANT SUMMARY DATA - PUNE

GENERAL	
Name & Location	: Cantonment water works, Pune
Year of construction	: 1885 (Augmented in 1915,1930, 1961,1978 & 1984)
Design Capacity	: 101 mld.
O & M Agency	: Maharashtra Water Supply and Sewerage Board
Raw water source	: Khadakwasala Dam (Right bank canal)
Treatment flow sheet	: Pre-chlorination and conventional treatment with rapid gravity filters
ENGINEERING	
Raw water pumping	: 4 Nos,1 standby
- Rising main Diameter	: 750 mm
Raw water flow measurement	: Encon systems ultrasonic flow meter with indicator
Pre-treatment	
Coagulation	
- Chemicals used	: Alum,lime, bleaching powder
- Method of mixing	: Hydraulic
Sedimentation	
- Type of Unit	: Rectangular
- No. & size of units	: 5 Nos
- Detention time	: 4 hrs 30 mins.

Filtration

- Type of unit(s)	: Rapid gravity filters
- No.& size of filters	: 23 Nos., i) 9 m x 6 m - 4 beds ii) 6 m x 2.4 m-10 beds iii) 9 m x 6 m - 9 beds
- Rate of filtration	: 4.3 m/hr (AV)
- Filter media details	
. Sand size	: E.S.- 0.5 mm, U.C.- 1.5
. Depth of sand	: 50 - 60 cm
. Gravel Size & depth	: 2 mm to 5 mm - 7.5 cm 5 mm to 10 mm - 7.5 cm 15 mm to 25 mm - 7.5 cm above 25 mm - 15 cm Backwash arrangements
. Method of backwash	: Air scour + Water wash
. Washwater tank cap.	: 2.5 lakh litres & 11.3 lakh litres

Disinfection

- Chemicals used	: Chlorine gas / Bleaching powder
- Chlorination details	: 3 Nos., Vacuum type

Clear Water reservoir

- No.,Type & Capacity	: 2 Nos.,Stone masonary of 6400 M^3

TABLE 14.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

CANTONMENT WATER WORKS - PUNE

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity(NTU)	2.5	1.2	6.0	3.5	70.0	4.6
pH	7.6	7.8	7.3	6.8	7.6	7.2
Total Alkalinity ($CaCO_3$)	38	38	32	28	40	40
Hardness $CaCO_3$						
Total	32	30	32	32	42	45
Carbonate	32	30	32	28	40	40
Non Carbonate	0	0	0	4	2	5
Calcium (Ca)	10	10	8	8	9	9
Magnesium (Mg)	1.5	1	3	3	5	6
Chlorides (Cl)	18	16	22	22	20	20
Sulphates (SO_4)	Tr	Tr	Tr	Tr	8	10
Iron (Fe)	0.3	-	0.2	-	0.4	-
Nitrates (NO_3)	Tr	-	Tr	-	Tr	-
Bacteriological (MPN/100 ML)						
Total coliform	4.6x106	Nil	2400	Nil	7.2x106	Nil
E.coli	Nil	Nil	Nil	Nil	-	-

All values except pH and turbidity are expressed as mg/l

Tr - Traces

TABLE 14.12

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

CANTONMENT WATER WORKS-PUNE

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	2.5	1.5	-	1.2
	II	6.0	5.0	-	3.5
	III	70.0	38	-	4.6
T.Coliform (MPN/100 ML)	I	4.6×10^4	1.1×10^6	Nil	Nil
	II	2400	930	Nil	Nil
	III	7.2×10^4	240	460	Nil
E.coli (MPN/100 ML)	I	Nil	Nil	Nil	Nil
	II	Nil	Nil	Nil	Nil
	III	Nil	Nil	Nil	Nil

NINGTHEMPUKHRI WATER WORKS - IMPHAL

INTRODUCTION

Imphal, the capital city of Manipur with a population of 30,000 (1981 census) draws its water supply from Imphal river. There are three water treatment plants meeting the water supply needs of the city, viz. (i) Ningthempukhri water works (4.5 mld), (ii) Kanchup water works (14.5 mld) and Singda water works (18.2 mld). The Ningthempukhri water works commissioned in the year 1982 was selected for evaluation study. The treatment plant provides for pre-settling, aeration, chemical dosing, flash mixing, flocculation,sedimentation, rapid gravity filtration and disinfection. The plant layout is shown in Fig. 15.1 and summary data is presented in Table 15.1.

PLANT APPRAISAL

Raw water quality

Imphal river, the source of raw water passes through the city and receives sullage, sewage and other run-off throughout the year. Raw water from the river is pumped intermittently (10-12 hrs) from an intake well to a large kuchha settling tank located in a crowded locality. The settling tank is not fenced and protected and is used for bathing, washing of clothes and cattle. Raw water is highly polluted as observed from the high coliform count of 4300-13000 per 100 ml. Turbidity of raw water was in the range of 17-95 NTU during study period (Table 15.2).

Pre-treatment

As the alkalinity of raw water is low (30-40 mg/l), alum along with lime is used for coagulation. Due to non-functioning of dosing equipment and regulating valve, alum slabs are dumped into the raw water channel leading to flash mixer. The actual alum dose was found to be 13 mg/l as agianst the reported dose of 50 mg/l.

Due to incorrect dosing of coagulant chemicals, floc formation was not satisfactory. The turbidity of settled water was in the range of 12-60 NTU. The sludge scraper mechanism of the clarifier was not working. As there are only 3 filter units, when one of them is taken out for backwashing, due to absence of flow regulation to the plant, the clarifier is flooded resulting the overflow and wastage of water.

Filtration

The condition of filters and their maintenance was far from satisfactory. The sand depth in the filters was found to be in the range of 38-46 cm and at some places, there was hardly any sand. The headloss and filter rate indicators were not in working condition. The air compressor for air scour was out of order. Heavy mud ball formation and cracks were observed in the filters confirming inadequate backwashing and poor maintenance. Frequency of filter backwashing was reported to be 12 hours. The performance of the filters was not satisfactory and the filtrate turbidity was in the range of 7.2-40 NTU (Table 15.3).

Disinfection

Bleaching powder was used for chorination of filtered water. Chlorine dose was reported to be 3 mg/l. The finished water had a residual chlorine of more than 1.0 mg/l and was free from coliforms.

Laboratory facilities

No laboratory facilities are available at the plant site.

RECOMMENDATIONS

* The kuccha settling tank should be fenced and protected from the human activities to prevent pollution of raw water.

* The clarifier sludge scraper mechanism should be repaired and brought into use for proper operation of the clarifier.

* The rapid gravity filters need to be overhauled with proper depth and grading of sand and gravel.

* The filter appurtenances need to be repaired/replaced to facilitate proper operation and control.

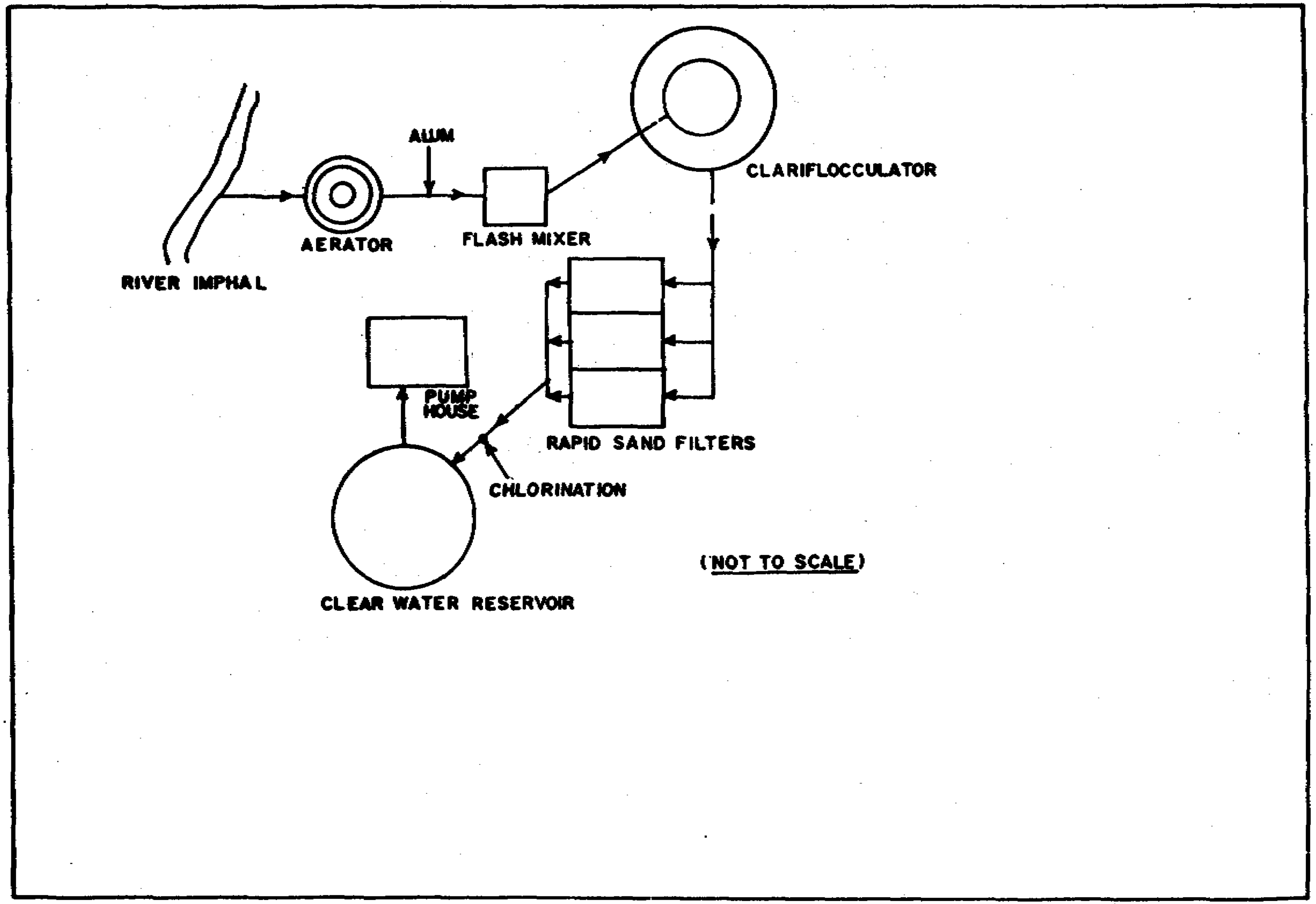


FIG 15.1 LAYOUT PLAN OF IMPHAL WATER TREATMENT PLANT, MANIPUR

TABLE 15.1

PLANT SUMMARY DATA - IMPHAL

GENERAL	
Name and location	: Ningthempukhri Water Works, Imphal
Year of construction	: 1982
Design capacity	: 4.5 mld
O & M Agency	: Public Health Engineering Department, Imphal
Raw water source	: River Imphal
Treatment flowsheet	: Conventional with Rapid Sand Filters (with presettling)
ENGINEERING	
Raw water pumping	: Two nos, (one standby), vertical turbine, 50 HP each
-Rising main diameter	: 300 mm
Raw water flow measurement	: Float type, capacity 400 m^3/hr
Pre-treatment	
Aeration	: Cascade type aerator
Coagulation	
- Chemicals used	: Lime & Alum
- Type of mixing	: Flash Mixer,
- Detention time	: 45 sec
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Dimensions	: One, 6.5 m dia, 3.5 m SWD
- Detention time	: 30 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: One, 16.5 m dia. and 3.5 m SWD
- Surface overflow rate	: 1.05 m/hr
- Detention time	: 3 hrs

Filtration

- Type of unit(s)	: Rapid sand filters
- No. & size of unit(s)	: 3 nos, each 4.2 x 5.2 m
- Rate of filtration	: 4.1 m/hr
- Filter media	
. Sand size	: E.S.- 0.5 mm, U.C.- 1.3
. Depth of sand	: 80 cm
. Gravel size	: 5 to 10 mm
. Depth of each layer	: 10 cm
- Backwash arrangements	
. Method	: Air scour & Water wash
. Wash water tank cap.	: 82.8 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed by manual mixing

Clear Water Reservoir

- Type, No. & Capacity	: RCC, one, 1270 m^3
- Pump details	: 2 nos, centrifugal pumps 50 HP each

TABLE 15.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

NINGTHEMPUKHRI WATER TREATMENT PLANT - IMPHAL

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	47	7.2	95	-	17	9
pH	7.0	7.0	8.5	7.0	7.5	7.5
Total Alkalinity ($CaCO_3$)	30	24	38	37	44	42
Conductivity (µS/cm)	122	133	145	145	129	143
Hardness ($CaCO_3$)						
Total	30	38	80	80	52	50
Carbonate	30	24	38	37	44	42
Non Carbonate	0	14	42	43	8	8
Calcium (Ca)	12	15	12	12	14	11
Magnesium (Mg)	7	9	12	12	4	5
Chlorides (Cl)	8	8	4	4	4	5
Sulphates (SO_4)	12	18	-	-	13	19
Iron (Fe)	2.8	0.7	1.1	0.3	0.4	0.2
Fluoride (F)	ND	ND	-	-	0.1	0.1
Nitrate (NO_3)	0.3	0.3	0.8	0.7	0.3	0.2
Bacteriological (MPN/100 ml)						
Total coliform	13000	0	9200	-	4300	0
Fecal coliform	3300	0	9200	-	4300	0
E.coli	3300	0	9200	-	2300	0
Fecal streptococci	4600	0	45	-	2100	0

All values except pH, Turbidity and Conductivity are expressed as mg/l   ND - Not detectable

TABLE 15.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

NINGTHEMPUKHRI WATER TREATMENT PLANT - IMPHAL

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	47	20	-	7.2
	II	95	60	40	-
	III	17	12	-	9
T.Coliform (MPN/100 ml)	I	13000	1300	49	0
	II	9200	130	2	-
	III	4300	93	49	0
E.Coli (MPN/100 ml)	I	3300	490	33	0
	II	9200	45	-	-
	III	2300	20	11	0

DAKHINPUR WATER WORKS - BERHAMPUR

INTRODUCTION

Piped water supply to Berhampur, a major coastal town of southern Orissa was commissioned in the year 1905 for a population of 30,000 with an impounded reservoir at Dakhinpur as the source of raw water. The treatment plant comprised slow sand filters (6 Nos.) with a design capacity of 2.7 mld. Subsequently, the water supply to the town was augmented to a total of 6.8 mld in the year 1967 by constructing another reservoir and by providing additional (4 nos) slow sand filters each of 0.45 mld capacity and a rapid gravity filter of 2.27 mld capacity. The plant layout is shown in Fig.16.1 and the plant summary data is presented in Table 16.1.

PLANT APPRAISAL

Source

The raw water storage reservoirs are fed by the tenth Rishikulya distributory canal which flows through a distance about 112 km. Visual observation during the visit showed that the raw water turbidity in reservoir No. 1 was apparently much higher than that in reservoir No.2. In spite of this, the capacity of reservoir No.2 could not be fully utilised due to the presence of a hump in the western side of the reservoir.

Raw water from Dakhinpur reservoir flows through a 600 mm dia. gravity main to the treatment plant located closeby. While there is no pre-treatment for slow sand filters the rapid gravity filters are preceded by chemical pre-treatment with flocculation in baffled channel followed by sedimentation. Alum slabs were dumped into the baffled mixing channel with the result there was no proper control on the dose. The settling tanks were not operated and desludged properly and were practically in disuse.

Slow Sand Filters

There is no provision to measure/regulate the plant inflow. Out of ten slow sand filters 2 were out of commission for renovation. The depth of sand was as little as 15-20 cm in the remaining filters. The sand in the filters had an E.S of 0.35 mm and U.C of 2.3. There was no significant reduction in turbidity after filtration (Table 16.2). All valves and rate control devices were found badly corroded and in disuse. Loss of head gauges and rate indicator devices have not been provided in any of the filters. No specific criteria were followed for filter cleaning. The overall operation and maintenance of slow sand filters was most unsatisfactory.

Rapid Sand Filter

The rapid gravity filter, designed and constructed departmentally, had many deficiencies. The minimum appurtenances such as rate of flow controller, rate indicator and loss of head gauges and valves required for proper operation and maintenance have not been provided. The filter maintenance was far from satisfactory. There was very little sand in the filter and the gravel layers were exposed. The filtered water turbidity (17 NTU) was more than the raw water turbidity (10 NTU) (Table 16.3).

Disinfection

Post-chlorination using bleaching powder solution was ineffective as confirmed from the poor bacteriological quality of finished water.

Laboratory Facilities

There were no laboratory ficilities at water works, neither the operators had undergone any formal training in plant operation.

RECOMMENDATIONS

* The point of abstraction of raw water should be shifted to the farthest western side of reservoir No. 2 so as to minimise the suspended solids and turbidity content of raw water entering the treatment plant.

* In order to enable maximum use of raw water stored in the reservoirs a suitable opening connecting the two reservoirs be provided

* The raw water reservoir (No.1) should be desilted to increase the storage capacity and to improve the quality of raw water.

* The present practice of pre-chlorination at the source by uncontrolled addition of bleaching powder needs to be discontinued. If raw water quality warrants pre-chlorination, the same should be done at the treatment plant.

* Provision should be made for measuring the raw water inflow to the plant and its regulation.

* Proper control on alum dosing and operation of settling tanks should be ensured for effective pre-treatment.

* All the slow sand filters and rapid sand filtersneed to be overhauled with proper depth of sand and gravel and provided with necessary regulating valves and appurtenances.

* Minimum laboratory facilities such as a residual chlorine kit and turbidity meter should be provided at the plant site for effective operation and control of the plant.

* The plant staff must be imparted formal training in routine operation and maintenance of the plant and record keeping.

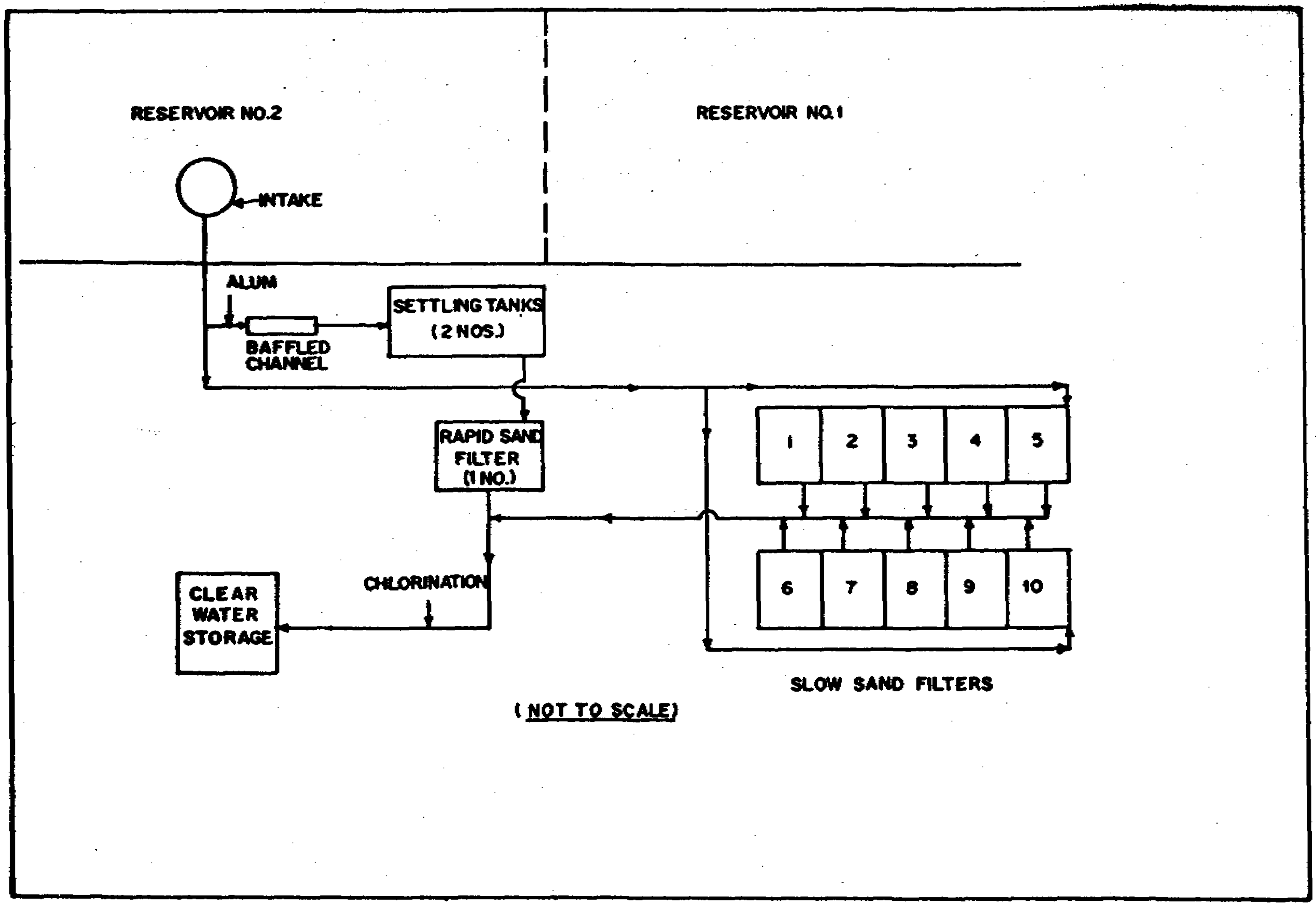


FIG 16.1 LAYOUT PLAN OF DAKHINPUR WATER WORKS - BERHAMPUR

TABLE 16.1

PLANT SUMMARY DATA - BERHAMPUR

GENERAL	
Name and location	: Dakhinpur Water Works Berhampur (Orissa)
Year of construction (Augmentation if any)	: 1905 and 1967(Augmentation)
Design capacity	: 6.8 mld
O & M Agency	: Public Health Engineering Department, Berhampur
Raw water source	: Reservoir
Treatment flowsheet	: Conventional with Slow Sand and Rapid Sand Filters
ENGINEERING	
Raw water pumping	: By gravity system
-Rising main diameter	: 600 mm
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Method of mixing	: Hydraulic (baffled channel)
Sedimentation	
- Type of unit(s)	: Rectangular, Horizontal flow
- No. & size of unit(s)	: 2 Nos, 7.8 m x 3.6 m

Filtration

- Type of unit(s)	: S S F	RGF (open to sky)
- No. & size of unit(s)	: 10 Nos.,each 4.65m x 4.3 m	1 No., 16.5 m x 16.5 m
- Rate of filtration	: 0.07 m/hr	
- Backwash arrangements		
. Method	: Water wash	

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Reservoir

- Capacity	: 250 m^3
- Pump details	: 50 HP x 2 Nos.

TABLE 16.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

DAKHINPUR WATER WORKS - BERHAMPUR

PARAMETERS	RAW	FINISHED (RGF)	FINISHED (SSF)
Physico-chemical			
Turbidity(NTU)	10	17	8.5
pH	7.9	8.1	8.1
Total Alkalinity ($CaCO_3$)	84	86	86
Conductivity (µS/cm)	175	172	175
Hardness($CaCO_3$)			
Total	76	68	64
Carbonate	76	68	64
Non Carbonate	0	0	0
Calcium (Ca)	18	20	17
Magnesium (Mg)	7	5	5
Chlorides (Cl)	7	7	7
Sulphates (SO_4)	1	3	1
Iron (Fe)	0.3	1.1	0.3
Fluoride (F)	0.2	0.2	0.2
Nitrates (NO_3)	0.3	N.D.	0.9
Bacteriological (MPN/100 ML)			
Total coliform	13	2	23
E.coli	4	0	2
Fecal streptococci	0	2	23

All values except pH, Turbidity and Conductivity are expressed as mg/l

N.D.-Not detectable

TABLE 16.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

DAKHINPUR WATER WORKS - BERHAMPUR

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	
			SSF	RGF
Turbidity (NTU)	10	7.3	8.5	17
T. Coliform (MPN/100 ML)	13	50	23	2
E. coli (MPN/100ML)	4	0	2	0

PALASUNI WATER TREATMENT PLANT - BHUBANESHWAR

INTRODUCTION

The water treatment plant at Palasuni (Bhubaneshwar) was constructed in the year 1974 for a design population of 1,18,590 with river Kuakhai as the source of raw water. The plant has a capacity of 27.2 mld and is maintained by PHED, Govt. of Orissa. The treatment comprises addition of chemicals (lime and alum) upstream of the Venturi flume in the raw water channel, flash mixing, flocculation, sedimentation in horizontal flow rectangular settling tanks, rapid gravity filtration and post chlorination.

Presently about 60-65 mld of water is drawn from the headworks located at Kuakhai of which 40 mld will be treated at the newly constructed water treatment plant which is under commissioning. According to PHED officials, the present source is adequate to meet the total requirement of 100 mld. The schematic flow sheet is shown in Fig. 16.2 and the plant summary data is presented in Table 16.4.

PLANT APPRAISAL

Raw water quality and flow measurement

No proper intake structure has been provided and river water is drawn directly by the pumps. It was, however, reported that a proposal for providing a proper intake is under consideration. The problem of silt/sand draft through the pumps to the treatment plant has been experienced. This was reported to be of a recurring nature. No source(s) of pollution were observed in the vicinity of the headworks. Raw water is pumped through a 600 mm dia.C.I. rising main to the treatment plant located about 5 km from the source of supply. Provision of standby pumps was found adequate.

A Venturi flume has been provided in the raw water channel to measure the raw water inflow to the plant. The float operated flow indicating device (Mahindra make) installed at the flume was in working condition. At the time of the visit the plant was overloaded (by 57 %) and the flow was beyond the capacity range of flow meter. The overloading of the plant was confirmed by actual measurement at site by lowering the water level in sedimentation basin and observing the rise in level for a known time interval.

The physico-chemical quality of raw and finished water samples are given in Table 16.5. All the parameters are found to be within the acceptable range for potable purposes except turbidity and total iron. The higher value of total iron is attributed to the presence of turbidity. Higher turbidity in finished water is due to addition of bleaching powder in the form of a slurry.

Pre-treatment

Lime and alum were applied at the raw water inlet channel. The method of addition of these chemicals was found unsatisfactory. These chemicals conveyed through plastic pipes were added at single points, with lime followed by alum.

At the time of visit, when the raw water turbidity was 26 NTU, a lime dose of 11.0 mg/l and an alum dose of 36 mg/l was reported to have been applied. However, the actual dose of lime and alum added was found to be 4.4 mg/l and 38.7 mg/l respectively.

While rapid mix units were in working condition the flocculators were not in use due to silt accumulation to the extent of 2 to 2.5 m. The scour valves were also found choked. It was reported by the plant authorities that the sludge from the sedimentation basin was removed frequently in order to avoid any choking problem. Though the plant was overloaded to the extent of 57 per cent, the performance of the sedimentation basin as judged from the settled water turbidity was satisfactory (Table 16.6).

Filtration

The filters were operated at rates higher than the design rate of 4.8 m/hr. The exact rate of filtration for individual filters could not be ascertained mainly because : (i) the rate of flow indicator was defunct, (ii) due to overloading, the filtered water outlet chamber was flooded. The filtered water turbidity from individual filters was in the range 0.5-9 NTU. However, the finished water (after chlorination) was free from coliforms.

The filter appurtenances such as rate controller, rate of flow indicator and headloss indicators in all the filters were found defunct. It was informed that the rate controllers were intentionally tampered with in order to facilitate overloading.The filters were backwashed once in 24 hrs as a matter of routine with no consideration to headloss or filtrate turbidity. Only hardwash without air-scour is practised. While the design provides for a backwash rate of 40 m/hr, actual backwashing rate was found to be 20 m/hr as measured by the rise in water level over a known period of time during backwashing.

The depth of filter sand in all the filters was observed to be less than desired value as considerable sand has been lost during backwashing even to the extent of exposing the gravel layers. The sand depth was also very uneven.

Disinfection

Chlorination using bleaching powder solution is practised. Adequate residual chlorine was observed in the sample collected from the clear water sump. The bleaching powder solution was fed in the form of a slurry as against the desired practice of feeding supernatant only. This resulted in an increase in the turbidity of filtered water in clear water sump.

Laboratory facilities

A PHED Laboratory for water analysis has been established in a building adjacent to the treatment plant. The laboratory undertakes water quality testing for the various treatment plants maintained by PHED in the state.

The laboratory is equipped with trained and qualified staff and instruments/ equipment necessary for testing of essential parameters of physico-chemical and bacteriological quality of water. None of the filter operators had undergone any formal training. Record keeping with respect to plant operation was found most unsatisfactory as no log books are maintained.

RECOMMENDATIONS

* Provision of a properly designed intake at the river to reduce the silt/sand draft through the pumps is essential to ensure satisfactory performance of the plant

* Necessary arrangements for raw water flow measurement and control need to be provided for effective operation and control of water treatment units

* Considering the large quantity of chemicals used and high cost involved, careful control over chemical dosing should be ensured for optimum results

* The practice of point addition of alum solution upstream of flume, should be dispensed with in favour of applying alum solution through a perforated pipe along the entire width of the channel upstream of the flume for effective mixing

* Mechanical flocculators be repaired and put into operation

* Filter appurtenances such as rate controllers,rate of flow indicators and head-loss gauges in all the filters need to be put into working order for effective operation and maintenance of the plant. Overhauling of all the filters be carried out to ensure proper grading and depth of sand and gravel

* The bleaching powder solution should be allowed to settle, preferably overnight, and only the supernatant be added to the filtered water discarding the bottom sediment

* Operating staff may be trained for proper operation, maintenance and control of the plant

* Proper operation and maintenance records be maintained

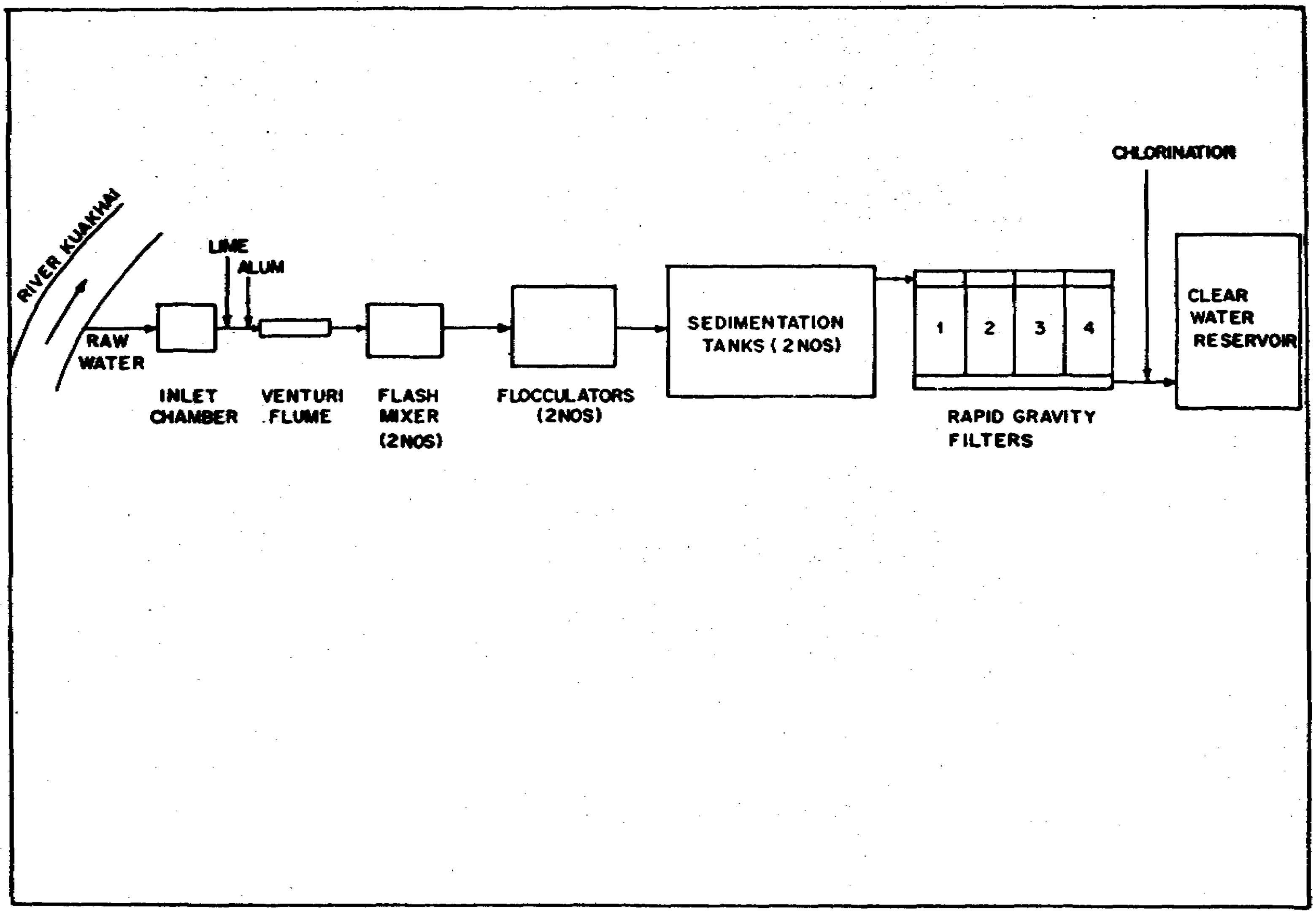


FIG 16.2 PALASUNI WATER TREATMENT PLANT (SCHEMATIC) BHUBANESHWAR

TABLE 16.4

PLANT SUMMARY DATA - BHUBANESHWAR

GENERAL		
Name and location	:	Palasuni Water Treatment plant, Bhubaneshwar (Orissa)
Year of construction	:	1974
Design capacity	:	27.2 mld
O & M Agency	:	Public Health Engineering Department, Bhubaneshwar
Raw water source	:	River Kuakhai
Treatment flowsheet	:	Conventional with rapid gravity filters.
ENGINEERING		
Raw water pumping	:	110 HP x 3 Nos, 115 HP x 1 No. 100 HP x 2 Nos
-Rising main diameter	:	600 mm
Raw water flow measurement	:	Venturi flume
Pre-treatment		
Coagulation		
- Chemicals used	:	Lime, Alum
- Type of mixing	:	Flash mixing
- Method of mixing	:	Mechanical
- Detention Time	:	2 minutes
Flocculation		
- Method / Type of unit	:	Mechanical
- No. & Dimensions	:	2 Nos,each 12 m x 6 m x 3.75 m SWD
- Detention time	:	30 minutes

TABLE 16.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

PALASUNI WATER TREATMENT PLANT - BHUBANESHWAR

PARAMETERS	RAW	FINISHED
Physico-chemical		
Turbidity (NTU)	24	12
pH	7.7	8.4
Total Alkalinity ($CaCO_3$)	61	66
Conductivity (µS/cm)	123	154
Hardness ($CaCO_3$)		
Total	55	66
Carbonate	55	66
Non Carbonate	0	0
Calcium (Ca)	17	19
Magnesium (Mg)	3	5
Chlorides (Cl)	6	9
Sulphates (SO_4)	4	9
Iron (Fe)	2.7	0.7
Fluoride (F)	0.1	0.1
Nitrates (NO_3)	0.4	1.8
Bacteriological (MPN/100 ML)		
Total coliform	>1600	0
E.coli	1600	0
Fecal streptococci	4	0

All values except pH,Turbidity and Conductivity are expressed as mg/l

TABLE 16.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

PALASUNI WATER TREATMENT PLANT - BHUBANESHWAR

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	24	9	1.5	12
T. Coliform (MPN/100 ML)	>1600	240	4	0
E. Coli (MPN/100 ML)	1600	4	2	0

RAJPURA WATER WORKS - RAJPURA

INTRODUCTION

Rajpura, a small town in Punjab with a present population of 56,000 draws its water supply from Bhakra canal (Narwana branch). Raw water from canal is pumped through a 3 km long rising main into two storage reservoirs at the plant site. Stored water is drawn into an intake well and is pumped to the treatment plant. The treatment plant of 14.3 mld capacity commissioned in the year 1985 provides for coagulation,tapered flocculation, sedimentation in horizontal flow settling tanks followed by rapid gravity filtration and disinfection. The schematic flow sheet is shown in Fig. 17.1 and the plant summary data is presented in Table 17.1. The plant is maintained by the Punjab Water Supply and Sewerage Board.

PLANT APPRAISAL

Raw water quality and flow measurement

Due to long storage,the raw water has a low turbidity and bacterial count (Table 17.2). During rainy season the raw water turbidity is reported to reach a maximum of 80 NTU. A Parshall flume is provided for raw water flow measurement. The flow recorder was in working condition. The plant output was restricted due to the limited capacity of the existing over head service reservoirs. At the time of visit the plant inflow was only 6.4 mld.

Pre-treatment

The alum dosing facilities, mechanical rapid mixers and flocculators were in working condition but not in operation as the raw water turbidity was low. Alum addition was also discontinued. It was reported that alum dosing is practised only when raw water turbidity is of the order of 50 NTU or more. Due to non-functioning of pre-treatment facilities turbidity did not show any appreciable reduction after sedimentation (Table 17.3).

Filtration

The rapid gravity filters are open to sky and only the operating gallary is under cover. Only three filters were in operation during the study, due to reduced inflow to the plant. All the appurtenances of rapid gravity filters were in working condition except one head loss indicator. The filtrate turbidity was within the limits recommended by CPHEEO. The filters were backwashed at a terminal head loss of 1.8 meter and the length of run was reported 48 to 72 hours in fair season and not less than 24 hours in monsoon season.

The spent backwash water and the sludge bleed from sedimentation tanks are collected in a sump well and pumped into two holding tanks. The supernatant is returned to the raw water storage tanks by gravity and the bottom sludge is removed periodically and disposed off on low lying areas.

Disinfection

The filtered water is disinfected using chlorine gas. The chlorinator was in working condition and the reported dose of chlorine was on an average 1 kg/hr. At the time of the visit no residual chlorine was detected in the finished water. Chlorination was inadequate as confirmed by the poorbacteriological quality of the finished water (Table 17.3).

Laboratory facilities

Adequate laboratory facilities for routine physico-chemical analysis are available at the plant. Tests for turbidity, pH and residual chlorine are carried out by the plant operators. Jar testing is done only during monsoon season. Records are maintained for plant inflow, pumping schedules etc.

Plant staff

One Junior Engineer is incharge of the plant supported by operators (7 nos.), helpers and chowkidars (7 nos). All the pump operators and fitters are ITI certificate holders. The operation and maintenance of the plant, in general, is satisfactory.

Financial aspects

The total expenditure for the year 1987 - 88 was Rs. 14.2 lakhs; the staff salary accounted for 17 per cent, chemical and power 69 per cent and maintenance and repairs 14 per cent. Information on revenue receipts for the year 1987 - 88 was not available. However, for the year 1986 - 87 the revenue from sale of water was Rs. 13.2 lakhs.

RECOMMENDATIONS

* Even during periods of low turbidity, a nominal dose of alum should be added to raw water and flash mixing provided for effective removal of impurities in the filter.

* Laboratory tests should be conducted regularly to decide the optimum dose of alum and chlorine.

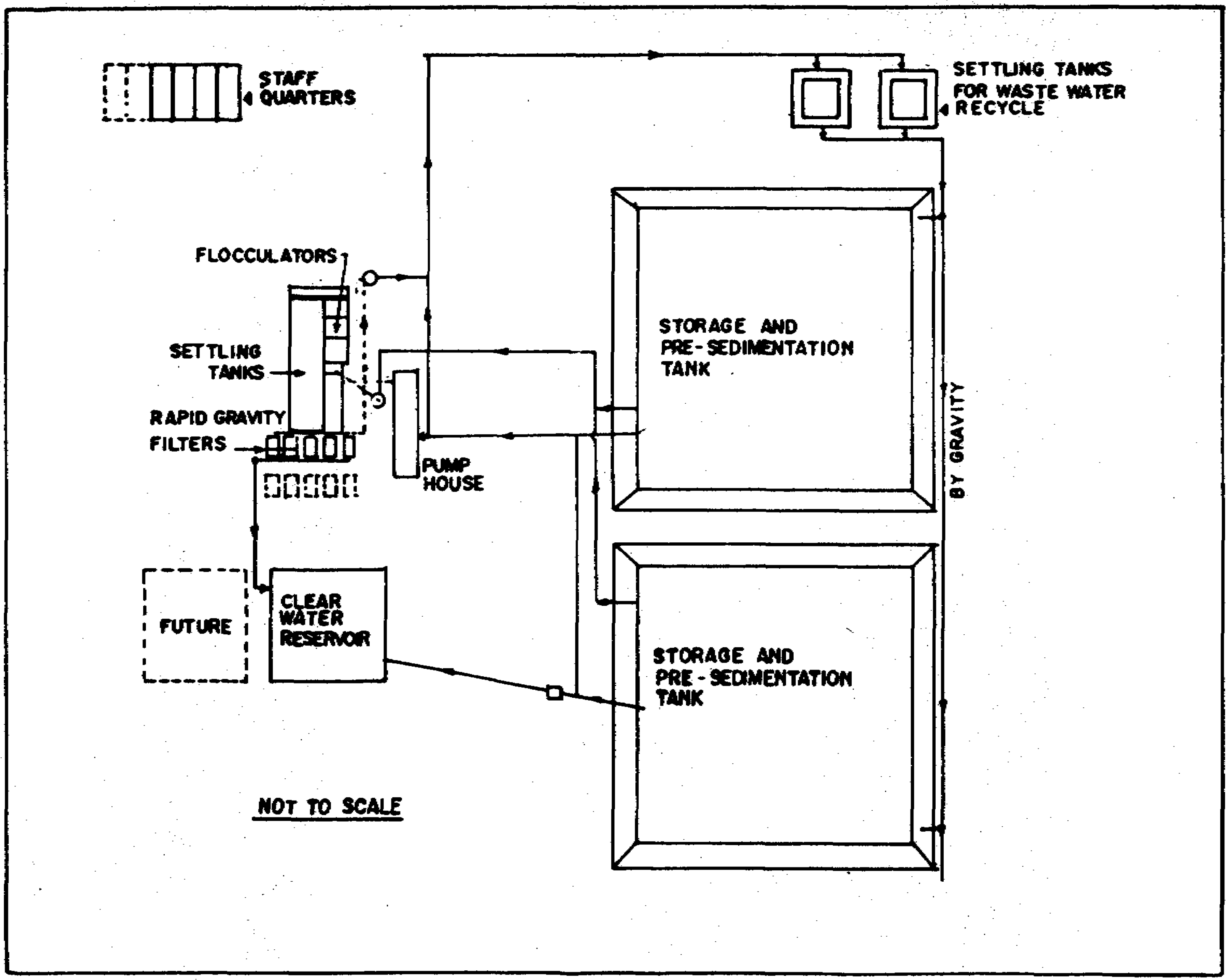


FIG 17.1 LAYOUT PLAN OF RAJPURA WATER TREATMENT PLANT

TABLE 17.1

PLANT SUMMARY DATA - RAJPURA

GENERAL		
Name and location	:	Rajpura Water Works, near village Bhadak, Patiala
Year of construction	:	1985
Design capacity	:	14.3 mld
O & M Agency	:	Punjab Water Supply and Sewerage Board
Raw water source	:	Bhakra main canal
Treatment flowsheet	:	Conventional with rapid gravity filters
ENGINEERING		
Raw water pumping	:	3 nos., centrifugal,each 275 m^3/hrone standby
-Rising main diameter	:	410 mm
Raw water flow measurement	:	Reliable make, float operated
Pre-treatment		
Coagulation		
- Chemicals used	:	Alum
- Type of mixing	:	Mechanical, flash mixer 1.5 x 1.5 x 2.4 m
- Detention time	:	33 sec.
Flocculation		
- Method / Type of unit	:	Mechanical Tapered flocculators
- No. & Dimensions	:	3 no., each 5.65 m x 5.65 m x 3.66 m
- Detention time	:	35 min,(36 rpm 5 HP, 21 rpm 3 HP, 14 rpm 2 HP)

Sedimentation

- Type of unit(s)	: Rectangular
- No. & size of unit(s)	: 1 no., 35.9 m x 10.7 m x 3 m
- Surface overflow rate	: 1.55 m/hr
- Detention time	: 2 hrs

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 5 nos., each 30 m^3
- Rate of filtration	: 4 m/hr
- Filter media	
. Sand size	: E.S - 0.62 mm, U.C - 1.6
. Depth of sand	: 68 cm
. Gravel size (mm)	: 50-37, 37-12, 12-6, 6-2.5
. Depth of each layer	: 80 mm
- Backwash arrangements	
. Method	: Air scour and water wash
. Wash water tank cap.	: 227 m^3

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: Pressure type, one no., chloro control make

Clear Water Reservoir

- Type, No. & Capacity	: RCC, 1 no. 2455 m^3
- Pump details	: 2 nos., 135 HP, Centrifugal, 1 standby

TABLE 17.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

RAJPURA WATER WORKS - RAJPURA

PARAMETERS	RAW	FINISHED
Physico-chemical		
Turbidity (NTU)	5.5	1.5
pH	8.2	8.1
Total Alkalinity ($CaCO_3$)	154	154
Conductivity(µS/cm)	262	252
Hardness ($CaCO_3$)		
Total	103	104
Carbonate	103	104
Non Corbonate	0	0
Calcium (Ca)	32	31
Magnesium (Mg)	6	6.3
Chlorides (Cl)	5	5
Sulphates (SO_4)	27	28
Iron (Fe)	Tr	Tr
Fluoride (F)	0.6	0.6
Nitrates (NO_3)	2.6	1.9
Bacteriological (MPN/100 ML)		
Total coliform	240	8

All results are expressed as mg/L except for pH, conductivity and turbidity Tr - Traces

TABLE 17.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

RAJPURA WATER WORKS - RAJPURA

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	5.5	5.4	1.5	1.5
T.coliform (MPN/100ML)	240	85	35	8

BHILWARA WATER WORKS - BHILWARA

INTRODUCTION

Bhilwara is a fast developing district town of Rajasthan. Water supply to the city with a population of 1.22 lakhs (1981 census) is drawn from Meja dam on Kothari river, about 15 km away from the town. The first water treatment plant of 4 mld was commissioned in 1959 and the capacity was augmented in 1976 by construction of a 9.1 mld plant.In addition about 900 m^3/day of water is obtained from 11 tubewells. The plant of 9.1 mld capacity has been selected for evaluation. The schematic flowsheet is shown in Fig.18.1 and the plant summary data is presented in Table 18.1.The plant is maintained by PHED, Govt. of Rajasthan.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from Meja dam is pumped to large earthen storage cum pre-sedimentation tanks. Due to severe drought conditions, sufficient quantity of raw water was not available at the time of evaluation study. During fair season, raw water has a low turbidity (<10 NTU). In summer due to low water level in the dam/ pre-sedimentation tanks the bottom sediments are sucked along resulting in turbid water. Considerable algal growth was also observed in the pre-sedimentation basins. The physico-chemical and bacteriological quality of raw water was fairly good (Table 18.2).

A Venturi flume provided for flow measurement was out of commission due to a pipe running through it. Raw water flow could not be measured during the visit by any accurate method.

Pre-treatment

A heavy dose of chlorine (about 7 mg/l) was applied using bleaching powder presumably for control of algae in raw water. Bleaching powder was added manually once in two hours and the dose is not controlled properly. The alum dosing facilities were out of order and alum slabs were dumped into the raw water channel. This resulted in uneven dosing with no proper control. The performance of the clariflocculator was not satisfactory as was evident from the settled water turbidity which was even more than that of raw water (Table 18.3). The poor efficiency can be attributed to the presence of algae and inadequate alum dose. The settled water showed a residual chlorine concentration of 4 mg/l and was free from coliform and E.coli. The clarifier bleed along with the spent backwash water was drained into the pre-sedimentation basins and recycled.

Filtration

The operation and maintenance of filters which are open to sky was far from satisfactory. The flow rate controllers were not in working condition. Very short filter runs of 10 hr duration were observed. The filter backwashing was ineffective as was evident from the high initial headloss. The filters were working on declining rate principle with an initial filtration rate of 6.75 m/hr declining to 2.45 m/hr at the end of the filter cycle. The residual chlorine concentration in filtrate was 3 mg/l.

Disinfection

The filtrate with 3 mg/l of residual chlorine was further chlorinated using chlorine gas. The finished water had a very high concentration (8 mg/l) of residual chlorine causing serious taste and odour problems.

Laboratory facilities

No laboratory facilities were available at the plant to facilitate any meaningful control of plant operation.

Plant staff

The staff for routine O & M of the plant consists of Junior Engineer (1 no.), Senior Filter Assistants (1 no.), Junior Filter Assistants (3 nos.) and helpers (10 nos.).

RECOMMENDATIONS

* Steps should be taken to minimise evaporation losses from the dam and the storage basins supplying raw water to the treatment plant.

* The raw water intake well constructed at the Meja dam site should be commissioned at the earliest to reduce the problem of drawal of bottom mud with the raw water.

* Appropriate flow measuring / indicating devices should be installed for each one of the treatment plants to facilitate proper operation and control.

* Indiscriminate addition of bleaching powder / chlorine gas should be discontinued and proper dose of chlorine based on chlorine demand test be applied to maintain a residual as recommended by CPHEEO.

* The alum preparation and dosing devices should be brought into working condition and the alum dose controlled as per jar tests.

*   All the filter appurtenances should be got repaired to facilitate filter operation and control and the efficiency of filter backwashing improved to maintain the filters clean.

*   Minimum laboratory facilities along with competent personnel should be provided at the plant for effective plant monitoring and control.

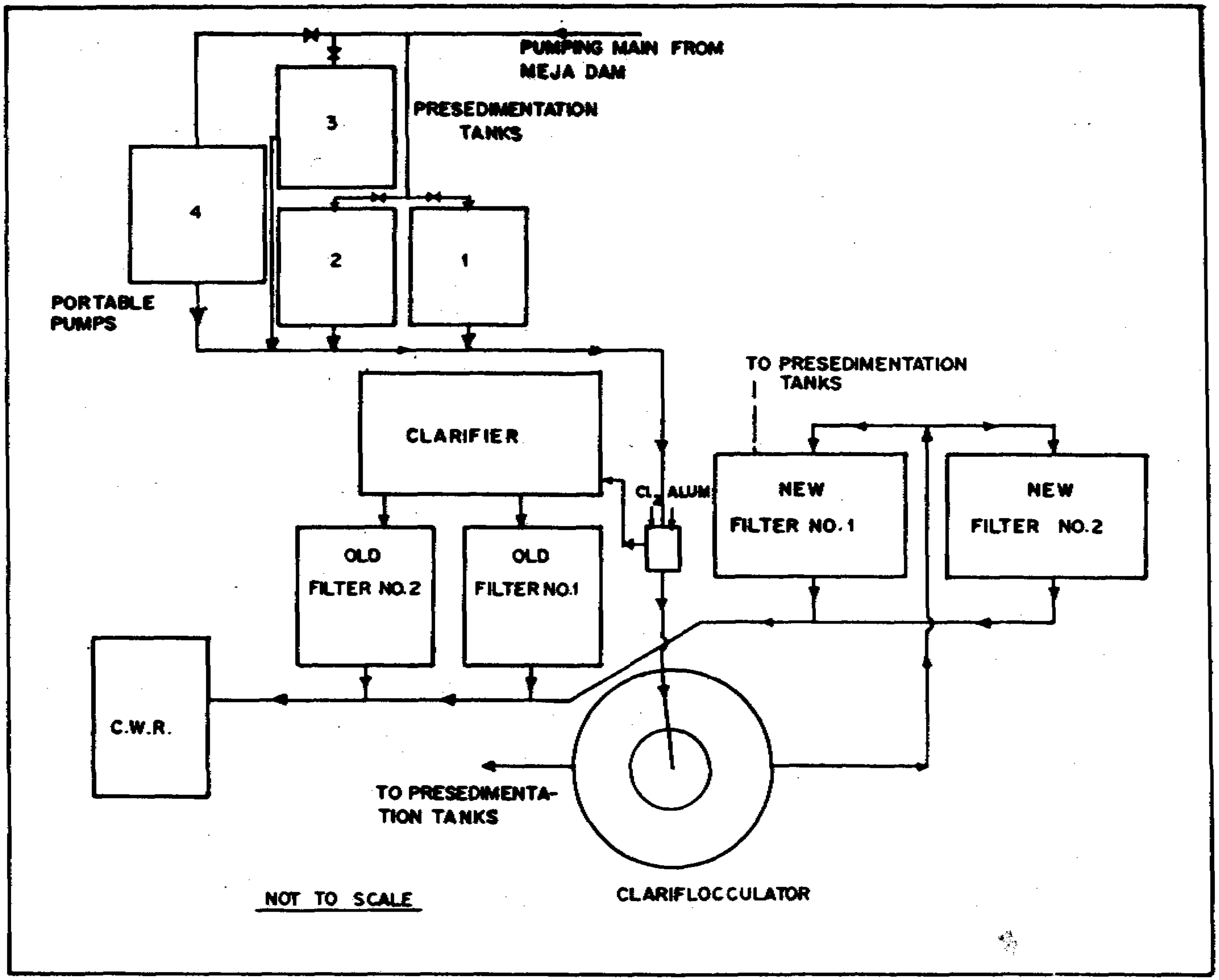


FIG 18.1 LAYOUT PLAN OF BHILWARA WATER TREATMENT PLANT

TABLE 18.1

PLANT SUMMARY DATA - BHILWARA

GENERAL	
Name and location	: Bhilwara Water Works, Bhilwara
Year of construction	: 1976
Design capacity	: 9.1 mld
O & M Agency	: Public Health Engineering Department, Govt. of Rajasthan
Raw water source	: Impoundment (Dam on Kothari River)
Treatment flowsheet	: Pre-chlorination and conventional treatment with rapid gravity filters
ENGINEERING	
Raw water pumping	: 2 centrifugal pumps of 4.5 lakh lits/hr capacity
-Rising main diameter	: 610 mm
Pre-treatment	
Pre-sedimantation	: 4 tanks, 91.5 m x 91m each
Pre-chlorination	: Bleaching powder
Coagulation	
- Chemicals used	: Alum, solution feed
- Type of mixing	: Hydraulic
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Size of unit(s)	: 1 No., 5 m diameter
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Circular Clarifier
- No. & size of unit(s)	: 1 no., 12 m dia., 3.2 m SWD
- Surface Overflow Rate	: 1 m/hr
- Detention time	: 3 hours

Filtration

- Type of unit(s)	: Rapid gravity filters (open to sky)
- No. & size of unit(s)	: 2 nos.,9.6 m x 5.35 m each
- Rate of filtration	: 4 m/hr
- Filter media	
. Sand size	: E.S.- 0.5 mm, U.C.- 1.6
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Air scour + water wash
. Wash water tank cap.	: 75 m^3

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Wet feed
- Chlorinator Details	: Chloronome, 1 no.

Clear Water Reservoir

- Type, & Capacity	: RCC, 1335 m^3
- Pump details	: 3 pumps of 40 HP each 2 pumps of 30 HP each

TABLE 18.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

BHILWARA WATER WORKS - BHILWARA

PARAMETERS	RAW	FINISHED
Physico-chemical		
Turbidity(NTU)	6.0	2.0
pH	7.8	7.5
Total Alkalinity ($CaCO_3$)	84	80
Conductivity (µS/cm)	200	-
Hardness ($CaCO_3$)		
Total	156	256
Carbonate	84	80
Non Carbonate	72	176
Calcium (Ca)	29	80
Magnesium (Mg)	21	32
Chlorides (Cl)	28	30
Sulphates (SO_4)	2	5
Iron (Fe)	0.6	-
Bacteriological (MPN/100 ML)		
Total coliform	93	0
Fecal coliform	0	0
E.coli	0	0
Fecal streptococci	7	0

All values except pH,turbidity and conductivity are expressed as mg/l

TABLE 18.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

BHILWARA WATER WORKS - BHILWARA

PARAMETERS	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	6	7.5	2.5	2.0
T. Coliform (MPN/100 ML)	93	0	0	0
E. Coli (MPN/100ML)	0	0	0	0

JODHPUR WATER WORKS - JODHPUR

INTRODUCTION

Jodhpur is located in the semi arid desert of Rajasthan. The first conventional water treatment plant of 11.4 mld capacity was constructed in 1938 with Hemawas reservoir on river Bandi as raw water source. Due to rapid growth in population the scheme was augmented twice, first in 1959 with 18.2 mld plant drawing raw water from Jawai Sagar about 152 km away and the second in 1976 with 25 mld. Two plants of 11.4 and 18.2 mld capacity have been selected for evaluation. The schematic flow sheet of the plant is shown in Fig.18.2 and the plant summary data is presented in Table 18.4. The plants are maintained by the PHED, Govt. of Rajasthan.

PLANT APPRAISAL

Raw water quality and flow measurement

As the raw water is brought from a long distance through a canal, many villages enroute including Pali town draw water from the same canal. The raw water sources are inadequate to meet the needs, the drought conditions worsening the situation. Raw water is pumped in 8 stages to the treatment plant on Chopasani hills and the surplus, whenever available is pumped to Takhat Sagar, a balancing reservoir constructed at an elevation on a nearby hillock. During the evaluation study, raw water supply was augmented from Takhat Sagar. Due to inadequacy of raw water, the plants were underloaded and at times shut down completely.

Considerable evaporation loss occurs at the Takhat Sagar balancing reservoir. Filter backwash along with clarifier sludge is discharged back into the canal near the intake. This coupled with interruptions in canal water supply makes the plant control difficult, adversely affecting the performance. Algal growth in the reservoir was also observed.

Considerable fluctuation in raw water turbidity was caused due to recycling of water works waste making it difficult to control the alum and chlorine doses. Chemical and bacteriological quality parameters, however, were within acceptable limits for raw water source (Table 18.5). The plant inflow could not be measured as the flow measuring devices were out of order.

Pre-treatment

The aeration unit that has been installed does not serve any useful purpose. During summer pre-chlorination is practised reportedly for algae control and to improve the raw water quality.

Alum dose control has been difficult due to sudden changes in water quality with the result the same dose was applied all through the day. The present practice of discharging filter backwash into the canal near the intake sump should be discontinued and only the supernatant be recycled after settling in a holding tank. The settled water turbidity ranged from 8 to 12 NTU. Following pre-chlorination substantial reduction in bacteriological count was also observed in settled water (Table 18.6).

Filtration

The filters were operated at high initial rates ranging from 7.6 to 9.5 m/hr resulting in short filter runs of about 16 hrs duration. Initial headloss was very high (76 to 105 cm) thereby indicating inadequate backwashing. The rate controllers and head loss indicators were not in working condition. Turbiditywise the filter performance was not satisfactory though the filtrate was free from E.coli presumably due to pre-chlorination.

Disinfection

Filtered water was chlorinated using chlorine gas. A high residual chlorine (4 mg/l) was observed in the clear water reservoir and the finished water was free from E.coli count (Table 18.6).

Laboratory facilities

A full-fledged laboratory has been set up in the city about 10 km away from the plant.

RECOMMENDATIONS

* Pre-chlorination should be practised all through the year and the dose of chlorine controlled by regular chlorine demand test.

* In view of the perennial water scarcity conditions as a conservation measure the water works waste should be taken through a holding tank and the supernatant recycled to the plant.

* Control over chemical dosing should be ensured based on regular laboratory tests.

* The condition of filters need to be improved through adequate backwashing to leave the filters clean and by putting the appurtenances into working order for proper filter control.

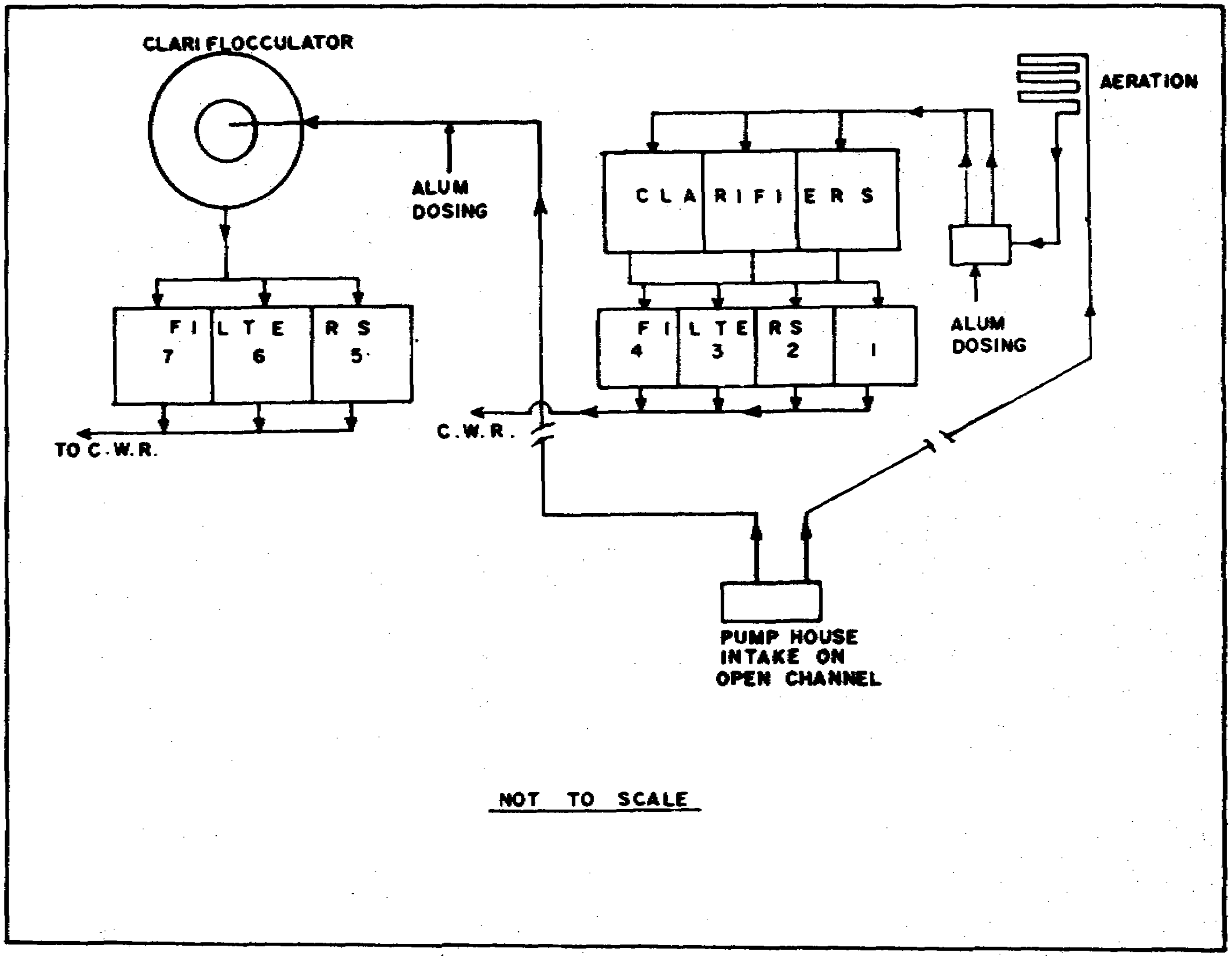


FIG 18.2 LAYOUT PLAN OF JODHPUR WATER TREATMENT PLANT - JODHPUR

TABLE 18.4

PLANT SUMMARY DATA - JODHPUR

GENERAL		
Name and location	: Jodhpur Water Works Chopasini Hills, Jodhpur	
Year of construction (Augmentation if any)	: 1938 (1959)	
Design capacity	: 29.6 mld (11.4 + 18.2 mld)	
O & M Agency	: Public Health Engineering Department, Govt. of Rajasthan	
Raw water source	: Canal from Jawai Sagar.	
Treatment flowsheet	: Conventional with rapid gravity filters	
ENGINEERING		
Raw water pumping	: Raw water pumped from a distance of 150 km with 8 lifting stations	
Raw water flow measurement	: Float and Venturi flume	
Pre-treatment	: A (11.4 mld)	B (18.2 mld)
Aeration	: Provided	not provided
Coagulation		
- Chemicals used	: Alum, lime wet feed	Alum wet feed
- Type of mixing	: Hydraulic	Hydraulic
Flocculation		
- Method / Type of unit	: Not provided	Mechanical (Clariflocculator)
- No. & Size of unit(s)	:	1 no.,8.6 m dia.

Sedimentation	:	A (11.4 mld)	B (18.2 mld)
- Type of unit(s)	:	Rectangular	Circular clarifier
- No. & size of unit(s)	:	3 nos.,	1 no.,27 m dia.
- Surface overflow rate	:		0.7 m/hr
Filtration			
- Type of unit(s)	:	Rapid gravity filters	
- No. & size of unit(s)	:	4 nos., 7 m x 5.5 m	3 nos., 8.7 m x 3.3 m
- Rate of filtration	:	4.8 m/hr	4.8 m/hr
- Filter media			
. Sand size	:	E.S.- 0.6mm, U.C.- 1.5	
. Depth of sand	:	60 cm	
- Backwash arrangements			
. Method	:	Air scour and water wash	
. Washwater tank cap.	:	91 m^3	
Disinfection			
- Chemicals used	:	Chlorine gas and bl. powder	
- Type of feed	:	Direct feed	
Clear Water Reservoir			
- Type, No. & Capacity	:	RCC, 2 nos., 3632 m^3 each	RCC, 4 nos. 2270 m^3 each
- Pump details	:	Supply by gravity	

TABLE 18.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

JODHPUR WATER WORKS - JODHPUR

PARAMETERS	I VISIT			II VISIT		
	RAW		FINISHED	RAW		FINISHED
	A	B		A	B	
Physico-chemical						
Turbidity(NTU)	8.5	41	5.0	58	32	4
pH	7.8	7.4	7.5	7.8	7.1	7.6
Total Alkalinity ($CaCO_3$)	108	104	106	148	140	124
Conductivity(μS/cm)	390	270	350	360	350	320
Hardness ($CaCO_3$)						
Total	196	184	-	240	208	240
Carbonate	108	104	-	148	140	124
Non Carbonate	88	80	-	92	68	116
Calcium (Ca)	42	35	-	55	38	38
Magnesium (Mg)	22	23	-	27	27	35
Chlorides (Cl)	64	28	60	44	32	36
Sulphates (SO_4)	7	3	16	5	3	9
Fluoride (F)	Nil	Nil.	-	0.5	0.5	0.4
Bacteriological (MPN/100 ML)						
Total coliform	93	>2400	0	2400	0	0
Fecal coliform	43	1100	0	23	0	0
E.coli	43	1100	0	0	0	0
Fecal streptococci	0	0	0	43	0	0

All values except pH,turbidity and conductivity are expressed as mg/l

TABLE 18.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

JODHPUR WATER WORKS - JODHPUR

PARAMETERS	VISIT	RAW WATER		SETTLED WATER		FILTERED WATER		FINISHED WATER
		A	B	A	B	A	B	
Turbidity (NTU)	I	8.5	41	8.5	12	5.0	6.2	5.0
	II	32	58	8.0	10	2.6	3.6	4.0
T.Coliform (MPN/100 ML)	I	93	>2400	9	43	0	0	0
	II	2400	-	0	-	43	23	0
E. Coli (MPN/100 ML)	I	43	1100	4	7	0	0	0
	II	0	-	0	0	0	0	0

KOTA WATER WORKS, AKELGARH - KOTA

INTRODUCTION

The city of Kota with a population of 3.58 lakhs (1981 census) draws its water supply from river Chambal. The first water supply scheme for the city was commissioned in 1927 with slow sand filters of 6.8 mld capacity. Subsequently, the water supply has been augmented from time to time with conventional rapid gravity filters to the present total capacity of 45 mld. The conventional 18.2 mld rapid sand filter plant and 6.8 mld slow sand filter plant have been taken up for evaluation. The schematic flow sheet is shown in Fig.18.3 and plant summary data is presented in Table 18.7. The plants are maintained by the Public Health Engineering Department, Govt. of Rajasthan.

PLANT APPRAISAL

Raw water quality and flow measurement

Impounded water from upstream of a barrage constructed across the perennial river Chambal is pumped to the treatment plants located at Akelgarh on the right bank of the river. The potential for pollution of raw water is very little. Due to impoundment, the raw water turbidity is very low, less than 5 NTU. Occasional rise in turbidity during rainy season is reported for a short period. Other physico-chemical characteristics are well within the limits recommended by CPHEEO. Raw water coliform MPN of less than 100 was observed during the visit (Table 18.8). There are two intakes from where raw water is pumped to the treatment plants. The rising mains are interconnected and the flow is regulated through gate valves. Due to frequent manipulation of valves when the pumps are put on or off, raw water flow to the individual treatment plant changes frequently. There is no provision for measuring the flow to the individual treatment plant. In the case of 18.2 mld plant, a Venturi type flow measuring flume has been provided but the flow indicating and recording devices were out of order.

Pre-treatment

The slow sand filters are preceded by large sedimentation basins in which the turbidity gets reduced from 2.8 to 1.0 NTU. As for rapid sand filtration plant, since the raw water has a low turbidity (2.8 to 3.4 NTU), coagulant addition is not practised for nearly 10 months of the year. In the absence of alum addition, only a marginal reduction in turbidity is obtained after sedimentation. The chemical characteristics of water remain unchanged during the passage of water through various treatment units (Table 18.9).

Filtration

During the visits, the rapid sand filters were either underloaded or were not in operation. Normal filter runs of 22.5 to 27 hrs with a terminal headloss of about 2.5 m were reported. The efficiency of filters in removal of coliform bacteria was not satisfactory (Table 18.9). Backwashing of filters was ineffective and higher rates of backwash should be applied to maintain a reasonably clean bed. Loss of head gauges and rate controllers were not working in all the filters. Considerable quantity of settled water was diverted to the clear water reservoir bypassing the filters.

The performance of slow sand filters was comparatively better. There was reduction in coliform count and the turbidity of filtrate was 0.5-1.0 NTU (Table 18.9).

Disinfection

Filtered water from all the treatment plants is chlorinated at the clear water reservoir before distribution. A high residual chlorine (5.0 mg/l) was observed in the finished water during the visits. The heavy dose of chlorine fixed arbitrarily leads to wastage of the chemical, odour problem and corrosion of equipment. During night hours, the drawal from clear water reservoir is reduced and flooding of the reservoir occurs. This leads to a rise in water level in the filtered water channels resulting in the submergence of the rectangular weirs in the filter outlet chambers.

Laboratory facilities

Laboratory facilities are not available at the plant site and the samples for routine analysis are sent to the Public Health laboratory located in the city.

RECOMMENDATIONS

* Raw water pumps for each one of the treatment plants should, as far as possible, be of the same duty to optimise their use and to provide for flexibility in operation and plant control.

* As adequate quantity of raw water is available throughout the year, manipulation of flow to the individual plant through interconnected valves in the pipelines should be minimised to facilitate smooth operation and control of the plants.

* The practice of dispensing with alum dosing during major part of the year should be discontinued and a nominal dose of alum be added to ensure effective treatment. Similarly, bypassing of settled water to clear water reservoir without filtration should be avoided.

* The plant output should be optimised and as far as possible maintained uniform by proper scheduling of clear water pumping to avoid overflow and wastage.

* The filter rate controllers, rate indicators and loss of head gauges should be got repaired and installed for proper operation and control of filters.

* Controlled chlorination should be ensured by regular laboratory testing for chlorine demand so as to leave enough residual chlorine at the treatment plant and in the distribution system.

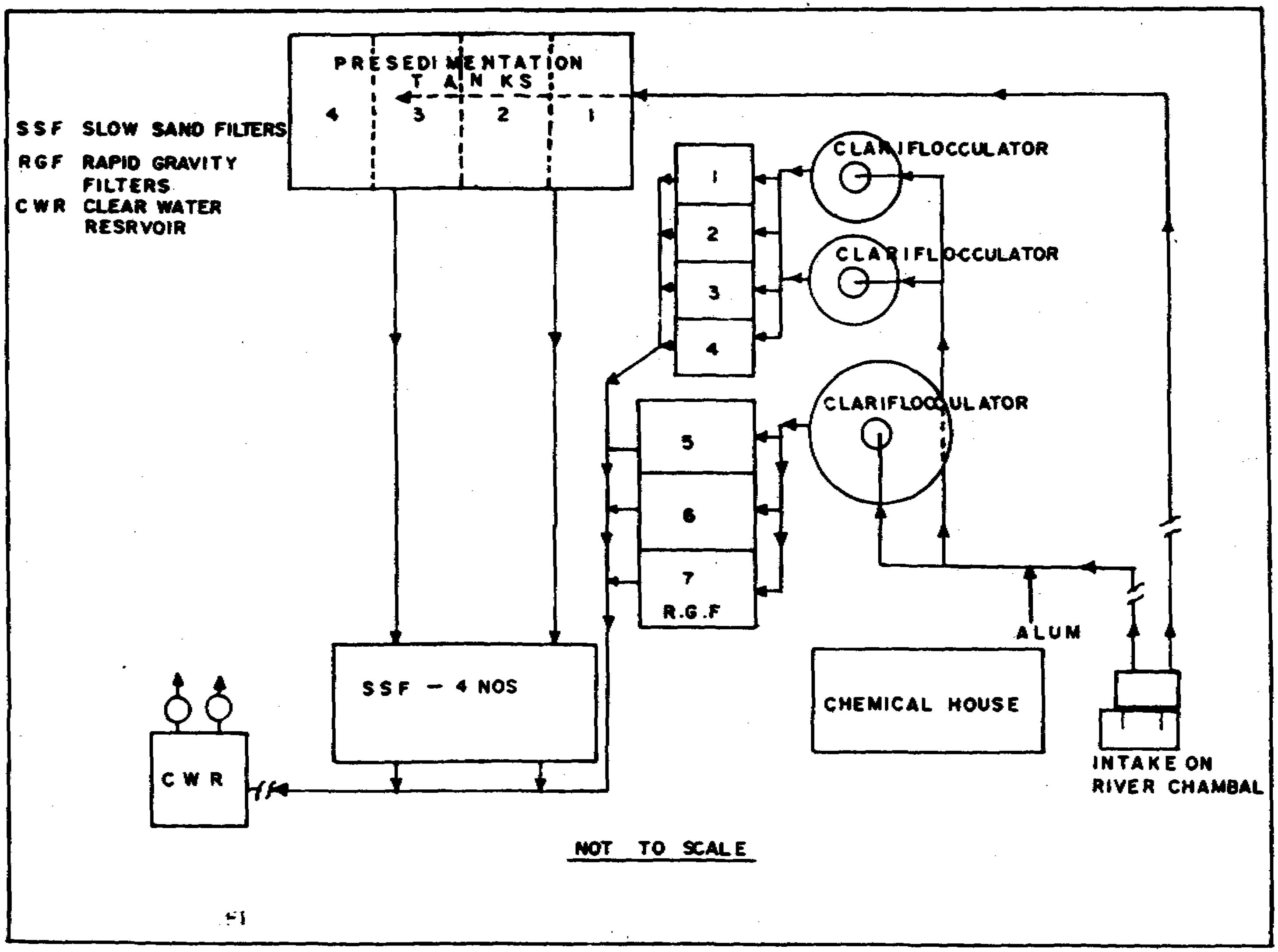


FIG 18.3 LAYOUT PLAN OF KOTA WATER TREATMENT PLANT

TABLE 18.7

PLANT SUMMARY DATA - KOTA

GENERAL	
Name and location	: Kota water works, Akelgarh, Kota
Year of construction (Augmentation if any)	: RSF in 1956 (SSF in 1927)
Design capacity	: 18.2 mld + 6.8 mld (SSF)
O & M Agency	: Public Health Engineering Department, Govt.of Rajasthan
Raw water source	: River Chambal
Treatment flowsheet	: Conventional with rapid gravity filtration (RGF), Slow sand filtration (SSF) with pre-sedimentation
ENGINEERING	
Raw water pumping	: Centrifugal, 3 intake pump stations
-Rising main diameter	: 450 mm for SSF & 450 mm for RGF
Raw water flow measurement	: Venturi flume
Pre-treatment	
Presedimentation tanks	: For SSF, 4 Nos, 31 m x 31 m
Coagulation	
- Chemicals used	: Alum (only during rainy season), solution feed
- Type of mixing	: Mechanical
Flocculation	
- Method / Type of unit	: Mechanical(clariflocculator)
- No. of unit(s)	: 1 No.
- Detention time	: 30 min

Sedimentation

- Type of unit(s)	: Circular clarifier	
- No. & size of unit(s)	: 1 No., 27.4 m dia.	
- Surface overflow rate	: 1 m/hr.	
- Detention time	: 2 hrs.	

Filtration

- Type of unit(s)	: SSF- 8 Nos,	RGF- 3 Nos
- Size of unit(s)	: 20.1m x 21.3m each	7.8m x 6.2m each
- Rate of filtration	: 0.1 m/hr	4.8 m/hr
- Filter media		
. Depth of sand	: -	60 cm
. No. of gravel layer	: -	5 to 6
. Depth of each layer	: -	15 cm
- Backwash arrangements		
. Method	: -	Air scour & water wash
. Wash water tank cap.	: -	227 m^3

Disinfection

- Chemicals used	: Chlorine gas/ Bl.powder
- Type of feed	: Solution feed
- Chlorinator Details	: 5 Nos

Clear Water Pumping

- No.& Cap.ofreservoir	: One, 2724 m^3
- Pump details	: Two pumps of 680 m^3/h capacity each + 2 standby

TABLE 18.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

KOTA WATER WORKS - KOTA

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity(NTU)	2.8	2.6	3.4	1.3
pH	8.1	8.0	7.5	-
Total Alkalinity ($CaCO_3$)	92	94	80	-
Conductivity (μS/cm)	230	270	150	155
Hardness ($CaCO_3$)				
Total	108	132	240	-
Carbonate	92	94	80	-
Non Carbonate	16	38	160	-
Calcium (Ca)	29	37	29	-
Magnesium (Mg)	9	10	41	-
Chlorides (Cl)	15	23	12	-
Sulphates (SO_4)	2	3	2	-
Iron (Fe)	0.1	0.1	0.4	-
Bacteriological (MPN/100 ML)				
Total coliform	28	0	75	0
Fecal coliform	0	0	43	0
E.coli	0	0	23	0
Fecal streptococci	4	0	4	0

All values except pH,turbidity and conductivity are expressed as mg/l

TABLE 18.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

KOTA WATER WORKS - KOTA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	2.8	2.0	0.9	2.6
	II	3.4	1.2	1.2	1.3
T. Coliform (MPN/100 ML)	I	28	43	23	0
	II	75	75	43	0
E. Coli (MPN/100ML)	I	0	0	0	0
	II	23	15	9	0

UDAIPUR WATER WORKS - UDAIPUR

INTRODUCTION

Udaipur, the city of lakes is a popular tourist resort. The lakes Fateh Sagar and Pichhola are the main sources of water supply to the city. The first water treatment plant of 3.4 mld was commissioned in 1932 at Fateh Sagar and the capacity was subsequently augmented by construction of additional plants. Doodh Talai water works of 13.6 mld capacity situated at Pichhola jheel has been selected for study. The plant provides for pre-chlorination followed by conventional treatment with rapid sand filtration and post-chlorination. The schematic flow sheet for the plant is shown in Fig.18.4 and the summary data is presented in Table 18.10. The plant is maintained by PHED, Govt. of Rajasthan.

PLANT APPRAISAL

Raw water quality and flow measurement

During the evaluation study, due to total failure of monsoon, water available in lake was not adequate to run the plant at its rated capacity. It was underloaded to the extent of 40 to 50 per cent and, in 1987 summer, raw water from other lakes was pumped to the plant as an emergency measure.

The raw water source is polluted due to human activities like bathing, washing and discharge of hotel wastes and sewage from nearby localities. Growth of water hyacinth was observed in the lake. Raw water had a high chlorine demand and odour problem. The raw water turbidity was low and fairly uniform throughout the year (Table.18.11)

A Venturi flume provided for flow measurement was observed in damaged condition. The raw water flow could not be measured during the visit by any accurate method.

Pretreatment

Considering the pollution level, the raw water is prechlorinated with 5 to 8 mg/l of chlorine round the year. The chloronome was out of order and chlorine gas was directly fed into the channel through locally fabricated column. Frequent leakage of gas has resulted in the corrosion of metallic fixtures at plant site.

During the first visit, alum dosing device was found to be out of order and manual feeding was resorted to. Subsequently, the valves of alum feeding tanks were repaired/replaced. Hydraulic mixing of alum was achieved.

As the plant was underloaded to the extent of 50 per cent, the detention time in clariflocculator was almost double the design value. Even with extended detention time, no appreciable reduction in turbidity was obtained. The turbidity of settled water ranged from 4 to 7 NTU with a raw water turbidity of 6 to 10 NTU (Table 18.12).Due to heavy organic load, settled sludge had become septic and patches of sludge were carried over. The actual alum dose applied for a raw water turbidity of 6 to 10 NTU was quite high (74 ppm). Traces of residual chlorine were observed in settled water.

Filtration

The filter appurtenances such as the rate controllers, rate of flow indicators, and headloss gauges, were not in working condition. Short filter runs of 5 to 6 hrs duration were observed. Backwash rates provided were found inadequate. This was also evident from the high initial headloss of 180-190 cm after backwashing.

Disinfection

Chlorine gas was used for disinfection. The chloronomes were found out of order and chlorine gas leakage has damaged the valves and fittings due to corrosion. Bacteriological quality of clear water from reservoir was satisfactory (Table 18.12).

Laboratory facilities

Presently the laboratory is located at a distance of about 1 km. In order to monitor the performance of the plant effectively, certain instruments like turbidimeter, chloroscope, jar testing machine should be provided at plant site.

RECOMMENDATIONS

* Necessary measures should be taken to prevent pollution at the source.

* Essential equipment like the chloronomes and alum dosing gear should be repaired and reinstalled without delay.

* The clarifier should be desludged regularly to avoid accumulation of sludge and development of anaerobic conditions.

* The backwashing operation should be made more effective so as to leave a clean bed.

* All the filter appurtenances should be repaired and brought into working order to facilitate proper operation and control of the filters.

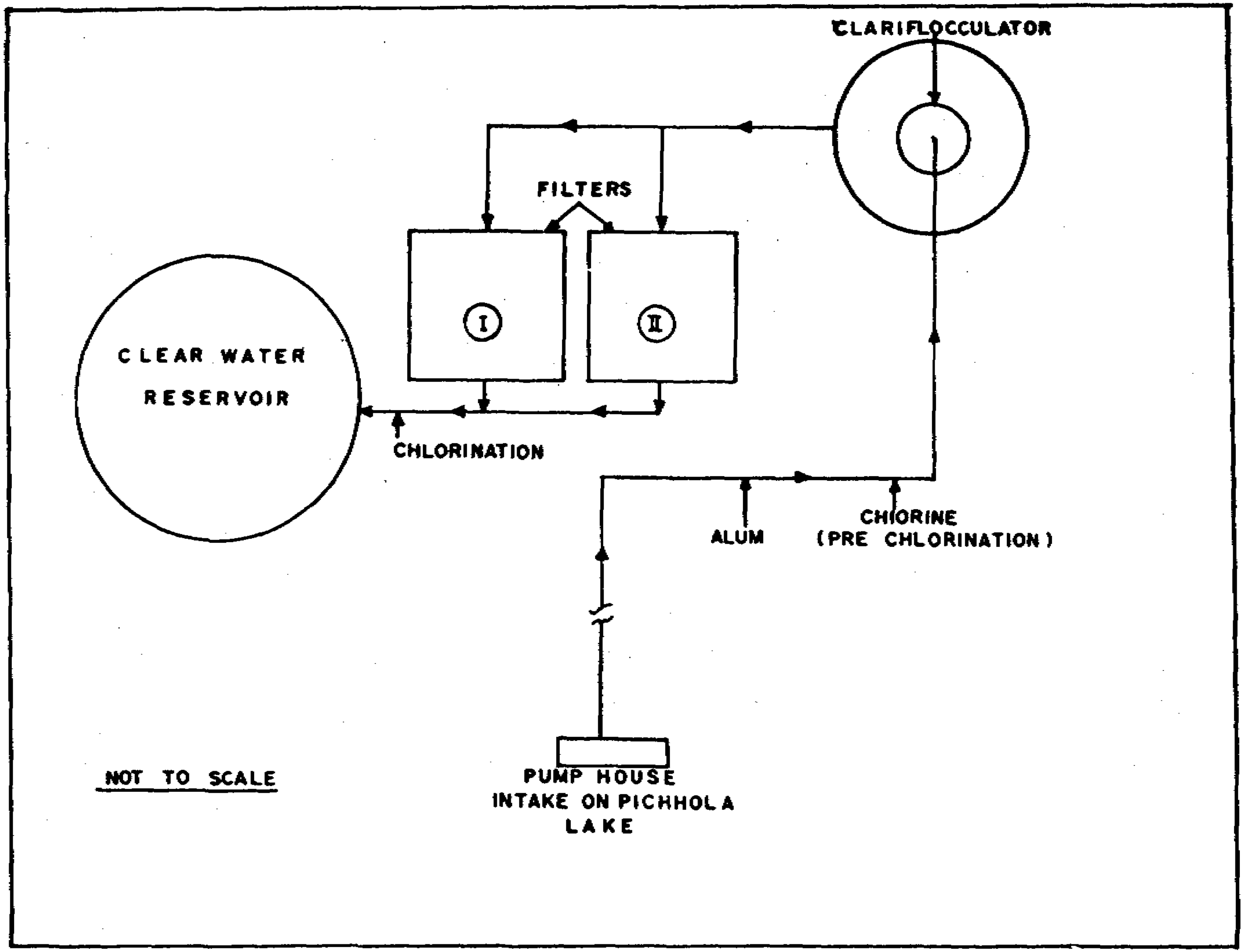


FIG 18.4 LAYOUT PLAN OF DOODHTALAI WATER TREATMENT PLANT - UDAIPUR

TABLE 18.10

PLANT SUMMARY DATA - UDAIPUR

GENERAL	
Name and location	: Doodh Talai Water Works Udaipur (Rajasthan)
Year of construction	: 1975
Design capacity	: 13.6 mld
O & M Agency	: Public Health Engineering Department,Rajasthan
Raw water source	: Pichhola lake
Treatment flowsheet	: Pre-chlorination and Conventional treatment with rapid sand filters
ENGINEERING	
Raw water pumping	: Three, Centrifugal type HP - 125 & 215
-Rising main diameter	: 450 mm
Raw water flow measurement	: Venturi flume
Pre-treatment	
Prechlorination	: Chlorine gas through column type chlorinator
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Hydraulic
Flocculation	
- Method/Type of unit	: Mechanical(clariflocculator)
- No. & size of unit(s)	: 1 No.,12.0 m dia.,4.5 m SWD
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Circular Clarifier
- No. & size of unit(s)	: 1 No.,29 m dia, 4.5 m SWD
- Surface Overflow Rate	: 1 m/hr.
- Detention time	: 4 hrs.

Filtration

- Type of unit(s)	: Rapid gravity filters
- No. & size of unit(s)	: 2 Nos., 7.9 m x 10.7 m each
- Rate of filtration	: 4 m/hr.
- Filter media	
. Sand size	: E.S.-0.64 mm, U.C.-1.56
. Depth of sand	: 60 cm
- Backwash arrangements	
. Method	: Air scour & Water wash
. Wash water tank cap.	: 177 m^3

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: Locally fabricated, column type, 2 Nos.

Clear Water Pumping

- No. & Capacity	: 1 NO., 3600 m^3
- Pump details	: Gravity supply

TABLE 18.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

UDAIPUR WATER WORKS - UDAIPUR

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity(NTU)	10	1.5	6.4	4.2
pH	7.4	7.2	7.9	7.1
Total Alkalinity ($CaCO_3$)	154	138	198	148
Conductivity (µS/cm)	505	520	520	545
Hardness ($CaCO_3$)				
Total	268	-	176	184
Carbonate	154	-	176	148
Non Carbonate	114	-	0	36
Calcium (Ca)	34	-	38	54
Magnesium (Mg)	45	-	20	12
Chlorides (Cl)	62	-	80	84
Sulphates (SO_4)	3	-	15	49
Iron (Fe)	0.4	-	0.3	-
Fluoride (F)	0.3	-	0.1	-
Bacteriological (MPN/100 ML)				
Total coliform	93	23	-	-
Fecal coliform	15	9	-	-
E.coli	4	0	-	-
Fecal streptococci	7	0	-	-

All values except pH,turbidity and conductivity are expressed as mg/l

TABLE 18.12

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

UDAIPUR WATER WORKS - UDAIPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	10	4.2-7.0	2.1-3.8	1.5
	II	6.4	3.8-4.8	2.8-3.2	4.2
T. Coliform (MPN/100 ML)	I	93	4	15	23
E. Coli (MPN/100 ML)	I	4	0	0	0

SIRUVANI WATER WORKS - COIMBATORE

INTRODUCTION

The major source of water supply to the city of Coimbatore is Indira Gandhi reservoir formed by the construction of a dam across river Siruvani. Impounded river water drawn through a 1.5 km long tunnel is provided complete conventional treatment consisting of aeration, alum dosing, flash mixing, flocculation, sedimentation, rapid gravity filtration and disinfection. The plant commissioned in the year 1980 is of 100 mld capacity and serves a population of 12 lakhs and is maintained by Tamil Nadu Water Supply and Drainage Board (TWAD). The schematic flowsheet is shown in Fig. 19.1 and summary data is presented in Table 19.1.

PLANT APPRAISAL

Raw Water quality and flow measurement

Due to impoundment at source, the turbidity of raw water is low and the physico-chemical characteristics do not vary much throughout the year. The turbidity of raw water during study period was in the range of 3.0-4.0 NTU. The raw water is soft having hardness in the range of 9-12 mg/l with low coliform count (Table 19.2).

The raw water inflow to the plant is measured by a venturiflume fitted with a flow indicator, recorder and integrator (Mahindra and Mahindra make). The plant inflow was found to be nearly equal to design capacity of the plant.

Pre-treatment

The diffused air aeration system provided at the plant was not functioning. Alum in the form of solution is applied at the raw water channel after aeration chamber. Due to very low turbidity, alum dose was also found to be low (16 mg/l). The chemical pre-treatment was effective as evidenced by good floc formation.

The turbidity of settled water was 0.23 to 1.8 NTU. Significant reduction in coliform count was also observed due to flocculation and sedimentation. The clarified water recorded either zero or single digit bacterial count during the study (Table 19.3).

Filtration

The rapid gravity filters were operated at an average filtration rate of 6 m/hr. The filters were well-maintained. The normal filter run when the turbidity was low was 48 hrs. The rate of flow indicators and loss of head gauges provided were in good working condition. The filters are backwashed using filtered water preceded by air-scour. The rate of backwash water is about 36 m /hr and delivered at about a static head of 15 m. Flow measuring devices for backwash water and compressed air have been provided.

The filtrate turbidity varied from 0.23 NTU to 0.6 NTU with nil count of E.coli. The functional efficiency of the filters was very good and the operation and maintenance of filters quite satisfactory.

Disinfection

The disinfection of filtered water is carried out at the clear water reservoir using bleaching powder solution. The finished water at the plant had a residual chlorine of 0.4-0.5 mg/l and was free from coliforms.

Laboratory facilities

No laboratory facility is available at the plant site.

RECOMMENDATION

* Adequate laboratory facilities with minimum required equipment and trained chemist should be provided at the plant to ensure proper operation and control of the plant.

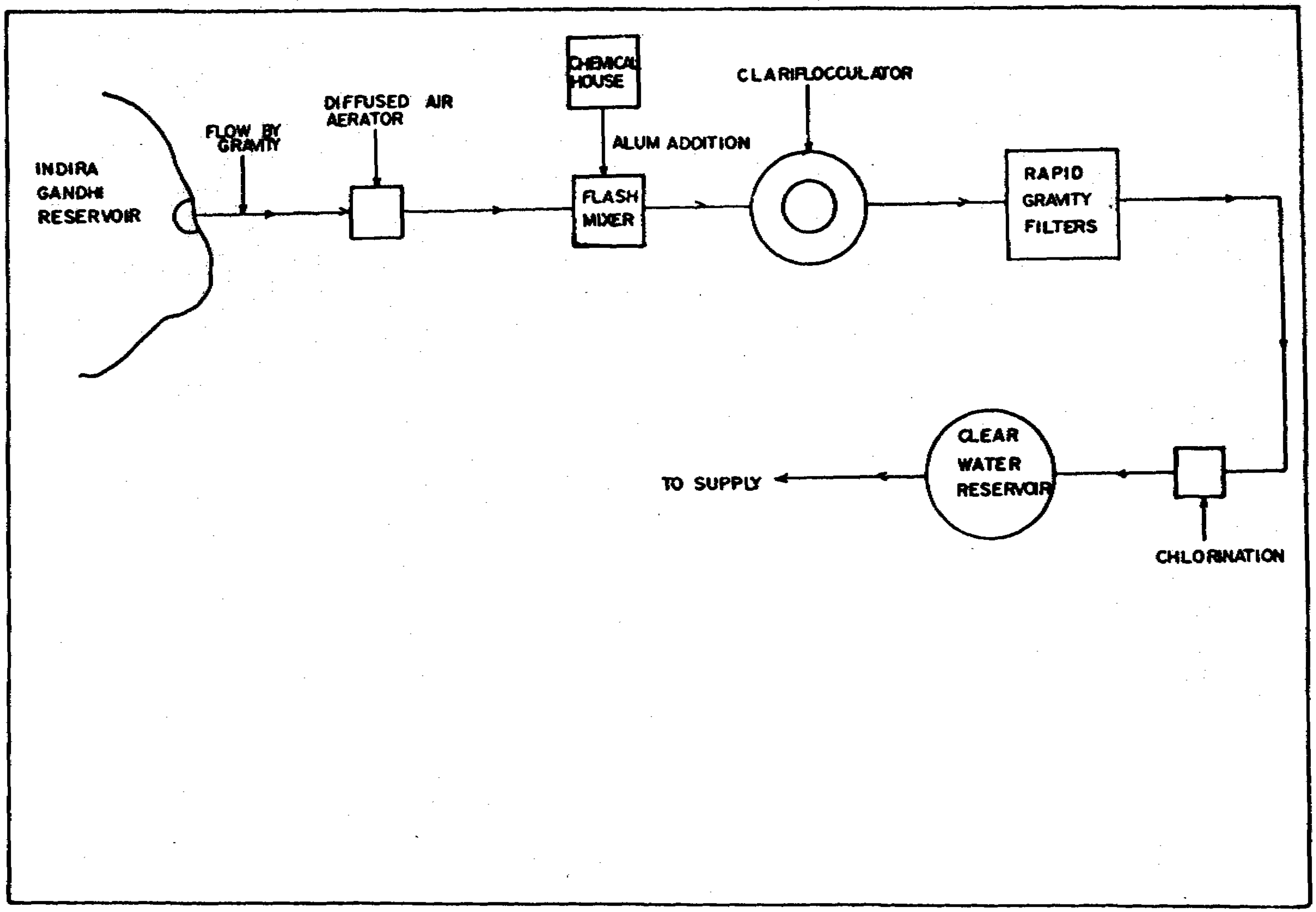


FIG 19.1 COIMBATORE WATER TREATMENT PLANT - SCHEMATIC

TABLE 19.1

PLANT SUMMARY DATA - COIMBATORE

GENERAL	
Name and location	: Siruvani Water Works Coimbatore
Year of construction	: 1980
Design capacity	: 101.4 mld
O & M Agency	: Tamilnadu Water Supply and Drainage Board (TWAD)
Raw water source	: Indira Gandhi Reservoir across river Siruvani
Treatment flowsheet	: Conventional with Rapid sand filters
ENGINEERING	
Raw water pumping	: Flow by gravity
Raw water flow measurement	: Mahindra and Mahindra flowmeter
Pre-treatment	
Aeration	: Diffused aeration system 16.2 x 23.4 m chamber
Coagulation	
- Chemicals used	: Alum (Solution)
- Type of mixing	: Flash mixer,2nos
- Detention time	: 1 min
Flocculation	
- Method / Type of unit	: Mechanical/Clariflocculator
- No. & Dimensions	: 2 nos, 17 m dia,4 m SWD
- Detention time	: 30 min

Sedimentation

- Type of unit(s)	: Clariflocculator
- No. & size of unit(s)	: 2 nos, 52 m dia, 3 m SWD
- Surface overflow rate	: 1.1 m/hr
- Detention time	: 180 minutes

Filtration

- Type of unit(s)	: Rapid Gravity Filters
- No. & size of unit(s)	: 16 nos, 7.4 x 8.6 m(twin bed) each
- Rate of filtration	: 4.5 m/hr
- Filter media	
. Depth of sand	: 62 cm
. Gravel size & depth	: 3-6 mm 15 cm depth 6-10mm 10 cm 10-13 mm 10 cm 13-37 mm 7.5 cm 37-55 mm 7.5 cm
- Backwash arrangements	
. Method	: Air scour and water wash
. Wash water tank cap.	: 5 lakhs litres

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed, manual

Clear Water Reservoir

- Type, No. & Capacity	: RCC,One,4500 m^3
- Pumg details	: Gravity supply

TABLE 19.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

SIRUVANI WATER WORKS - COIMBATORE

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	4.0	0.2	3.7	0.5	3.0	1.3
pH	6.8	6.7	7.6	7.4	7.7	7.7
Total Alkalinity ($CaCO_3$)	12	10	21	19	12	10
Conductivity (µS/cm)	51	43	269	258	66	63
Hardness ($CaCO_3$)						
Total	8	8	9	8	12	12
Carbonate	8	8	9	8	12	12
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	3	3	2	2	3	3
Magnesium (Mg)	1	1	1	1	1	1
Chlorides (Cl)	5	5	7	6	5	5
Sulphates (SO_4)	2	3	2	3	2	3
Iron (Fe)	0.2	0.1	0.3	0.3	0.2	0.1
Fluoride (F)	0.1	0.1	0.1	0.1	0.1	0.1
Bacteriological (MPN/100 ml)						
Total coliform	1100	0	11000	0	70	0
Fecal coliform	1100	0	750	0	7	0
E.coli	28	0	230	0	4	0
Fecal streptococci	460	0	4600	0	9	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l

TABLE 19.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

SIRUVANI WATER WORKS - COIMBATORE

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	4.0	0.23	0.39	0.19
	II	3.7	1.2	0.7	0.5
	III	3.0	1.8	0.6	1.3
T.Coliform (MPN/100 ml)	I	1100	0	9	0
	II	11000	7	4	0
	III	70	0	15	0
E.Coli (MPN/100 ml)	I	28	0	0	0
	II	230	0	0	0
	III	4	0	0	0

KILPAUK WATER WORKS - MADRAS

INTRODUCTION

Madras, the capital of Tamil Nadu is the fourth largest metropolis in the country and has a population of 32.7 lakhs as per 1981 census. The city draws its water supply from four reservoirs, viz. (i) Poondi.(ii) Cholavaram,(iii) Red Hills and (iv) Chembarampakkam. The first three are interconnected by open channels and RCC mains and water from Poondi and Cholavaram can flow by gravity to Red Hills. These three lakes supply about 200 mld of water to the city through its treatment works at Kilpauk.

In addition about 53 mld of ground water extracted from Minjur, Panjetty and Tamaraipakkam well fields is supplied to the industries. The city supply has been augmented by about 25 mld from the above well fields. About 7 mld of water is being extracted from Thiruvanmiyur and southern coastal aquifer south of Thiruvanmiyur. Thus, the quantity of water that can be supplied to the city in a year of normal rainfall is about 240 mld.

The Kilpauk water works consists of old slow sand filters of 68 mld capacity and rapid gravity filters of 182 mld capacity with conventional pre-treatment comprising of alum addition, coagulation, flocculation and sedimentation. The plant layout is shown in Fig. 19.2 and the summary data is presented in Table 19.4. The plant is maintained by Madras Metropolitan Water Supply and Sewerage Board (MMWSSB).

PLANT APPRAISAL

Raw water quality

Being from an impounded source, the raw water has a low turbidity. During the evaluation study the turbidity of raw water was in the range of 5.5 to 8.8 NTU with a coliform content of 2400 to 4600 MPN per 100 ml. During drought periods, ground water from the well fields is blended with surface water due to which the dissolved solids in the raw water goes high (Table 19.5).

Water from Red Hills lake is drawn for treatment through an intake tower and twin roughing filter basin which arrests floating coarse material. During summer, when the water level falls below the bottom-most inlet, raw water is pumped into the conduits. Bathing and cattle washing by people from the nearby village were observed in the vicinity of the intake.

Pre-treatment

Rapid gravity filter system

Raw water is received at the treatment plant in two sump wells where pre-chlorination is carried out. The chlorine dose varies from 3 to 5 mg/l. Chlorine gas from cylinder is fed directly into the water and this practice leads to loss of chlorine gas. Pre-chlorinated water is then pumped to an elevated stilling chamber with a weir where alum solution is added. The flow over the weir creates heavy turbulence thereby achieving initial mixing. Lime (3 to 10 mg/l) is also added to raw water as a coagulant aid. The dose of lime is applied in the flow distribution box located near the clariflocculators.

No reduction in turbidity of raw water was observed due to sedimentation and the settled water turbidity was more than raw water turbidity. This is attributed to use of lime slurry, improper flocculation and insufficient alum dose (Table 19.6).

Filtration

There are 24 nos. of rapid gravity filters with a total output of 182 mld at a filtration rate of 3.8 m/hr. Depth of sand in all the filters was 62 cm with an E.S greater than 0.75 mm. Normal filter runs was reported to be 24 to 48 hrs. Filter backwash is preceded by air scour for 2 minutes. Rate of application of wash water found to be 24 m/hr (which is less than CPHEEO recommended rate). The performance of the filters was not satisfactory as judged by the turbidity of filtered water which was in the range of 1.5-6.7 NTU (Table 19.6)

Slow sand filter system

There are 14 slow sand filter beds with design filtration rate of 0.06 m/hr as against the normal rate of 0.1 m/hr. Raw water is directly admitted into the filters. Occassionally prechlorination is practised to control algal problem. Depth of sand in the filters was only 15-20 cm. Sand washing machines have been provided at the plant to wash the sand and reuse the same in the bed. During times of acute shortage of raw water in the lake, the filters are operated intermittently on alternate days. Normal filter runs were reported to be 3 to 6 months with a maximum permissible headloss of 60 cm. The performance of the filters was not satisfactory. The turbidity of filtered water was in the range of 2.2 - 5.4 NTU and coliform MPN in the range of 23 to 240 per 100 ml.

Disinfection

Post-chlorination is carried out in the clear water reservoir by directly bubbling chlorine gas. Residual chlorine in finished water was 0.5 to 0.6 mg/l. Chlorination was found to be effective as observed from the absence of coliform and E.coli in the finished water.

Laboratory facilities

The plant has a well-equipped laboratory with trained staff to carry out physico-chemical and bacteriological analysis of water. Water quality monitoring is carried out systematically and records are well maintained.

RECOMMENDATIONS

* A perennial source of raw water of adequate and reliable yield should be identified to make optimum use of the treatment plant capacity - A flow measuring device should be installed to record the raw water inflow and facilitate its regulation and control of chemical dosing and other unit operations of the plant.

* The filter appurtenances such as rate of flow indicators, should be rectified for proper operation and control of the filters.

* The Slow sand filters should have a minimum sand depth of 45 cm to ensure satisfactory performance and practice of intermittent operation should be discontinued in favour of continuous operation.

* Direct addition of chlorine gas from chlorine cylinder should be avoided and the chlorinator should be repaired and put to use.

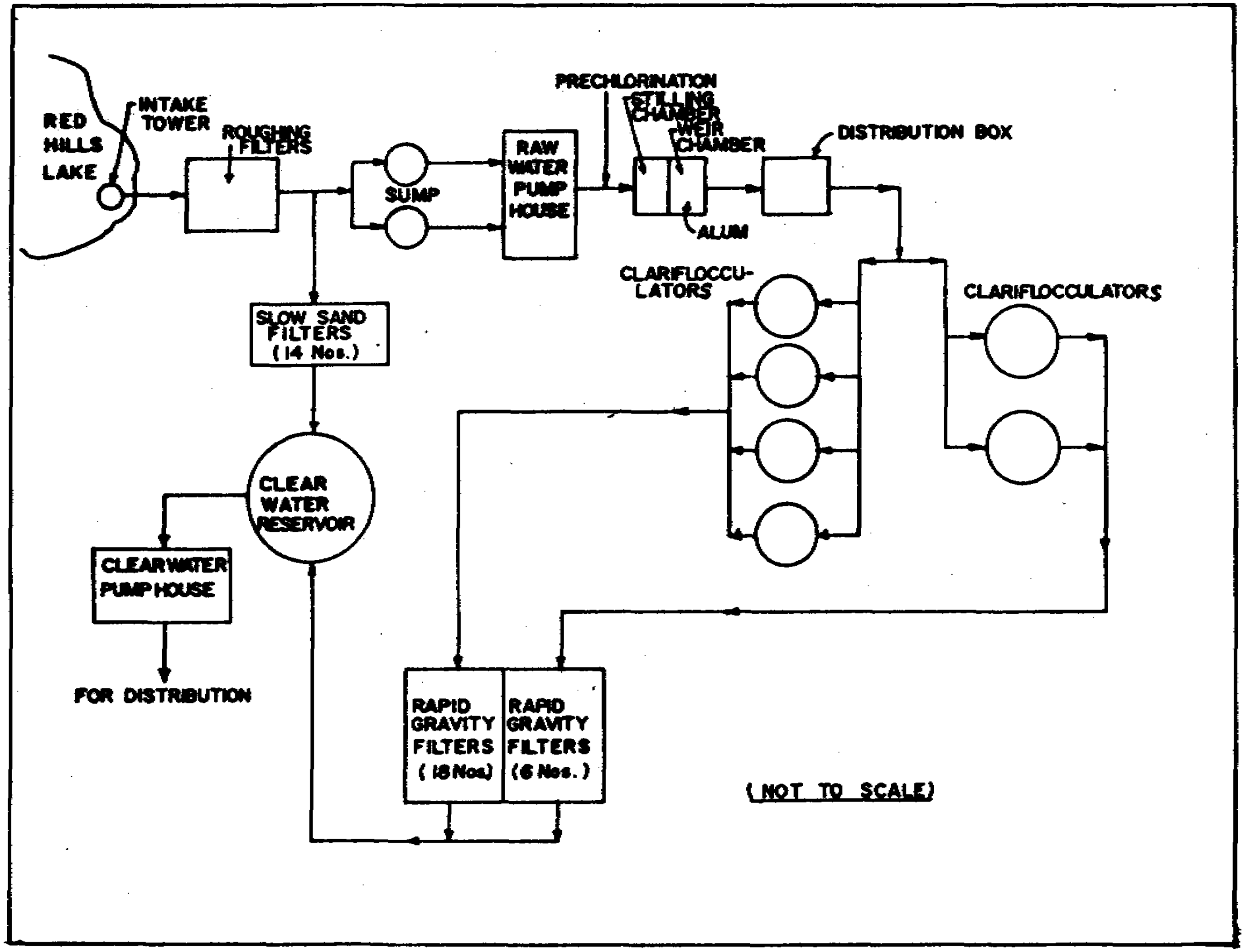


FIG 19.2 LAYOUT PLAN OF KILPAUK WATER TREATMENT PLANT, MADRAS

TABLE 19.4

PLANT SUMMARY DATA - MADRAS

GENERAL	
Name and location	: Kilpauk Water Works Madras
Year of construction (Augmentation if any)	: 1957 (Augumented in 1969 by 136 mld).
Design capacity	: 250 mld
O & M Agency	: Madras Metropolitan Water Supply and Sewerage Board (MMWSSB).
Raw water source	: Poondi, Cholavaram and Red Hills lakes (interconnected)
Treatment flowsheet	: i) Conventional with Rapid sand filters - 182mld ii) Slow sand filters - 68 mld
ENGINEERING	
Raw water pumping	: Six pumps 220 HP;72 m^3/min - 2 nos. 120 HP;31.8 m^3/min - 1 no. 51 HP ;15.9 m^3/min - 2 nos. 105 HP;31.8 m^3/min - 1 no.
Raw water flow measurement	: Sharp edged suppressed weir of length 4.8 m.
Pre-treatment	
Coagulation	
- Chemicals used	: Alum and lime (solutions)
- Type of mixing	: Hydraulic jump
Flocculation	
- Method/Type of unit	: Mechanical(Clariflocculators)
- No. & Dimensions	: 6 nos, 11 m dia x 4.3 SWD 2 nos. 22.7 mld each 15.5 m dia x 5.5 m SWD-4 nos. 34 mld each
- Detention time	: 27 min-2 nos, 42 min-4nos

Sedimentation

- Type of unit(s)	: Mechanical/Clariflocculators	
- No. & size of unit(s)	: 6 nos, 30.5 m dia x 4.3 m SWD 2nos. 22.7 mld each 42.7 m dia x 5.5 m SWD, 4 nos, 34 mld each	
- Surface overflow rate	: 1.5 m/hr (22.7 mld) 1.1 m/hr (34 mld)	
- Detention time	: 2 hrs 50 min (22.7 mld) 4 hrs 50 min (34 mld)	

Filtration

- Type of unit(s)	: Rapid Sand	Slow Sand
- No. & size of unit(s)	: 24 nos 11 m x 7.6 m	14 nos, 61 m x 55 m
- Rate of filtration	: 3.8 m/hr	0.06 m/hr
- Filter media		
. Sand size	: E.S. - 0.3 mm	
. Depth of sand	: 62 cm	15 cm
. Gravel size	: 2.5 mm-50 mm	9 mm-18 mm
. Depth of Gravel	: 40 cm	10 cm
- Backwash arrangements		
. Method	: air scour and water wash	
. Wash water tank cap.	: 340.5 m^3	

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Solution feed
- Chlorinator Details	: 6 nos,capacity 12.5 kg/hr
Clear Water pumps	: 7 nos, each 575 HP, 5.450 m^3/hr 3 nos. 325 HP, 2.72 m^3/hr -4 nos.

TABLE 19.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

KILPAUK WATER WORKS - MADRAS

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	5.5	-	8.8	4.2	6.0	2.0
pH	7.8	7.6	7.9	8.0	8.2	8.0
Total Alkalinity ($CaCO_3$)	34	28	118	130	206	154
Conductivity (μS/cm)	697	680	337	825	880	790
Hardness ($CaCO_3$) Toatal	78	72	145	170	240	200
Carbonate	34	28	118	130	206	154
Non Carbonate	44	44	27	40	34	46
Calcium (Ca)	14	11	44	48	90	70
Magnesium (Mg)	·10	10	9	12	4	6
Chlorides (Cl)	41	67	67	80	125	100
Sulphates (SO_4)	13	15	53	62	62	59
Iron (Fe)	Tr	Tr	ND	ND	ND	ND
Fluoride (F)	-	-	<0.1	<0.1	<0.1	<0.1
Bacteriological (MPN/100 ml)						
Total coliform	2400	0	4600	0	2400	0
Fecal coliform	2400	0	150	0	15	0
E.coli	-	0	23	0	9	0
Fecal streptococci	1500	0	210	0	240	0

All values except pH, Turbidity and Conductivity are expressed as mg/l ND- Not detectable Tr.- Traces

TABLE 19.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

KILPAUK WATER WORKS - MADRAS

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER RGF	FILTERED WATER SSF	FINISHED WATER
Turbidity (NTU)	I	5.5	8.2	6.7	5.4	6.4
	II	8.8	13.6	2.5	2.2	4.2
	III	6.0	3.5	1.5	3.5	2.0
T.Coliform (MPN/100 ml)	I	2400	0	-	240	0
	II	4600	9	9	23	0
	III	2400	0	0	93	0
E.Coli (MPN/100 ML)	I	-	-	-	-	-
	II	23	0	0	0	0
	III	9	0	0	0	0

AGARTALA WATER WORKS - AGARTALA

INTRODUCTION

Agartala, the capital of Tripura State with a population of 1.31 lakhs (1981 census) meets its water needs from surface as well as ground water sources. The municipal water works of capacity 6.8 mld constructed in 1966 and situated near college Tilla was taken up for evaluation. The treatment plant draws raw water from river Howrah and provides for aeration, coagulation, flocculation, sedimentation, rapid gravity filtration and disinfection. The schematic flowsheet is shown in Fig. 20.1 and summary data is present in Table 20.1. The plant is maintained by the PHED, Govt. of Tripura.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from river Howrah drawn through an intake well, is pumped to the treatment works situated 100 m away. The screens provided at the intake well were found corroded. Considerable human activity was observed in the river near the raw water intake point. During the evaluation study, the turbidity of raw water was 37 NTU. Due to prevailing pollution, raw water coliform count was in the range of 3500-24000 per 100 ml (Table 20.2).

Plant inflow as measured at the 'V' notch was found to be nearly equal to design flow ; however, the plant was operated only for about 18 hours a day due to intermittent power supply which is reported to be a regular feature.

Alum is used as the coagulant and the solution is applied in the channel leading to the flocculators. Lime addition is also practised occasionally. No mechanical flash mixer is provided and chemical mixing is achieved in the baffled channel. The performance of the clariflocculator was satisfactory as observed by the considerable reduction in turbidity as well as bacterial count in the settled water (Table 20.3).

Filtration

The rate of flow and headloss indicators of the filters were not in working condition. Depth of sand in the filters was around 60 cm. Filters were backwashed using air and water after 24 hrs of filter run. Backwashing was ineffective as observed from the persence of mudballs in the filters. In general, the performance of the filters was not satisfactory and the filtrate turbidity was in the range of 4-4.6 NTU.

Disinfection

Bleaching powder is used for chlorination of filtered water. The chlorine demand of filtered water was 1.0 mg/l and the finished water had a residual chlorine of 0.2 mg/l and was found to be free from coliforms.

Laboratory facilities

A fairly well equipped laboratory with a chemist for routine testing and plant control is available at the plant. However, most of the instruments were not in working condition.

RECOMMENDATIONS

* Immediate measures should be taken to prevent pollution of raw water due to human activities near intake well.

* The filter backwashing operation should be improved to keep the filters clean and to avoid mudball formation. The filter appurtenances need to be repaired and maintained in working condition to facilitate proper operation and control.

* The instruments in the laboratory should be got repaired/replaced to monitor water quality and plant control.

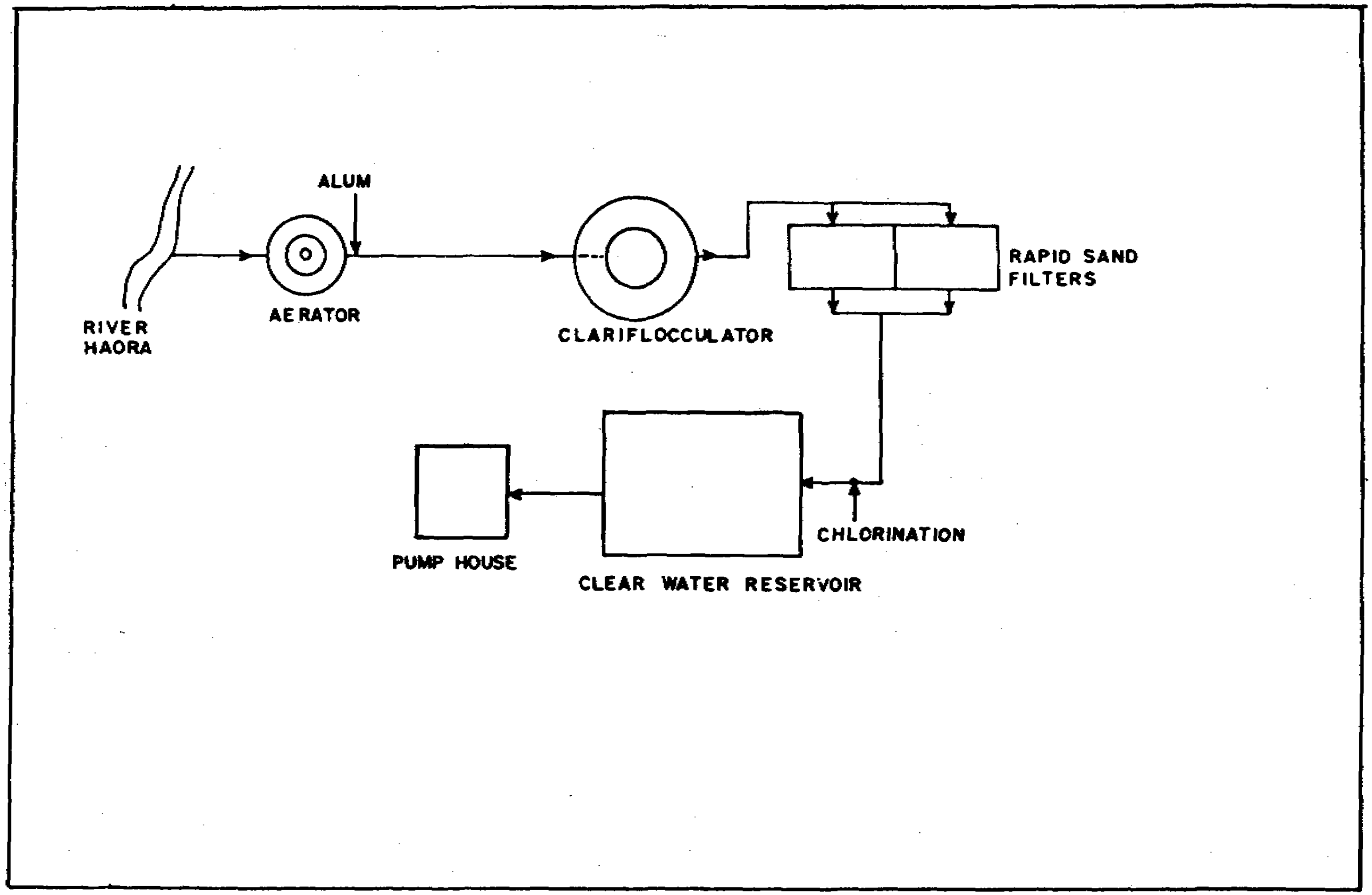


FIG 20.1 AGARTALA WATER TREATMENT PLANT - SCHEMATIC

TABLE 20.1

PLANT SUMMARY DATA - AGARTALA

GENERAL	
Name and location	: Agartala Water Treatment Plant, College Tilla.
Year of construction	: 1966
Design capacity	: 6.8 mld
O & M Agency	: Public Health Engineering Department Agartala
Raw water source	: River Haora
Treatment flowsheet	: Conventional with Rapid Sand Filters
ENGINEERING	
Raw water pumping	: Three nos, centrifugal pumps, each of capacity 189.3 m^3/hr (one Standby)
-Rising main diameter	: 45 cm
Raw water flow measurement	: V notch
Pre-treatment	
Aeration	: Cascade aerator
Coagulation	
- Chemicals used	: Alum (7% solution)
- Type of mixing	: Hydraulic
- Method of mixing	: Rectangular channel with 10 baffles each of size 0.5 x 0.15 x 0.5 m, placed
- Detention time	: 35 sec
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Dimensions	: One, 5.3 m dia, 4.0 m SWD
- Detention time	: 19 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: One no, 21 m dia. and 3.0 m SWD
- Surface overflow rate	: 0.87 m/hr
- Detention time	: 3 hrs 24 mimutes

Filtration

- Type of unit(s)	: Rapid Sand Filters
- No. & size of unit(s)	: 2 nos, 9.8 x 4.5 m each (twin bed)
- Rate of filtration	: 4.8 m/hr
- Filter media	
. Sand size	: E.S.- 0.55 mm, U.C.-1.5
. Depth of sand	: 60 cm
. Gravel size	: 5 mm to 25 mm
. Depth of each layer	: 4 layers each 11 cm
- Backwash arrangements	
. Method	: Air scour & Water wash
. Wash water tank cap.	: 75.7 m^3

Disinfection

- Chemicals used	: Bleaching powder
- Type of feed	: Solution feed

Clear Water Reservoir

- Type, No. & Capacity	: RCC, one, 15 lakh lits.
- Pump details	: 3 nos, centrifugal pumps each of capacity 189 m^3/hr

TABLE 20.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

AGARTALA WATER TREATMENT PLANT - AGARTALA

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	37	4.6	36	4
pH	7.0	7.0	7.0	7.0
Total Alkalinity ($CaCO_3$)	64	52	81	78
Hardness ($CaCO_3$)				
Total	100	125	54	72
Carbonate	64	52	54	72
Non Carbonate	36	73	0	0
Calcium (Ca)	20	20	14	19
Magnesium (Mg)	12	18	5	6
Chlorides (Cl)	5	5	3	7
Sulphates (SO_4)	14	22	12	23
Fluoride (F)	-	-	0.1	0.1
Nitrate (NO_3)	0.4	0.8	0.7	0.5
Bacteriological (MPN/100 ml)				
Total coliform	24000	0	3500	0
Fecal coliform	24000	0	3500	0
E.coli	24000	0	2800	0
Fecal streptococci	16000	-	1100	0

All values except pH and Turbidity are expressed as mg/l

TABLE 20.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

AGARTALA WATER TREATMENT PLANT - AGARTALA

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	37	12	4.6	-
	II	36	11	-	4
T.Coliform (MPN/100 ml)	I	24000	920	23	0
	II	3500	540	330	0
E.Coli (MPN/100 ml)	I	24000	920	13	0
	II	2800	350	130	0

AGRA WATER WORKS - AGRA

INTRODUCTION

Agra water works is the oldest plant in Uttar Pradesh. The first plant with a capacity of 27 mld was constructed in 1888 with plain sedimentation of Yamuna river water followed by slow sand filtration. The plant has been subsequently augmented in stages and the present capacity is 198 mld which is again inadequate to meet the needs of the growing population of the city. The present supply is also supplemented with tube well waters and further augmentation is under consideration.

There are three raw water mains, all interconnected, four clariflocculators, two new settling tanks (Hudson type), four batteries of rapid gravity filters and six slow sand filters as shown in the plant layout (Fig. 21.1). The plant summary data is given in Table 21.1. No detailed drawings were available for any of the plants. The water works is maintained by Agra Jal Sansthan.

PLANT APPRAISAL

Raw water quality and flow measurement

The surface flow in river Yamuna, the source of raw water, has been depleting over the years and is inadequate to meet the needs during summer season. To tide over the situation, water from Keetham reservoir is diverted into river Yamuna during May and June. The surface flow in the river has drifted away from the intake well. A channel about 150 m long, 6-8 m wide and 1-1.2 m deep has been dug to get desired raw water flow at the intake. Constant vigilance is maintained and dredgers are used when necessary to ensure sufficient flow towards the intake well.

The river is heavily polluted in its entire stretch of 200 km. The river water at the intake was highly polluted (chlorine demand 4-8 mg/l), and algae laden. None of the flow measuring devices originally provided at the plant was in working condition. Flow measurement at the time of visit by float method indicated a plant flow of 162 mld.

Pre-treatment

In view of the poor quality of raw water, pre- chlorination has been resorted to. Chlorine gas conveyed through plastic tubing is directly bubbled into the raw water channel at two locations. In the absence of proper diffusers, chlorine gas was escaping into the atmosphere as abandoned by the heavy chlorine experienced in the vicinity. According to plant authorities, prechlorination has helped in the control of algae in various units and in improving the performance of the settling tanks and filters. However, control on pre-chlorination was far from satisfactory.

Alum dosing

Alum solutionising and dosing tanks originally provided near the Parshall flumes are in disuse. Alum filled in a basket made of wiremesh is immersed in the raw water intake well from where the alum mixed water is pumped to the settling tanks/ clariflocculators. Requisite quantity of alum is added hourly into the cage.

As the raw water quality fluctuates, jar tests are conducted regularly and accordingly the number of alum bricks to be added is decided by the plant chemist. Except in baffled-channel flocculator where formation of microflocs was observed, the flocculator paddles were not in working condition.

Sedimentation

During one of the visits, the plant was underloaded to the extent of 14 per cent. The effluent turbidity from the sedimentation tanks and clariflocculators ranged between 2.0 and 5.0 NTU compared to raw water with 8 NTU. The 'Hudson type' sedimentation tanks gave a relatively better performance. During another visit when the raw water turbidity was low, the clarified water did not show any improvement.

Filtration

One battety of rapid sand filters of 45 mld capacity is kept neat and clean. The filter box of 90 mld capacity plant was leaking very heavily at the expansion joints as also all the valves, leading to considerable loss of water. No filter appurtenance is in working condition. Filter operators are illiterate and supervision is poor. Filters are backwashed once in 24 hours irrespective of the headloss or the filtrate turbidity. Large cracks and undulations and mud ball formation were noticed in the sandbed. The backwash water distribution was uneven as observed at the time of backwashing.

The depth of sand in some of the filters was less than 60 cm. The operation and maintenance of the filters was far from satisfactory as confirmed by the poor efficiency of the filters.

In slow sand filters, flow measuring devices were all missing and the flow rate was adjusted by trial and error. The effluent quality from slow sand filters was comparatively better than rapid sand filters.

Disinfection

There are seven chlorinators but all of them were not in working order during the time of visits. Chlorine gas was injected directly into clear water reservoir. The residual chlorine in finished water was satisfactory.

Laboratory facilities and staff

The laboratory facilities provided are adequate with experienced and trained staff. For operation and maintenance of the plant, 12 filter attendants, 5 chlorine mechanics and 40 Khalasis exclusively look after the plant. Apart from this staff from pumping station helps in repair works. Filter operators and khalasi are uneducated and have not received any formal training.

Financial Aspects

The annual expenditure for 1985-86 was 113.2 lakhs whereas the annual revenue from sale of water is 146 lakhs. The staff salary accounts for nearly 54 per cent of the expenditure. Chemicals and energy 16.2 and 10.6 per cent respectively and maintenance and repairs 19.2 per cent.

In view of the frequent change in the raw water quality in river Yamuna, Regular monitoring of river water quality is recommended to enable adequate control on treatment and to ensure a finished water of prescribed standards.

RECOMMENDATIONS

* As the river water source is highly polluted, provision for drawal of raw water directly from Keetham reservoir may be considered as an alternative

* Instead of dumping alum slabs at the intake alum solution should be fed for prechlorination. - Flow measurement devices, filter appurtenances are necessary for proper control over unit operations

* Overhauling of underdrains is necessary. Proper sand and gravel should be provided in the filters.

* Loss of chlorine gas can be avoided by providing packed gravel bed towers for prechlorination in canal water

* Chlorinators are essential for controlled dosing arrangement based on chlorine demand of filtrate

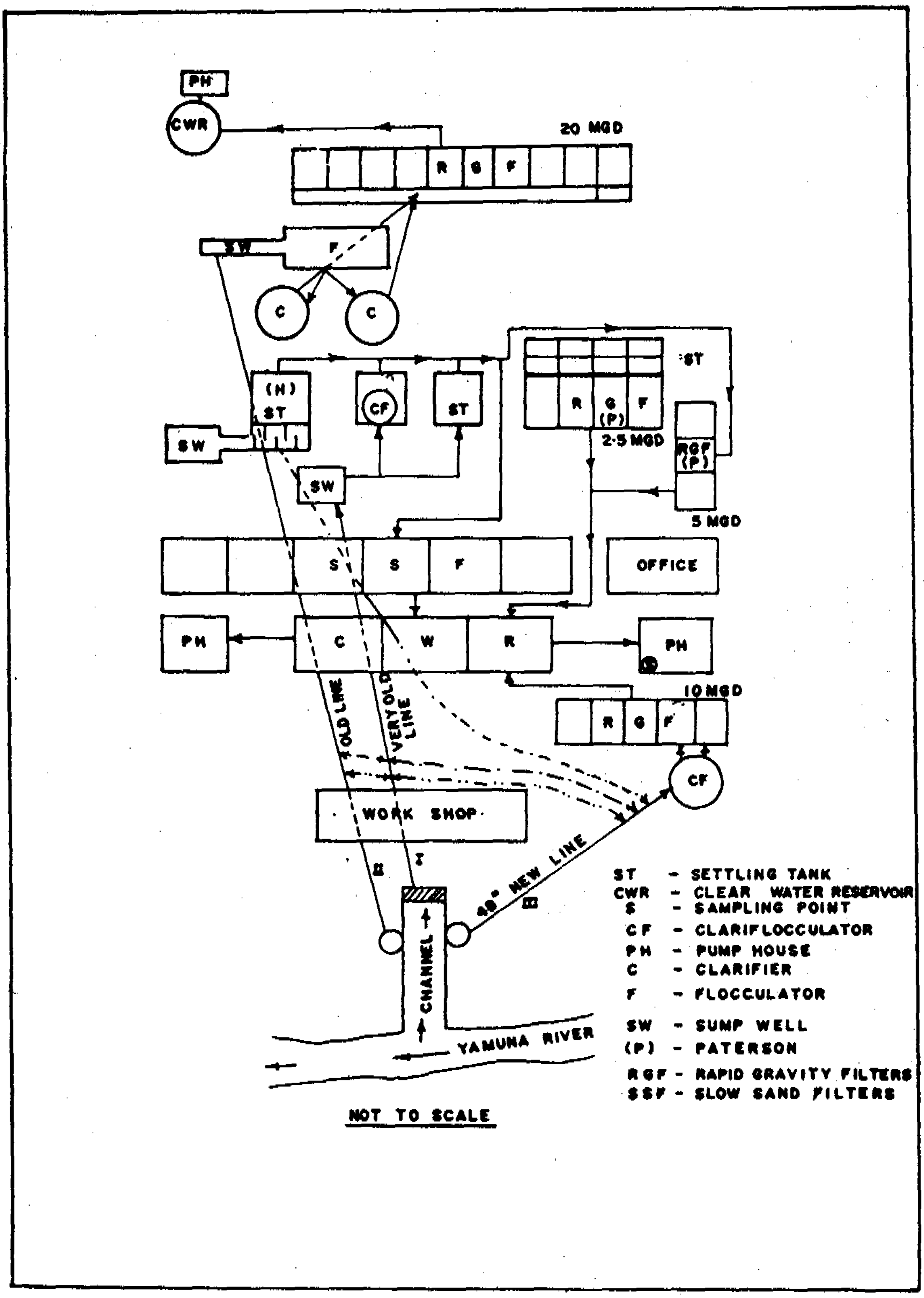


FIG 21.1 LAYOUT PLAN OF AGRA WATER WORKS

Table 21.1

PLANT SUMMARY DATA - AGRA

GENERAL		
Name and location	:	**Agra Water Works near Jawahar bridge**
Year of construction (Augmentation if any)	:	**1888-1929-1954-1964-1976**
Design capacity (mld)	:	**27 39 61 107 198**
O & M Agency	:	**Agra Jal Sansthan**
Raw water source	:	**River Yamuna**
Treatment flowsheet	:	**Conventional with slow sand/rapid sand filtration**
ENGINEERING		
Raw water pumping	:	**Horizontal and Vertical Turbine pumps (3 standby)**
-Rising main diameter (mm)	:	**3 nos., 1100, 1200, 760**
Raw water flow measurement	:	**Parshall flume,4 nos Rectangular notch 1 no**
Pre-treatment		
Coagulation		
- Chemicals used	:	**Alum**
- Type of mixing	:	**Hydraulic/mechanical**
- Method of mixing	:	**Near Parshall flume at intake well and paddles**
Flocculation		
- Method / Type of unit	:	**Mechanical / Hydraulic**
- No. & Dimensions	:	**4 nos., 2.4 x 3.6 m**
- Detention time	:	**35 minutes**

Sedimentation

- Type of unit(s)	:	Pre-settling Rectangular	Circular
- No. & size of unit(s)	:	2	4

Filtration

- Type of unit(s)	:	Rapid Gravity Filters
- Capacity (mld)	:	11.3 22.7 45 91
- No. of unit(s)	:	4 3 5 10
- Size of unit(s) (m)	:	5.4x4.4,7.6x10.9,10.7x7.6,9.1x8.5 ,4.4x4.4
- Rate of filtration	:	4.8 to 6 m/hr
- Filter media		
. Sand size	:	E.S.- 0.5 to 0.7 mm U.C.- 1.5 to 1.8
. Depth of sand	:	60 cm
. Gravel size	:	2.5-6 6-12 12-38 38-50 mm
. Depth of each layer	:	150 75 150 76 mm
- Backwash arrangements		
. Method	:	Air + water through overhead reservoir or direct pumping
. Wash water tank cap.	:	45 and 110 m^3

Filtration

- Type of unit(s)	:	slow sand filters,Rectangular
- No. & size of unit(s)	:	6 nos., (61 x 30.5 m)
- Rate of filtration	:	0.1 m/hr
- Filter media		
- Sand size	:	E.S.- 0.3 to 0.4 mm U.C.- 2.8 to 3.0

- Depth of sand	: 76 cm	
- Depth of each layer	: 200 mm	
- Underains	: Brick work	
- Depth of sand scraping	: 10-20 mm	
- Average time required to put filter back into service after scraping	: 1 to 2 days	
Disinfection		
- Chemicals used	: Chlorine gas/ Bleaching powder	
- Type of feed	: Pressure / gravity	
Clear Water Reservoir		
- Type, No. & Capacity	: Rectangular Lime and brick	RCC
- Number	: 3	3
- Pump details	: Centrifugal, 3 nos.,	Vertical Turbine 13 nos.

TABLE 21.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

AGRA WATER WORKS - AGRA

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	5.0	3.7	8.0	2.0	10	2
pH	8.5	8.0	8.3	8.5	8.1	7.9
Total Alkalinity ($CaCO_3$)	280	220	236	220	200	230
Conductivity(μS/cm)	1535	1680	1960	2050	1470	-
Hardness ($CaCO_3$)						
Total	360	348	312	304	262	288
Carbonate	280	220	236	220	200	230
Non Corbonate	80	128	76	84	62	58
Calcium (Ca)	71	65	48	48	38	35
Magnesium (Mg)	45	47	47	47	41	49
Chlorides (Cl)	114	117	274	274	124	154
Sulphates(SO_4)	-	-	138	131	74	100
Iron (Fe)	0.4	0.1	-	-	2	0.4
Fluoride (F)	-	-	0.5	0.5	0.5	0.6
Nitrates (NO_3)	0.3	2.0	-	-	9.7	6.1
Bacteriological (MPN/100 ML)						
Total coliform	13000	0	24000	17-33	16000	14
Fecal coliform	2300	0	24000	17-33	-	-
E.coli	2300	0	900	0	-	-
Fecal streptococci	0	0	-	-	-	-

All results are expressed as mg/L except for pH, conductivity and Turbidity

TABLE 21.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

AGRA WATER WORKS - AGRA

PARAMETERS	VISIT	RAW	SETTLED	FILTERED	FINISHED
Turbidity (NTU)	I	5.0	4.0-5.0	1.6-4.5	3.5
	II	8.0	2.0-4.8	1.5-3.0	2.0
T.coliform (MPN/100ML)	I	13000	-	46-2400	0
	II	24000	-	11-79	33
	III	16000	230-3500	22-2400	14

BENAZHABER WATER WORKS - KANPUR

INTRODUCTION

The first piped water supply scheme for Kanpur city was commissioned in the year 1892 with a design capacity of 18 mld for a population of 2 lakhs. Since then the supply has been augmented from time to time and presently the supply including that from tube wells is about 200 mld serving a population of nearly 17 lakhs. The raw water source is river Ganga tapped directly and through the lower Ganga Canal. The treatment consists of alum coagulation, flocculation and sedimentation in rectangular settling tanks followed by filtration (both slow and rapid) and chlorination. The plant layout is shown in Fig.21.2 and the plant summary data is given in Table. 21.4 The treatment plant is operated and maintained by Kanpur Jal Sansthan.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from lower Ganga canal passes through two manmade lakes which are now nearly silted up. The dredged channel in river Ganga supplies about 160 mld of raw water to the treatment plant. As the river flow changes very frequently, the maintenance of the channel presents difficulties. Dredging of raw water channel and maintenance of intake and pumps are facilitated by a workshop put up near the site. Wastewater from "Purana nallah" joins upstream of the intake well. The physico-chemical and bacteriological quality of raw water is presented in Table 21.5. Pollution potential of both the canal water and the river water is quite significant. Raw water flow is estimated based on the rated pump capacities as there is no flow indicating and recording devices at the water works.

Pre-treatment

Raw water from dredged channel is pumped to horizontal flow settling basins (1 and 2) operated in parallel. One of the tanks is completely silted up and is full of weeds and aquatic growth. Another tank is out of commission for the last two years for modifications. Works of capital nature including cleaning and desilting of settling tanks is with U.P. Jal Nigam which has not been able to desilt the tanks for want of funds. Due to buildup of silt load on the common wall of settling tanks 2 and 3, part of the wall has collapsed and a temporary wall of sand bags has been provided.

Alum blocks are added to the presettled water in the baffled channel leading to settling tanks 3 and 4. Flocculation in the baffled channel is not complete. The mixer assembly in the flocculator has been removed as it was out of order. Being of very old construction the clariflocculators are in a dilapidated condition. Settling efficiency of the clariflocculators 3 and 4 is satisfactory as indicated by water quality Table 21.6. Due to financial constraints the alum stock available was inadequate to meet even a few days requirements.

Filtration

All the appurtenances of rapid gravity filters are out of order. The depth of sand in the filters is 20-30 cm only and the sand is coarse. The filtration efficiency is very poor. Filter sand is periodically treated with bleaching powder to avoid slime growth and coating on sand grains. In the new plant two filters have been converted into dual media filters with bituminous coal as top layer. These filters are reported to give longer runs with better quality of filtrate than the conventional sand filters. Backwashing of filters is carried out once a day with air scour for 2 minutes followed by waterwash for 10 minutes.

Most of the slow sand filters are with shallow depth of coarse (E.S. 0.44 mm, U.C. 1.8) sand. The normal filter run reported is 60 days. Out of 36 slow sand filters 12 are idle for want of resanding. The filter appurtenances are not in working order. Two filters were under renovation at the time of visit.

Disinfection

There are in all seven chlorinators working satisfactorily. Separate chlorinators have been installed for filtrate from slow sand filters and two batteries of rapid sand filters. The chlorine demand of filtered water is estimated daily and an average 2 - 2.5 mg/l chlorine dose is applied so as to maintain a residual of 1 to 1.5 mg/l at the clear water reservoir. Safety equipment at the chlorine house are available. Pre-chlorination is also practised at the raw water intake channel when river water quality is poor.

Laboratory facilities

Adequate laboratory facilities are available at the plant and water quality testing is done regularly at various stages of treatment. Log books are maintained for bacteriological analysis, turbidity, chlorine applied and plant inflow.

Plant staff

The total staff employed exclusively for water works is about 340 of which only 6 are of supervisory cadre. Most of the operating staff are not qualified and have no formal training in O & M of waterworks.

Financial aspects

The statement expenditure for the year 1985-86 (last available) indicates the following breakup. Chemicals and power 62 per cent, staff salary 35 per cent, operation and maintenance 3.0 per cent.

RECOMMENDATIONS

* The wastewater outfalls upstream of the river intake should be diverted to prevent pollution of raw water.

* Provision for raw water flow measurement should be made to ensure effective chemical dosing and plant control.

* The plain sedimentation tanks which have been silted up, need to be desilted and renovated into 'Hudson type' settlers which have been reported to perform better.

* A flocculation chamber with necessary mixing arrangements should be provided for effective pre-treatment.

* Rapid and slow sand filters need to be resanded with sand of appropriate apecifications so as to provide a filtered water meeting the prescribed quality standards.

* The clear water reservoirs must be cleaned periodically to avoid sludge accumulation.

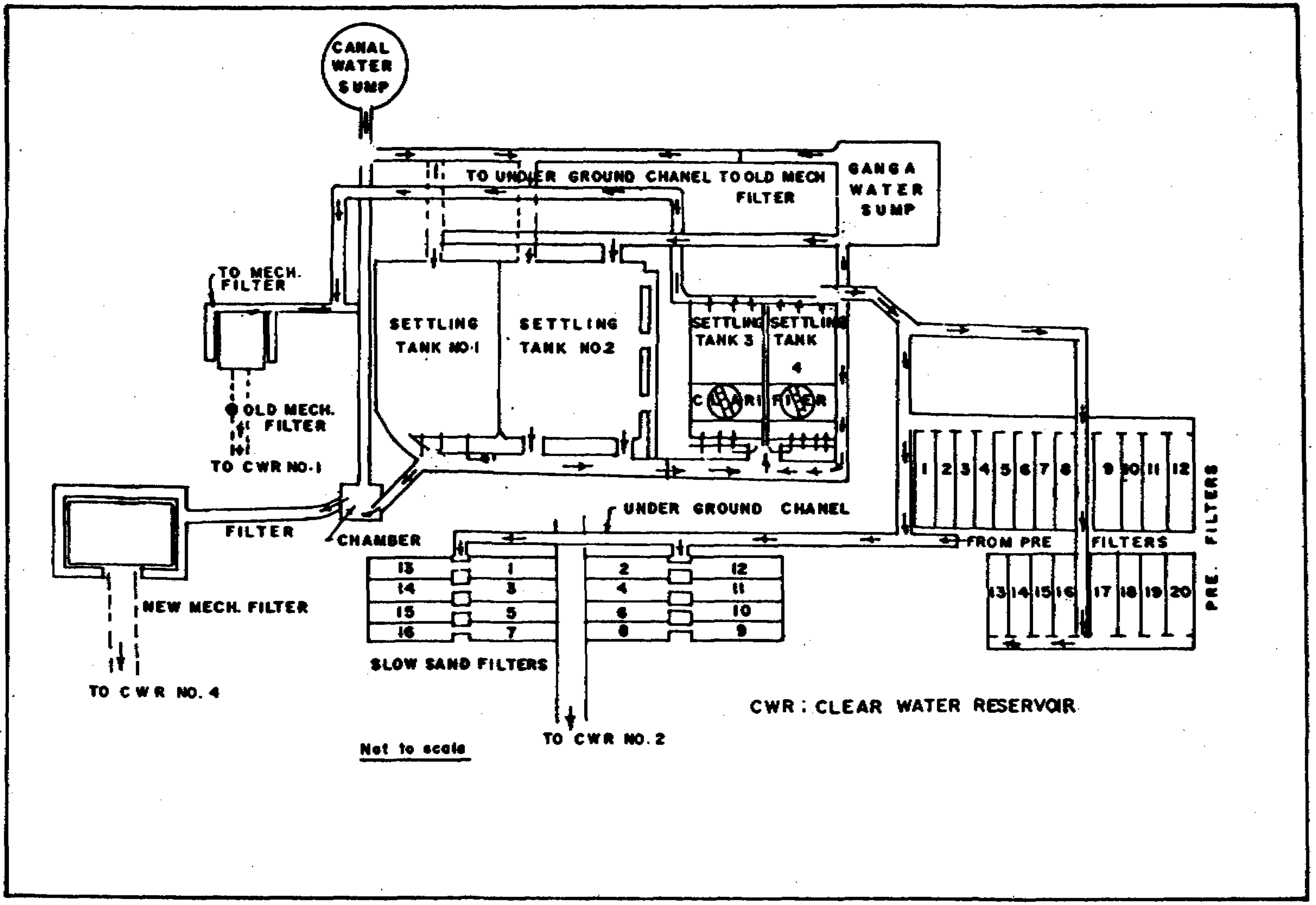


FIG 21.2 LAYOUT PLAN OF BENAZHABER WATER WORKS, KANPUR

TABLE 21.4

PLANT SUMMARY DATA - KANPUR

GENERAL		
Name and location	: Benazaber Water Works, Kanpur	
Year of construction (Augmentation if any)	: 1892 1937 1977	
Design capacity (mld)	: 18 180 138	
O & M Agency	: Kanpur Jal Sansthan	
Raw water source	: River Ganga, lower Ganga canal	
Treatment flowsheet	: Conventional with slow sand/rapid sand filters	
ENGINEERING		
Raw water pumping	: Ganga Vertical 6 nos., 40 HP each	Canal Centrifugal 4 nos., 140 HP each
-Rising main diameter (mm)	: 1 x 1200 mm 1 x 600 mm 2 x 500 mm	1 x 700 mm 1 x 600 mm
Raw water flow measurement	: not available	
Pre-treatment		
Coagulation		
- Chemicals used	: Alum	
- Type of mixing	: Hydraulic	
- Method of mixing	: Near Parshall flume	
Flocculation		
- Method / Type of unit	: Mechanical, Rectangular	

Sedimentation		
- Type of unit(s)	: Secondary Presettling Rectangular	Rectangular
- No. & size of unit(s)	: 2 Nos,	2 Nos 90 x 61 x 4 m
- Detention time	: 1 hr	2 hrs
Filtration		
- Type of unit(s)	: Rapid gravity	Slow sand
- No. & size of unit(s)	: 6, 7.3 x 5.5 m 6, 7.6 x 7.6 m 4, 9.8 x 7.6 m	16,61x30.4 m
- Rate of filtration	: 4.4 to 11.7 m/hr	0.1 m/hr
- Filter media		
. Sand size (mm)	: 0.5-0.7	0.2-0.35
. Depth of sand (mm)	: 60	76
. Gravel size (mm)	: 2.5-50	Brick underdrain
. Depth of each layer	: 7.5 to 15 (cm)	
- Backwash arrangements		
. Method	: Air scour + Water wash	
. Wash water tank cap.	: 327 m^3	
Disinfection		
- Chemicals used	: Chlorine gas	
- Type of feed	: solution feed	
- Chlorinator Details	: Vacuum type	
Clear Water Reservoir		
- Type, No. & Capacity	: RCC, 33450 m^3	
- Pump details	: Centrifugal, 15 nos.	

TABLE 21.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

KANPUR WATER WORKS - KANPUR

PARAMETERS	I VISIT			II VISIT			III VISIT		
	RAW (R1)	RAW (R2)	FINISHED	RAW (R1)	RAW (R2)	FINISHED	RAW (R1)	RAW (R2)	FINISHED
Physico-chemical									
Turbidity (NTU)	30.0	23.0	1.6	14.0	30.0	7.0	6.0	27.0	2.2
pH	8.3	8.0	7.8	8.1	8.1	7.6	7.8	8.2	8.0
Total Alkalinity ($CaCO_3$)	210	120	185	240	120	190	190	135	170
Conductivity(μS/cm)	390	250	370	490	260	-	490	240	490
Hardness ($CaCO_3$)									
Total	116	112	-	184	120	190	138	76	130
Carbonate	116	112	-	184	120	190	138	76	130
Non Corbonate	0	0	-	0	0	0	0	0	0
Calcium (Ca)	37	31	35	43	29	42	-	-	-
Magnesium (Mg)	18	9	17	18	12	21	-	-	-
Chlorides (Cl)	16	8	16	38	6	27	14	3	18
Sulphates (SO_4)	15	16	17	38	29	39	19	14	25
Iron as Fe	1.1	1.3	Tr	0.7	1.4	0.4	0.2	0.9	0.1
Fluoride (F)	-	-	-	0.5	0.3	0.4	0.3	0.2	0.3
Bacteriological (MPN/100 ML)									
Total coliform	35000	-	0	0*	11000	0	-	-	-
Fecal coliform	35000	-	0	0	7000	0	-	-	-
<u>E.coli</u>	5000	-	0	0	7000	0	-	-	-

Results are expressed as mg/L except for pH, Turbidity and conductivity

* Prechlorinated raw water

TABLE 21.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

KANPUR WATER WORKS - KANPUR

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	25-30	7.5	1.2-2.5	1.5
	II	14-30	9.5-12	2.5-9.0	7.0
T.coliform (MPN/100ML)	I	3500	920	220-1600	0
	II	0-11000	0-1400	72400	0
E. Coli (MPN/100ML)	I	5000	30	20	0
	II	0-7000	0-1400	72400	0

AISHBAG WATER WORKS - LUCKNOW

INTRODUCTION

Lucknow, the capital city of Uttar Pradesh with a population of 9 lakhs (1981 census) draws its water supply from river Gomati and a network of tube wells. The first treatment plant commissioned in 1894 consisted of slow sand filters preceded by plain sedimentation of the river water. Subsequently the plant capacity was augmented with conventional rapid gravity filters with chemical pretreatment. The present total capacity of the plant is 172 mld. The city supply is further augmented by providing 130 tubwells with a total yield of 120 mld. The water works located at Gaughat is operated and maintained by Lucknow Jal Sansthan.

River water drawn through intake well is pumped through three rising mains discharging into a common inlet chamber at the treatment works. Required quantity of alum slabs (arrived at by jar tests) are dumped periodically into this chamber. No separate mixing arrangements have been provided. The alum mixed water flows through a long (215 m) rectangular channel feeding the three sedimentation tanks. Settled water from these tanks flows to 10 slow sand filters and 3 batteries of rapid sand filters with a total capacity of 127 mld. A separate pipeline laid underground delivers 45 mld of alum dosed water to a clariflocculator and then to a battery of rapid sand filters. The schematic layout of the plant is shown in Fig. 21.3 and plant summary data is given in Table 21.7.

PLANT APPRAISAL

Raw water quality and flow measurement

As the surface flow at the intake point has receded, raw water is diverted to the intake through an open channel about 200 meters long. The channel is dredged regularly to maintain the flow. No master meters are provided at the pumping station pump discharges and the flow is reckoned by the rated capacity of pumps. Raw water flow measured at the time of visit indicated that the plant was overloaded by 25 per cent. The physico-chemical characteristics of the river water are within the prescribed limits for use as raw water Table 21.8.

Pre-treatment

The plain settling tanks originally provided for slow sand filters are used as sedimentation tanks after alum addition. One of the settling tanks has been modified into 'Hudson type' sedimentation tank while the other two were silted up. The Hudson type baffled channel flocculator / sedimentation tank was, therefore, overloaded. Due to this, the floc formation was poor, reduction in turbidity due to sedimentation was only marginal and bacterial removal efficiency was not satisfactory.

The flocculator paddles and the sludge scraper mechanism for the 45 mld clariflocculator were not in working condition and the efficiency of the unit was very poor.

Filtration

The operation and maintenance of rapid sand filters was far from satisfactory. The depth of sand in all the filters was less than the minimum value recommended by CPHEEO. Defective washing has resulted in loss of sand. Heavy cracks and undulations were observed in the filter beds. Filter rate controllers, rate indicators, loss of head gauges and other appurtenances were not in working condition.

Renovation and overhauling of two of the filters was in progress at the time of visit. It was reported that the nozzle type underdrain system used in the filters was a failure as it got choked leading to reduced filter output and ineffective backwashing.

The slow sand filters also received alum coagulated settled water. The depth of sand was less than the minimum desirable value. Resanding of filters has not been done due to financial constraints and two filters were out of service only because sand was not available. Floating algal scum on the slow sand filters was not cleaned. The flow measurement devices were missing and the filtration rate was adjusted by trial and error. In general, the maintenance of the filters was very poor.

Disinfection

A new chlorination system has been installed recently and the unit operation has been given out on contract to a private enterpreneur. It was a unique experience to see that the chlorination system has been well maintained and the water works authorities have had no difficulties in ensuring proper chlorination.

Financial Aspects

The financial administration of the water works has not been satisfactory. The annual revenue receipt from sale of water is of the order of Rs. 250 lakhs. The expenditure on staff salary and electricity charges for the year 1986 was Rs. 149 lakhs and Rs. 180 lakhs respectively. The allocation for maintenance and repairs was Rs. 16 lakhs which was highly inadequate.

Plant Staff

The regular staff employed for plant operation and maintenance including the distribution system is 1086. Additionally about 500 daily wage workers are employed. The operation and maintenance staff employed at the water works alone is about 150. However, the plant maintenance has been poor due to non-cooperation and apathy on the part of the staff. The operators had not received any formal training in filter operation and control.

Laboratory facilities

Adequate laboratory facilities with qualified and trained staff are available at the plant.

RECOMMENDATIONS

* Provision for raw water flow measurement should be made to ensure effective chemical dosing and plant control.

* Optimum alum dose (based on jar test) should be applied in solution form and arrangements for rapid mixing and flocculation be made to improve efficiency of chemical pre-treatment.

* The plain settling tanks should be converted into 'Hudson type' settling tanks with desludging arrangements.

* Overhauling / renovation of existing rapid and slow sand filters be undertaken so as to produce a filtrate that will meet with the prescribed quality standards.

* The clear water reservoirs in which considerable sludge accumulation has been observed must be cleaned periodically.

* The contract system of maintenance found successful for chlorination may further be extended and tried forthe whole treatment plant.

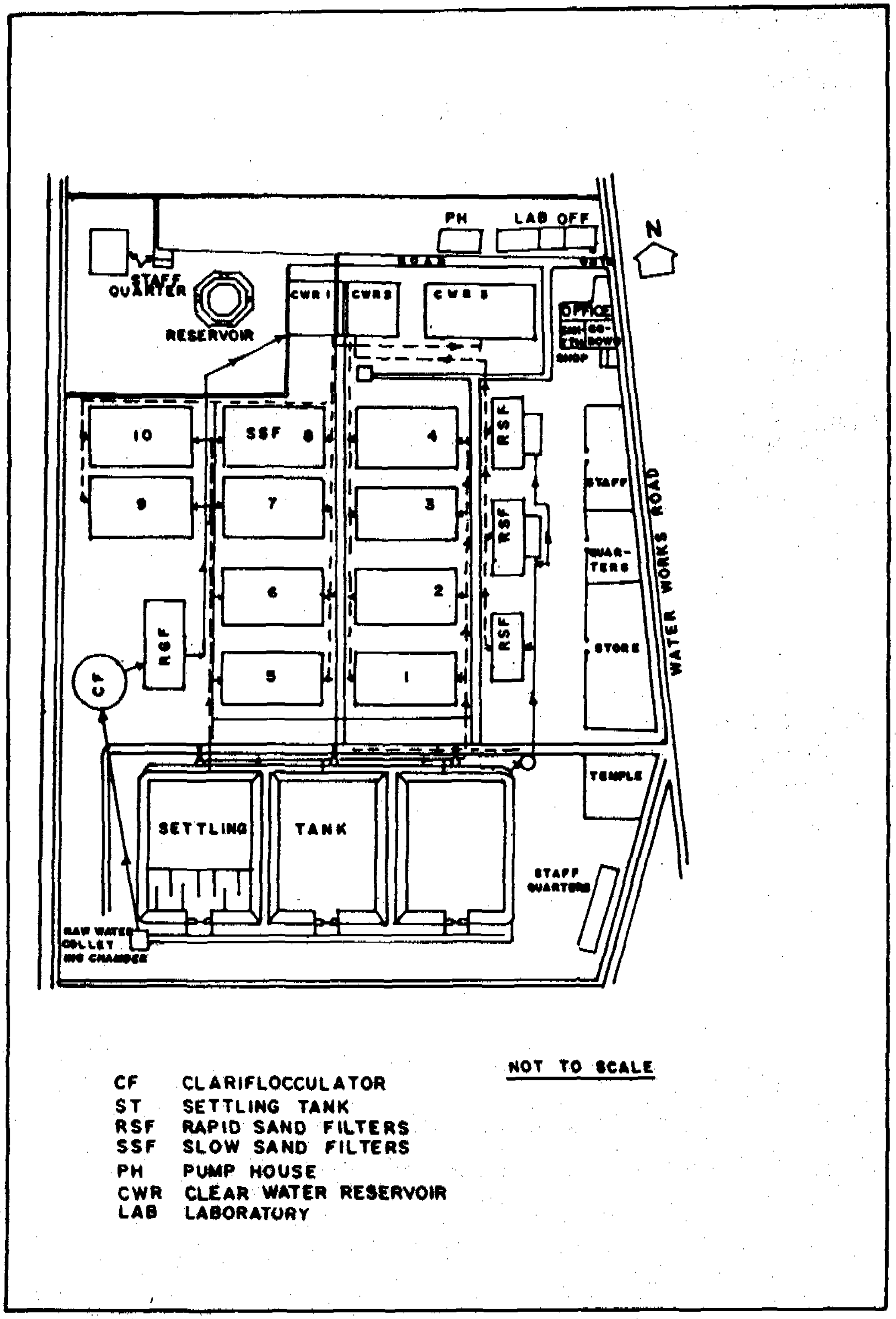


FIG 21.3 LAYOUT PLAN OF AISHBAGH WATER WORKS, LUCKNOW

TABLE 21.7

PLANT SUMMARY DATA - LUCKNOW

GENERAL

Name and location	:	Lucknow Water Works, Aishbag				
Year of construction (Augmentation if any)	:	1892	1923	1929	1953	1975
Design capacity (mld)	:	48	62	72	127	172
O & M Agency	:	Lucknow Jal Sansthan				
Raw water source	:	River Gomati				
Treatment flowsheet	:	Conventional with rapid and slow sand filters				

ENGINEERING

Raw water pumping	:	7 pumps + 4 standby
-Rising main diameter	:	1200, 680, 500 mm
Raw water flow measurement	:	Not provided
Pre-treatment		
Coagulation		
- Chemicals used	:	Alum
- Type of mixing	:	Hydraulic
- Method of mixing	:	Near inlet channel to settling tank
Flocculation		
- Method / Type of unit	:	Hydraulic/Mechanical both
- No. & Dimensions		Not available

Sedimentation

- Type of unit(s)	: Rectangular
- No. & size of unit(s)	: 3 nos., 76 x 61 x 5.4 m
- Surface Overflow Rate	: 12.3 m^3/m^2/day
- Detention time	: 10.5 hrs.

Filtration

- Type of unit(s)	: Rapid gravity filters A	B	C	SSF
- No.& size of unit(s)(m)	: 10 5.4x6	8 12x6	5 10.5x7.6	10 60x30
- Rate of filtration(m/hr)	: 4.7	5	6	0.1
- Filter media	: Sand	sand	sand	sand
. Sand size	: E.S.-0.5-0.55 mm U.C.-1.7			0.29-0.35 2-3
. Depth of sand (cm)	: 55			60
. Gravel size (mm)	: 2.5-63,2.5-63,2.5-63,			2.5-50
. Depth of layers (mm)	: 75 to 125			75-100
- Backwash arrangements				
. Method	: Air scour + Water wash Scraping			
. Wash water tank cap.	: 1136 m^3			

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: Gravity feed
- Chlorinator Details	: Auqa make

Clear Water Reservoir

- Type, No. & Capacity	: RCC and masonary,19089 m^3
- Pump details	: Centrifugal pumps, 4 nos., total 887 - HP

TABLE 21.8

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

LUCKNOW WATER WORKS - LUCKNOW

PARAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	29	2.5	12	5.4	23	3.8
pH	8.6	8.4	8.4	8.4	8.8	8.7
Total Alkalinity ($CaCO_3$)	236	230	230	220	255	245
Conductivity(μS/cm)	440	440	325	325	430	430
Hardness ($CaCO_3$) Total	184	182	160	160	196	193
Calcium (Ca)	36	36	29	29	38	30
Magnesium (Mg)	23	22	21	21	24	24
Chlorides (Cl)	6	9	7	10	8	8.5
Sulphates(SO_4)	5	5.4	12	20	10	12
Iron (Fe)	2	0.2	0.7	0.3	1.6	0.2
Fluoride (F)	-	-	0.5	0.6	0.4	0.4
Nitrates (NO_3)	-	-	-	-	0.3	0.3
Bacteriological (MPN/100 ML)						
Total coliform	9000	0	1700	0	3500	9
Fecal coliform	9000	0	260	0	50	0
E.coli	1600	0	140	0	50	0

Results are expressed as mg/L except for pH, conductivity and turbidity

TABLE 21.9

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

LUCKNOW WATER WORKS - LUCKNOW

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	29	5-11	1.5-5.0	2.5
	II	12	10-11	2.5-5.4	-
	III	23	8-9	1.9-3.9	3.8
T.coliform (MPN/100 ML)	I	9000	300-700	240-500	0
	II	1700	350-490	0-27	0
	III	3500	940-16000	1800-2200	9
E.Coli (MPN/100 ML)	I	1600	130-270	4-14	0
	II	140	33-110	0-14	0
	III	50	0-50	0-40	0

MALLITAL WATER WORKS - NAINITAL

INTRODUCTION

Nainital water supply commissioned in 1898 is one of the oldest in the State of U.P. The present population (permanent residents) of the city is about 50,000, while during peak summer it increases to one lakh due to tourist inflow. The water supply needs of the city are met from Nainital lake and springs. The treatment plant for lake water consists of two rapid gravity filters of 3.5 mld capacity constructed in 1958 and two pressure filters of 2 mld capacity commissioned in 1986. The supply is further augmented (1.5 mld) from a spring with chlorination as the only treatment.

Raw water from Nainital lake is directly pumped to the rapid gravity and pressure filters without any pre-treatment. The filtrate is chlorinated before distribution through overhead reservoirs. The schematic flow sheet is shown in Fig 21.4 and plant summary data given in Table 21.10 . The plant is owned and maintained by Kumaon Jal Sansthan.

PLANT APPRAISAL

Raw water quality

Although the spring water is of good quality, it is of limited yield while abundant raw water is available from the lake receives considerable amount of waste water discharges from 28 outfalls from all sides. One of the waste water outfalls drains in the vicinity of raw water intake. Due to shifting of waterline in the lake, especially during summer, floating pumps are installed to meet the water needs. There is no provision for standby pumps. The lake water turbidity remains below 10 NTU throughout the year Table 21.11.

Filtration

There is no provision for alum addition and raw water is directly pumped to the filters. Filtration is not effective and the turbidity removal is only marginal. The poor performance of the filters is also due to coarse sand used both in rapid gravity filters (E.S. - 0.85 mm and U.C. - 1.3) and pressure filters (E.S.-0.78 mm and U.C.-1.4). The filter appurtenances are also not in working condition.

Disinfection

Filtered water is disinfected using chlorine gas or a solution of bleaching powder. The chlorinator was in working condition and at the time of visits, dose was 0.2 to 0.4 mg/l.

Laboratory facilities

The laboratory facilities at the plant are inadequate for routine testing and process control. However, laboratory staff and plant personnel are adequate to ensure proper operation and maintenance.

Financial Aspects

The annual O & M expenditure on the plant is Rs. 55 lakhs whereas total revenue from sale of water is only Rs. 30 lakhs. The break-up of expenditure is - staff salary 17 per cent,repairs and maintenance 5 per cent and energy charges 78 per cent.

RECOMMENDATIONS

* Standby pumps for raw and treated water are necessary to avoid interruption in water supply.

* Direct filtration with a nominal dose of alum will improve the treated water quality. Hence, provision for alum dosing is a must.

* The existing laboratory facilities need to be augmented to ensure regular water quality monitoring and process control.

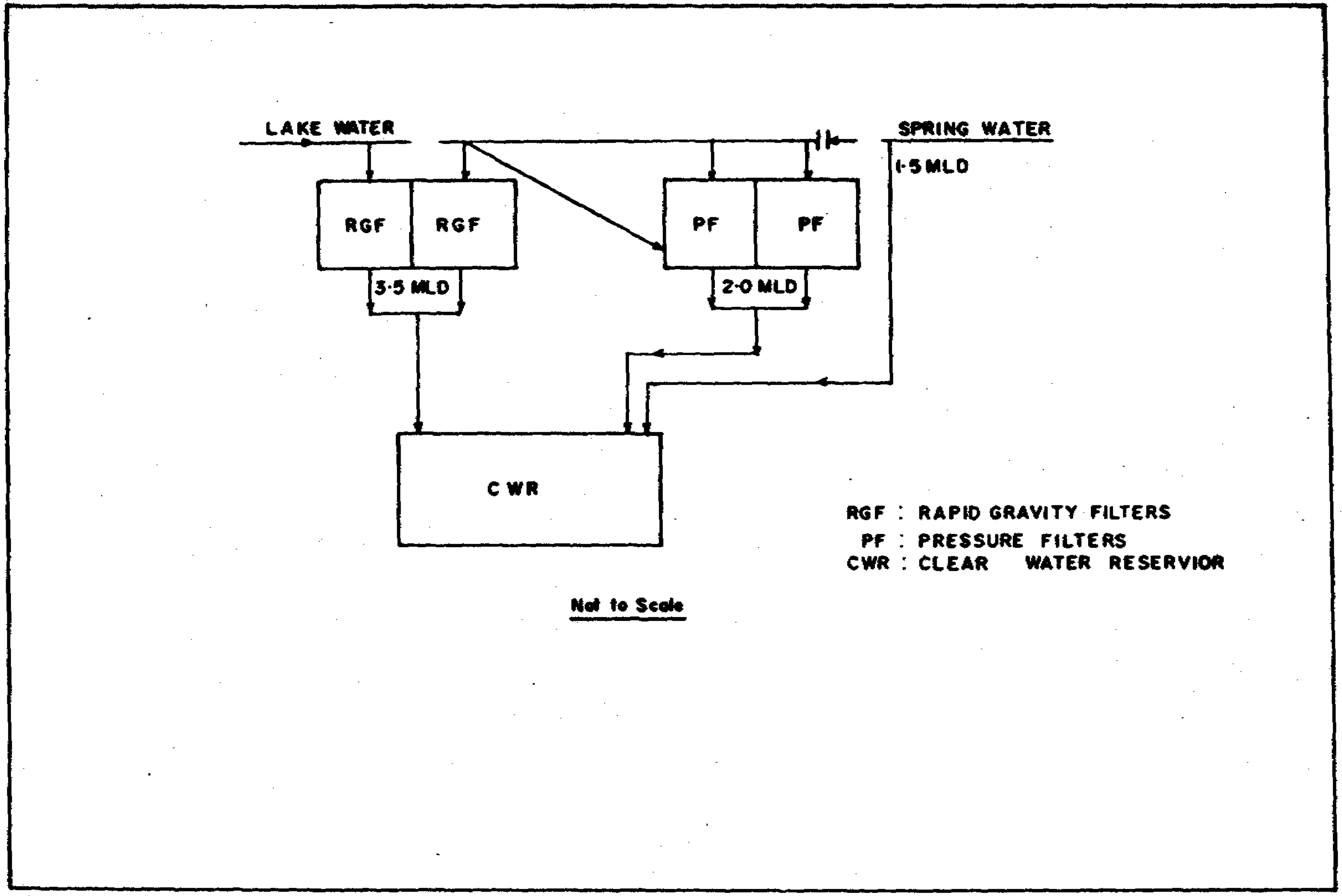


FIG 21.4 LAYOUT PLAN OF MALLILAL WATER WORKS, NAINITAL

TABLE 21.10

PLANT SUMMARY DATA - NAINITAL

GENERAL	
Name and location	: Nainital Water Works, Mallital.
Year of construction (Augmentation if any)	: 1898 1986
Design capacity	: 2.0 mld 3.5 mld
O & M Agency	: Kumaon Jal Sansthan
Raw water source	: Lake Nainital, springs
Treatment flowsheet	: Direct filtration.
ENGINEERING	
Raw water pumping	: Six centrifugal pumps 20-30 HP capacity.
-Rising main diameter	: 250 mm,200 mm,100 mm, 63 mm
-Raw water flow measurement	: Rectangular weir
Filtration	
-Type of unit(s)	: Rapid gravity filters.
-No. & size of unit(s)	: 2 Nos, 2.33 m x 5.8 m
- Filter media	
. Sand size	: E.S.- 0.85 mm,U.C - 1.3
. Depth of sand	: 0.6 m
. Gravel size	: 2.5-50 mm, 5 layers

. Depth of each layer	: 75 mm
- Backwash arrangements	
. Method	: Air scour + water wash
. Wash water tank cap.	: 460 m^3

Disinfection

- Chemicals used	: Chlorine gas/Bleaching powder
- Type of feed	: Pressure type
- Chlorinator Details	: Aqua make

Clear Water Reservoir

- Type, No. & Capacity	: RCC, 1 no., 306 m^3
- Pump details	: Centrifugal, multi-stage total capacity 800 HP.

TABLE 21.11

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

NAINITAL WATER WORKS - NAINITAL

PARAMETERS	I VISIT			II VISIT		
	RAW (R1)	RAW (R2)	FINISHED	RAW (R1)	RAW (R2)	FINISHED
Physico-chemical						
Turbidity (NTU)	3.0	5.0	2.5	6.0	2.5	2.5
pH	7.7	7.7	7.9	7.8	7.9	7.9
Total Alkalinity ($CaCO_3$)	300	260	280	280	280	280
Conductivity(µS/cm)	650	770	-	860	870	870
Hardness ($CaCO_3$)						
Total	414	396	392	360	404	380
Carbonate	300	260	280	280	280	-
Non Corbonate	114	136	112	80	124	-
Calcium (Ca)	63	61	68	50	50	51
Magnesium (Mg)	ND	ND	ND	58	48	61
Chlorides (Cl)	13	11	12	7	9	11
Sulphates (SO_4)	96	112	98	44	50	40
Iron (Fe)	ND	0.1	0.1	0.1	0.1	-
Fluoride (F)	0.1	0.1	0.1	0.1	0.1	0.1
Nitrate(NO_3)	1.8	2.1	1.8	1	1.8	1.3
Bacteriological (MPN/100 ML)						
Total coliform	540	0	0	1600	0	0
E.coli	130	0	94	0	0	0

Results are expressed as mg/L except for pH, Turbidity and conductivity. ND - Not Detectable

BHELPURA WATER WORKS - VARANASI

INTRODUCTION

The city of Varanasi with a population of 7 lakhs (1981 census) drawn its water supply from the river Ganga. The earliest plant constructed in the year 1892 comprised slow sand filters of 63.5 mld preceded by plain sedimentation. Subsequently in 1956 the plant capacity was augmented to 125 mld by providing rapid gravity filters only. The supply has been further augmented by 100 mld through tube wells. The treatment for river water consists of alum coagulation, sedimentation in rectangular settling tanks, filtration through rapid gravity/slow sand filters and chlorination. The schematic flow sheet is shown in Fig 21.5 and plant summary data is presented in the Table 21.12. The plant is operated and maintained by Varanasi Jal Sansthan.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from the Ganga is pumped to the treatment plant located 2 km away. One of the water outfalls from the city joins the river about 500 m upstream of the intake. A rectangular weir has been provided in the raw water channel for flow measurement but the flow indicating and recording system was absent. Pumping is done intermittenly so as to avoid overflow through the settling tanks, when the subsequent units are unable to handle the plant inflow. Flow measurement at the time of visit indicated that the plant was underloaded to the extent of 17 per cent.

Pre-treatment

Alum dosing facilities were added to the plant only in 1986. However, provision for chemical mixing has not been made. It was reported that except during monsoon season alum is not used due to poor financial condition of the Jal Sansthan.

Though the plant capacity was augmented by constructing rapid gravity filters, no provision has been made for additional sedimentation tanks. At the time of the visits, two tanks were silted up and the flow was bypassed while the third tank was being desilted. Considerable weed growth was observed in the silted tanks. Sedimentation was more or less totally ineffective as confirmed by observation that the turbidity of both raw and settled water was practically the same.

Filtration

Only four out of 14 slow sand filters were in operation during the time of visit. Rest were out of commission for cleaning. The four slow sand filters in use were also not operated and maintained properly. Profuse growth of algae and weeds was observed in the filters. All the filter appurtenances were missing or stolen. The flow rate was adjusted by trial and error by noting the head over the 'V' notch at the outlet as there was no flow indicating device.

As for rapid gravity filters, the situation was similar. All the filters were working without rate controllers and rate indicators. The filters were overloaded and the filtration efficiency was very poor as turbidity removal was only marginal. One of the rapid gravity filters was out of service for want of repairs. Filter backwashing was ineffective and sand depth was uneven over the filter area. The filter outlet valves were leaking heavily.

Disinfection

Filtered water is disinfected by bubbling chlorine gas directly into the filtered water channel. None of the chlorinators was in working order and many of them had been dismantled. Chlorine odour was felt in and around the filter area indicating heavy leakage of chlorine gas. Bleaching powder solution was used for disinfection when chlorine gas was in short suppply.

Laboratory Facilities

Available laboratory facilities are adequate for regular monitoring of the plant performance. However, these facilities were not being used.

Plant Staff

The number of personnel of different categories available at the plant for operation and maintenance is 108. The labour for cleaning and maintenance of slow and filters is 35; but still 10 filters were out of service for cleaning and the rest were not maintained satisfactorily.

Financial Aspects

As per the statement of expenditure for the year 1985-86 an amount of nearly Rs. 81 lakhs was spent on salary and Rs. 40 lakhs on operation and maintenance. The electricity bill for the year was Rs.125 lakhs which the Jal Sansthan has been unable to pay. The annual revenue receipts from sale of water was only around Rs.121 lakhs.

RECOMMENDATIONS

* The sewer outfall upstream of the river intake should be diverted to prevent pollution of raw water.

* To ensure proper mixing of alum, baffles should be provided in the raw water channels. Alternatively, a separate flocculation chamber with mixing arrangement be provided.

* The plain sedimentation tanks which have been silted up completely, need to be desilted and renovated into Hudson type settlers with desludging facilities.

* The slow sand filters need to be resanded to a depth of 80-100 cm ; cleaning of the filters must be done at the appropriate time by scraping the top layer of the sand and routine maintenance be ensured by removing floating algae and weeds from the filters.

* A number of rapid sand filters need complete overhauling including replacement of sand and gravel of appropriate size and depth and provision of necessary appurtenances for proper operation and control.

* The present practice of bubbling chlorine gas directly into the filtered water channel should be discontinued in favour of preparing a concentrated solution of chlorine gas and applying the same to the filtered water. Chlorinators of adequate capacity need to be installed so as to regulate and control the rate of chlorine dose.

* A review and rationalisation of the staff structure at the plant and reduce expenditure on salary component.

* The possibility of entrusting the O & M of the plant on contract to professionally competent agencies may be considered.

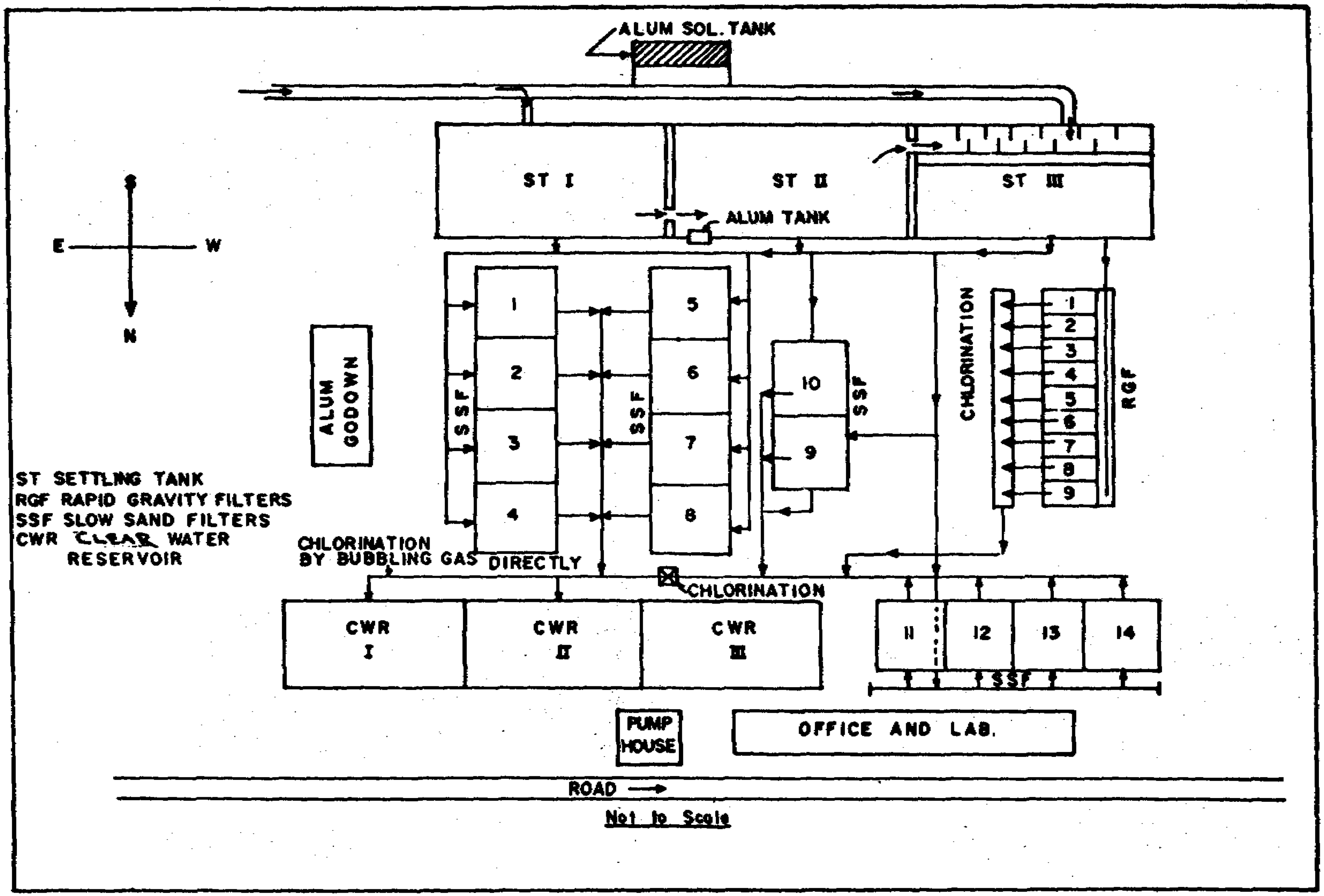


FIG 21.5 LAYOUT PLAN OF BHELPURA WATER WORKS, VARANASI

TABLE 21.12

PLANT SUMMARY DATA - VARANASI

GENERAL

Name and location	:	Varanasi water works, Bhelpura.
Year of construction (Augmentation if any)	:	1892 1956 1961
Design capacity	:	63.5, 104, 125
O & M Agency	:	Varanasi Jal Sansthan
Raw water source	:	River Ganga
Treatment flowsheet	:	Convential with slow sand filters and rapid sand filters

ENGINEERING

Raw water pumping	:	5 Nos., 200 - 750 HP range
-Rising main diameter	:	760 mm CI pipe 1200 mm Hume pipe
Raw water flow measurement	:	Rectangular weir
Pre-treatment		
Coagulation		
- Chemicals used	:	Alum solution, alum blocks
- Type of mixing	:	Hydraulic
Sedimentation		
- Type of unit(s)	:	Plain sedimentation tanks Rectangular
- No. & size of unit(s)	:	3 nos., 135 x 78 x 5.4 m each
- Surface overflow rate	:	4 $m^3/m^2/day$
- Detention time	:	11 hours

Filtration

- Type of unit(s)	:	RGF	SSF
- No. & size of unit(s)	:	9 nos., 10.8 x 7.9 m,	14 nos., 60 x 30 m
- Rate of filtration	:	3.3 m/hr	0.1 m/hr
- Filter media			
. Sand size	:	E.S.-0.72 mm U.C.-2.0	E.S.-0.2-0.5 mm U.C.-1.5
. Depth of sand	:	0.6 m	0.6 m
. Gravel size	:	12-50 mm	125 mm
. Depth of each layer	:	2 layers 250 mm each	1 layer 230 mm
- Backwash arrangements			
. Method	:	Air scour + water wash	
. Wash water tank cap.	:	1136 m^3	

Disinfection

- Chemicals used	:	Chlorine gas
- Type of feed	:	solution, gravity feed
- Chlorinator Details	:	Paterson type, 3 nos.

Clear Water Reservoir

- Type, No. & Capacity	:	Brick masonary, 3 nos 840 m^3
- Pump details	:	5 nos., Centrifugal pumps 245-365 HP

TABLE 21.13

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

BHELPURA WATER WORKS - VARANASI

PARAMETERS	I VISIT		II VISIT	
	RAW	FINISHED	RAW	FINISHED
Physico-chemical				
Turbidity (NTU)	8.5	3.0	5.0	2.5
pH	8.1	8.2	8.2	8.0
Total Alkalinity ($CaCO_3$)	180	180	200	215
Conductivity(μS/cm)	360	360	520	500
Hardness ($CaCO_3$)				
Total	142	142	172	170
Carbonate	142	142	172	170
Non Corbonate	0	0	0	0
Calcium (Ca)	34	34	34	32
Magnesium (Mg)	14	14	21	22
Chlorides (Cl)	20	20	29	31
Sulphates (SO_4)	18	20	32	32
Iron (Fe)	-	-	0.1	0.1
Fluoride (F)	0.3	0.3	0.3	0.3
Nitrates (NO_3)	-	-	1.2	1.2
Bacteriological (MPN/100 ML)				
Total coliform	1700	23	3500	0
Fecal coliform	1400	2	1700	0
E.coli	170	0	90	0

All results are expressed as mg/L except for pH, conductivity and Turbidity

TABLE 21.14

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

BHELPURA WATER WORKS - VARANASI

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	8.5	8.0	1.5-3.5	3.0
	II	5.0	1.9	0.8-0.9	2.5
T.coliform (MPN/100ML)	I	1700	940	49-1100	23
	II	3500	350	90-340	0
E.Coli (MPN/100ML)	I	170	90	13-70	0
	II	90	0	0	0

KALYANESHWARI WATER WORKS - ASANSOL

INTRODUCTION

Kalyaneshwari water treatment plant located at Kalyaneshwari about 25 km from Asansol was commissioned in the year 1972. The plant with a design capacity of 47.2 mld serves about 200 villages in the Raniganj coalfield area which covers the entire Asansol sub-division of the district Burdwan. The source of raw water to the plant is Mython dam constructed across river Borakar. The treatment plant provides for a alum and lime addition, coagulation, flocculation, sedimentation, rapid gravity filtration and chlorination. The schematic flowsheet of the plant is shown in Fig. 22.1 and summary data is presented in Table 22.1. The plant is operated and maintained by the PHED, Govt. of West Bengal.

PLANT APPRAISAL

Raw water quality and flow measurement

Raw water from the Mython dam flows to the treatment plant by gravity for most of the time. However, provision for pumping of raw water has been made to meet any difficult situation during periods of drought. As the dam area is well protected, no human activity or any other potential source of pollution was observed in the vicinity of raw water intake. Considerable variation in raw water turbidity (10-820 NTU) was observed during the visits. Raw water has a low alkalinity (of 29-70 mg/l) with chlorine demand of 2-3 mg/l (Table 22.2).

Raw water inflow to the plant is measured in a Venturi flume fitted with a flow indicating, recording and integrating system (Mahindra and Mahindra make) which was in good working condition. The plant was working more or less at its rated capacity.

Pre-treatment

Alum solution is used for coagulation. During monsoon, when turbidity of raw water is high and alkalinity is low, lime is used along with alum. The actual alum dose applied was found to be less than the reported dose. The performance of the clarifier was satisfactory as observed from the settled water turbidity which was in the range of 20.8-25 NTU.(Table 22.3). There is scope for improvement in performance with proper control on chemical dosing and clarifier operation.

Filtration

Rate of flow indicators and headloss indicators in some of the filters were not in working condition. The depth of sand in filters was found to be around 63 cm. Filters are backwashed using water only. Frequency of filter backwashing was reported to be once in 48 hrs. The performance of the filters was not satisfactory as observed from the filtered water turbidity which was in the range of 2.5-15 NTU (Table 22.3).

Disinfection

Chlorine gas is used for disinfection. Chlorination control was not effective as observed from the presence of coliforms in finished water during one of the visits.

Laboratory facilities

A laboratory with minimum required facilities has been provided at the plant. Some of the instruments were not in working condition.

RECOMMENDATIONS

* The instruments in the laboratory should be repaired and a trained chemist posted to carry out regular testing of water for proper plant control.

* The filters should be properly backwashed and maintained to improve their performance.

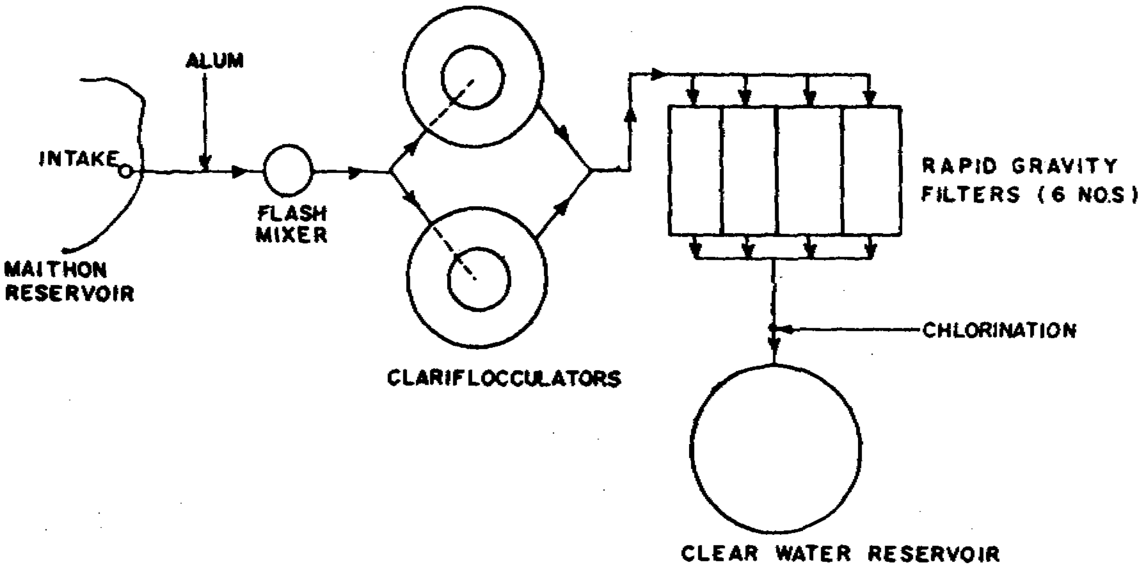


FIG 22.1 KALYANESHWARI WATER TREATMENT PLANT (SCHEMATIC) - ASANSOL

TABLE 22.1

PLANT SUMMARY DATA - ASANSOL

GENERAL	
Name and location	: Kalyaneswari Water Treatment Plant, Asansol
Year of construction	: 1972
Design capacity	: 472 mld
O & M Agency	: Public Health Engineering Department, West Bengal
Raw water source	: Mython dam on river Borkar
Treatment flowsheet	: Conventional with Rapid Sand Filters
ENGINEERING	
Raw water pumping	: 5 nos, centrifugal pumps each of cap. 153.3 lit/sec (2 Standby)
-Rising main diameter	: 750 mm
Raw water flow measurement	: Venturi meter, (Mercury flow system)
Pre-treatment	
Coagulation	
- Chemicals used	: Alum & lime (solution feed)
- Type of mixing	: Mechanical flash mixing
- Detention time	: 1 minute
Flocculation	
- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Dimensions	: two, 14.6 m dia, 3.96 m SWD
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: 2 nos., 38.1 m dia. and 3.05 m SWD
- Surface overflow rate	: 1.02 m/hr
- Detention time	: 3 hrs

Filtration

- Type of unit(s)	: Rapid sand filters
- No. & size of unit(s)	: 6 nos, each 67.4 m2 (twin bed)
- Rate of filtration	: 4.9 m/hr
- Filter media	
. Sand size	: E.S.- 0.5 mm, U.C.-1.5
. Depth of sand	: 63 cm
. Gravel size	: 0.25 cm - 5 cm
. Depth of each layer	: 7.6 cm - 15 cm
- Backwash arrangements	
. Method	: Water wash only
- Wash water tank cap.	: 563 m^3

Disinfection

- Chemicals used	: Clorine gas
- Type of feed	: Solution feed
- Chlorination Details	: Pressure Chlorinators, 2 nos

Clear Water Reservoir

- Type, No. & Capacity	: RCC, one, 410 m^3
- Pump details	: 5 nos, 350 HP each capacity 184 L/sec

TABLE 22.2

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

ASANSOL WATER TREATMENT PLANT - ASANSOL

PARTAMETERS	I VISIT		II VISIT		III VISIT	
	RAW	FINISHED	RAW	FINISHED	RAW	FINISHED
Physico-chemical						
Turbidity (NTU)	10.0	2.5	820	15	170	4.5
pH	8.1	7.9	6.9	6.8	7.5	7.0
Total Alkalinity ($CaCO_3$)	70	72	29	18	70	60
Conductivity (µS/cm)	197	211	320	187	275	221
Hardness ($CaCO_3$)						
Total	92	90	84	74	-	-
Carbonate	70	72	29	18.4	-	-
Non Carbonate	22	18	55	55.6	-	-
Calcium (Ca)	18	18	18	17	-	-
Magnesium (Mg)	11	10	10	10	-	-
Chlorides (Cl)	6	6	2	3	6	6
Sulphates (SO_4)	2	9	1	28	5	27
Iron (Fe)	0.5	0.3	ND	ND	5.7	0.4
Fluoride (F)	0.8	0.8	0.5	0.4	0.4	0.2
Bacteriological (MPN/100 ml)						
Total coliform	21	0	2400	33	91	0
Fecal coliform	-	-	-	-	91	0
E.coli	-	-	-	-	91	0
Fecal streptococci	2	6	79	4	230	0

All values except pH ,Turbidity and Conductivity are expressed as mg/l

ND - Not detectable

TABLE 22.3

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

ASANSOL WATER TREATMENT PLANT - ASANSOL

PARAMETERS	VISIT	RAW WATER	SETTLED WATER	FILTERED WATER	FINISHED WATER
Turbidity	I	10	-	2.5	2.5
(NTU)	II	820	25	14	15
	III	170	20.8	-	4.5
T.Coliform (MPN/100 ml)	I	21	-	-	0
	II	2400	-	-	33
	III	91	9	0	0
E.Coli (MPN/100 ml)	I	-	-	-	-
	II	-	-	-	-
	III	91	9	0	0

PALTA WATER WORKS - CALCUTTA

INTRODUCTION

Calcutta, the capital of West Bengal is one of the largest metropolitan towns in the country. Palta water works constructed in phases from 1870 onwards with Hoogly river as raw water source caters to the needs of a major part of Calcutta city. The treatment plant have both slow sand as well as rapid sand filtration systems with a total capacity of 728 mld. The old plant consists of slow sand filters of 373 mld and rapid gravity filters of 82 mld capacity with conventional pre-treatment.The new plant with a capacity of 273 mld provides for alum dosing, flash mixing, flocculation, sedimentation, rapid gravity filtration and disinfection. The schematic flowsheet is shown in Fig.22.2 and summary data is presented in Table 22.4. The plants are maintained by Calcutta Municipal Corporation.

PLANT APPRAISAL

Raw water quality and flow measurement

Being a river source, there is a considerable variation in raw water turbidity. During the study period, the turbidity of raw water was in the range of 32-120 NTU. The raw water is also highly polluted as evidenced by the high coliform count of 13000-24000 MPN per 100 ml and chlorine demand of 2.1-2.2 mg/l (Table 22.5).

At the raw water pumping stations of the old plant a master meter of the Venturi type has been installed for flow measurement. However, the flow indicator and recorder system was not functioning. In the new plant, Venturi flumes with floats and indicators are provided but indicators were not in working condition. Plant inflow is calculated on the basis of working hours of pumps and their capacities.

Old plant

Pre-treatment

Alum solution is used for coagulation. The chemical pre-treatment was effective as evidenced by good floc formation. The settled water turbidity at the outlet of clariflocculators was in the range of 13-15 NTU. Significant reduction in coliform count was also observed due to flocculation and sedimentation. The settled water from the clariflocculators is stored in kuchcha holding basins having a detention time of 72 hours. The turbidity of settled water fed to filters from the holding basins was in the range of 3.0-8.2 NTU (Table 22.6). Algal growth was observed in the holding basin.

Filtration

Rapid gravity filters : There are 12 rapid gravity filters with design filtration rate of 4.5 m/hr. Headloss and filter rate indicators were not in working condition. Depth of sand in one of the filters was 33 cm with E.S.of 0.54-0.79 mm and U.C. of 1.25 -1.67. The filters are backwashed routinely after 24 hours of run using water only for a duration of 12 minutes. Undulations were observed on the filter beds. The filtrate turbidity was in the range of 0.5-1.4 NTU.

Slow sand filters

There are 53 slow sand filters with the design filtration rate of 0.1 m/hr. Depth of sand in the filters was around 77 cm with E.S. of 0.19-0.23 mm and U.C. of 2-2.87. Normal filter runs were reported to be 72-120 days. Average time required to put the filter back into service after cleaning (scraping) was reported to be 4 days and the frequency of resanding once in 19 months. Occasionally, pre-chlorination is practised to control algae in filter beds. The performance of the filters was not quite satisfactory, the turbidity of filtered water was in the range of 2.0-2.5 NTU and coliform MPN in the range of 11-1300 per 100 ml.

Disinfection

Chlorination of filtered water is carried out using chlorine gas. The average chlorine demand of filtered water was 1 mg/l. Chlorination control was not effective as evidenced from the presence of coliforms in finished water during one of the visits (Table 22.6).

New Plant

Pre-treatment:

Alum solution is used for coagulation and is applied at the flash mixing chamber. The flash mixing units were not in working condition. Rotating bridges of clariflocculators, however, were found working. The settled water turbidity was in the range of 1.5-15 NTU. Significant reduction in coliform count was also observed due of flocculation and sedimentation.

Filtration

There are 31 rapid sand filters with design filtration rate of 4.6 m/hr. The headloss and filter rate indicators were not in working condition. Depth of sand in the filters was 50 cm with E.S. of 0.64-0.66 mm and U.C. of 1.91-2.19. Filters were backwashed after 24 hours of run using only water. No backwash water tank is provided. The filtered water from the pumping station manifold is pumped directly for backwashing of the filters at a pressure of 2.8 kg/cm ^{2}. Undulations on the filter beds were observed and the performance of the filters was not satisfactory as observed from the turbidity of filtered water (0.5-3.6 NTU).

Disinfection

Chlorine gas is used for disinfection. The dose is applied at the sump of the clear water pumping station. The finished water had a residual chlorine of more than 0.2 ppm and was free from coliform.

Laboratory facilities

Adequate laboratory facilities with necessary instruments required for physico-chemical as well as bacteriological analysis of water have been provided at the plant.

RECOMMENDATIONS

* The raw water flow measuring system at both the old and new plants should be put into working condition to know the plant inflow and to facilitate proper chemical dosing and effective plant control.

* The filter rate and headloss indicators should be repaired/replaced for proper operation and the underdrains of filters showing undulations on the bed should be examined and repaired, if necessary.

* The facilities and personnel available at the central laboratory need to be reviewed and strengthened, if necessary, to ensure effective monitoring and control of the treatment plants.

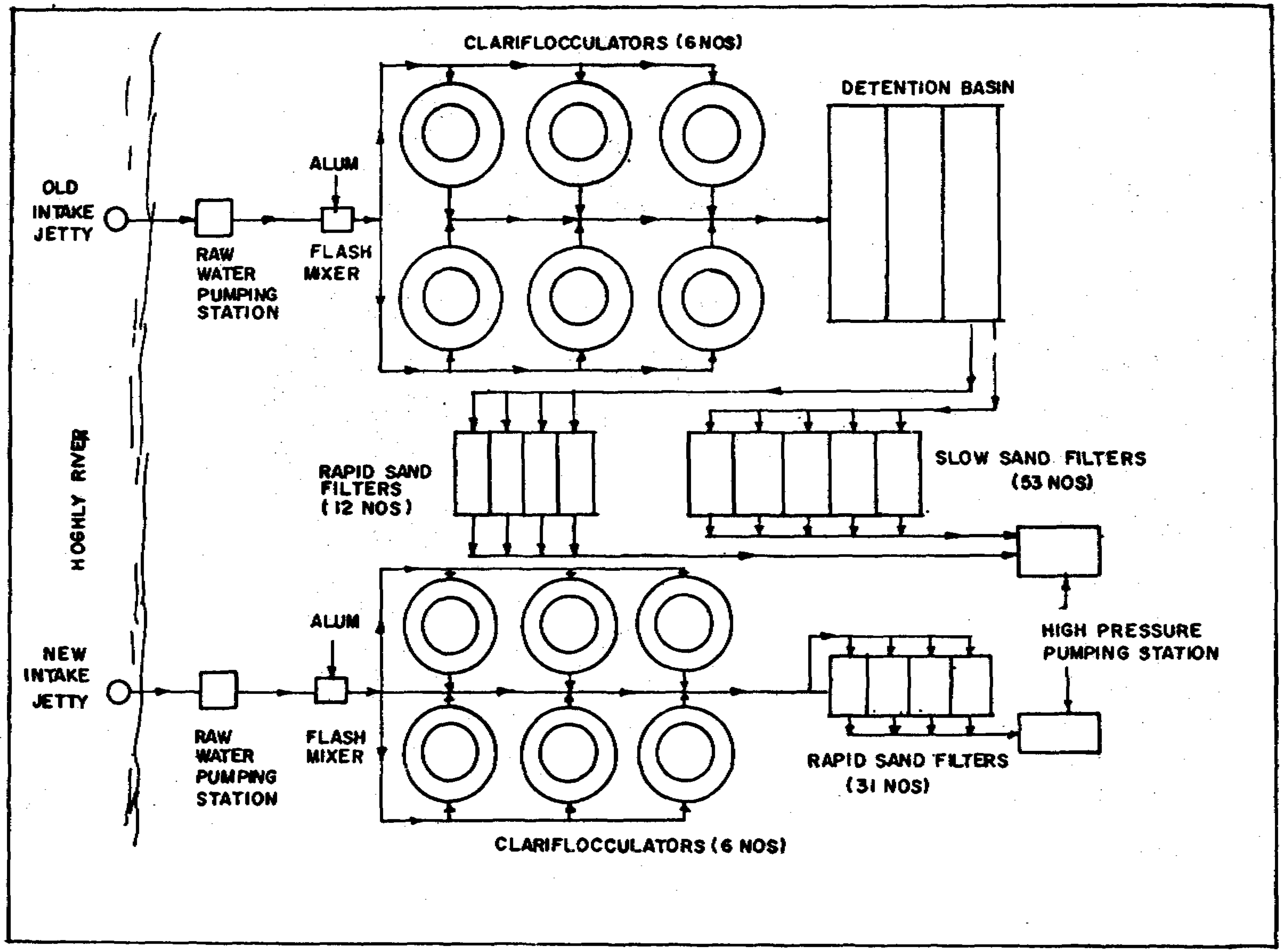


FIG 22.2 PALTA WATER WORKS (SCHEMATIC) - CALCUTTA

TABLE 22.4

PLANT SUMMARY DATA - CALCUTTA

GENERAL	
Name and location	: Palta Water Works Barracpore, Calcutta
Year of construction (Augmentation if any)	: In Phases from 1870 onwards
Design capacity	: 727 mld
O & M Agency	: Calcutta Municipal Corporation
Raw water source	: River Hooghly
Treatment flowsheet	: i) Conventional with rapid gravity filtration ii) Slow Sand Filtration
ENGINEERING	
	(Old plant)
Raw water pumping	: 4 nos., 3 nos., 9 mlh each 1 no, 7.8 mlh
-Rising main diameter	: 2 nos., 137 cm each
Raw water flow measurement	: Venturi flume with indicator
Pre-treatment	
Coagulation	
- Chemicals used	: Alum
- Type of mixing	: Mechanical flash mixer
- Detention time	: 5 sec
Flocculation	
- Method / Type of unit	: Mechanical Clariflocculator
- No. & Dimensions	: 6 Nos., 21.2 m dia.,6 m SWD
- Detention time	: 40 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: 6 nos.,54.8 m dia.,5.5 m SWD
- Surface overflow rate	: 1.58 $m^3/m^2/hr$
- Detention time	: 3.5 hrs.

Filtration

- Type of unit(s)	: Rapid gravity filters, Slow sand filters (Rapid gravity filters)
- No. & size of unit(s)	: 12 nos.,each 4.6 x 6.8 m x 2 (twin bed)
- Rate of filtration	: 4.5 m/hr
- Filter media	
. Sand size	: E.S.- 0.5-0.66 mm, U.C.- 2.0
. Depth of sand	: 63.5 cm
. Gravel size	: 2.5 mm - 60 mm
. Depth of each layer	: 7.5 cm - 15 cm
- Backwash arrangements	
. Method	: Water wash only
(Slow sand filters)	
- No. & size of unit(s)	: 53 nos., 61 x 30.5 m - 30 nos. 61 x 64 m - 6 nos. 61 x 98 m - 17 nos.
- Rate of filtration	: 0.1 m/hr
- Filter media	
. Sand size	: E.S.- 0.2-0.3 mm, U.C.- 2.5
. Depth of sand	: 76 cm
. Gravel size	: 6 mm - 25 mm

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: solution feed
- Chlorinator Details	: Vacuum type total 6 nos.
Clear Water pumping	: 4 nos.(2 standby), 1500 HP centrifugal - 3 nos. 1630 HP Turbine - 1 no.

(New plant 273 mld)

Raw water pumping	: 3 nos.,centrifugal pumps (one standby)each with capacity 7.9 ml/hr
-Rising main diameter	: 2 nos., each 1.2 m dia.
Raw water flow measurement	: Venturi flume with float indicator

Pre-treatment

Coagulation

- Chemicals used	: Alum
- Type of mixing	: Mechanical flash mixer
- Detention time	: 3 sec

Flocculation

- Method / Type of unit	: Mechanical(Clariflocculator)
- No. & Dimensions	: 6 Nos., 18 m dia.x 6.4 m SWD
- Detention time	: 50 minutes

Sedimentation

- Type of unit(s)	: Mechanical(Clariflocculator)
- No. & size of unit(s)	: 6 nos.,each 41 dia.,5.2 m SWD
- Surface overflow rate	: 1.77 $m^3/m^2/hr$
- Detention time	: 3 hrs.

Filtration

- No. & size of unit(s)	: 31 nos., each 3.5 x 11.25 m x 2 (twin beds)
- Rate of filtration	: 4.6 m/hr
- Filter media	
. Sand size	: E.S.- 0.5-0.66 mm,
. Depth of sand	: 63.5 cm
. Gravel size	: 2.5mm - 60 mm
. Depth of each layer	: 7.5 cm to 15 cm
-Backwash arrangements	
Method	: Water wash only

Disinfection

- Chemicals used	: Chlorine gas
- Type of feed	: solution feed
Clear Water pumping	: 4 nos. (2 standby) Centrifugal 1150 HP (2 nos), 1300 HP (1 no.) Turbine 1630 HP (1 no.)

TABLE 22.5

PHYSICO - CHEMICAL AND BACTERIOLOGICAL QUALITY OF RAW AND FINISHED WATERS

PALTA WATER WORKS - CALCUTTA

PARAMETERS	I VISIT			II VISIT		
	RAW	FINISHED old	FINISHED new	RAW	FINISHED old	FINISHED new
Physico-chemical						
Turbidity (NTU)	32	-	3.6	120	-	0.5
pH	-	7.5	7.5	7.5	7.5	7.5
Total Alkalinity ($CaCO_3$)	189	181	174	188	179	180
Hardness ($CaCO_3$)						
Total	150	144	142	140	136	148
Carbonate	150	144	142	140	136	148
Non Carbonate	0	0	0	0	0	0
Calcium (Ca)	34	33	33	48	43	48
Magnesium (Mg)	16	15	14	5	6	7
Chlorides (Cl)	11	10	11	11	10	10
Sulphates (SO_4)	21	25	25	12	19	20
Iron (Fe)	1.3	0.1	0.1	-	-	-
Fluoride (F)	0.1	0.1	0.1	0.1	0.1	0.1
Bacteriological (MPN/100 ml)						
Total coliform	13000	11	0	24000	0	0
Fecal coliform	3400	8	0	24000	0	0
E.coli	2700	0	0	24000	0	0
Fecal streptococci	1700	2	0	2300	0	0

All values except pH and Turbidity are expressed as mg/l

TABLE 22.6

PLANT PERFORMANCE AT VARIOUS STAGES OF TREATMENT

PALTA WATER WORKS - CALCUTTA

(Old plant)

PARAMETERS	VISIT	RAW	CLARIFIED kuccha tank	SETTLED	FILTERED SSF	FILTERED RGF	FINISHED
Turbidity (NTU)	I	32	13.0	3.0	2.4	1.4	-
	II	120	15.0	8.2	2.5	0.5	-
T. Coliforms (MPN/100 ml)	I	13000	-	-	11	790	11
	II	24000	400	-	1300	40	0
E.Coli (MPN/100 ml)	I	2700	-	-	0	110	0
	II	24000	200	-	490	40	0

(New plant)

PARAMETERS	VISIT	RAW WATER	CLARIFIED WATER	FILTERED WATER	FINISHED WATER
Turbidity (NTU)	I	32	15.0	3.6	-
	II	120	1.5	0.5	-
T. Coliforms (MPN/100 ml)	I	13000	2700	72	0
	II	24000	680	230	0
E.Coli (MPN/100 ml)	I	2700	2700	37	0
	II	24000	200	130	0