MANUAL

ON

DRINKING WATER QUALITY

SURVEILLANCE

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Unit of Drinking Water Quality Surveillance,
Division of Engineering Services,
Ministry of Health, Malaysia,
Kuala Lumpur.

November, 1983.

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PREFACE

The purpose of this document is to serve as a working manual on the various aspects of drinking water quality surveillance, primarily on the 3 key elements ie monitoring, sanitary survey and remedial action plan. It is the hope of the, Ministry of Health that this document will be of interest and benefit to all personnel involved in the quality surveillance of drinking water.

This manual was prepared by the Unit of Drinking Water Quality Surveillance, Ministry of Health under the expert guidance of Dr. K. M. Yao and Dr. M. Nakamura of the World Health Organisation, Western Pacific Regional Centre for the Promotion of Environment Planning and Applied Studies (WHO-PEPAS) and their valuable assistance is acknowledged with thanks.

Like the Guidelines and Programme, this manual was vetted by a panel of representatives from the Public Works Department (PWD), Department of Chemistry (DOC) and Department of Environment (DOE). To these representatives we acknowledge their time and effort with thanks.

CONTENTS

1. Introduction

1.1. This manual describes the procedures and the detailed methodologies in fulfilling the requirements stipulated in the National Guidelines for Drinking Water Quality. They are namely:—

(i) Monitoring

(ii) Sanitary Survey

(iii) Remedial Action

(iv) Data Processing and Evaluation and

(v) Institutional Examination

1.2. It has been prepared specially for relevant health and water works officials for application in the National Drinking Water Quality Surveillance Programme (a work-plan aimed at accomplishing the objectives set in the National Guidelines).

1.3. This manual details the criteria and step by step procedures in the formulation and implementation of the district drinking water quality monitoring programme, the sanitary survey programme and the remedial action plan.

1.4. Data processing and evaluation and institutional examination are major topics by themselves. Although these activities are mainly to be carried out at the federal level (Unit of Drinking Water Quality Surveillance, Ministry of Health), a brief discussion is given here for the purpose of giving an overall picture of the whole programme.

1.5. In-plant monitoring or process quality control testings are also included in the manual to facilitate the waterworks to implement as soon as possible process quality control in water treatment plants. This is considered to be a vital element in the control of drinking water quality.

1.6. The procedures, methods presented here have been demonstrated to be feasible in other countries. It is therefore recommended that all relevant authorities shall adhere to these procedures and methods in order to achieve uniformity of the programme for better data handling and interpretation.

1.7. However, such adherence to the recommendations contained in this manual is not to be without exception. Progressive innovation on the part of the officials concerned is encouraged, but major departures from the proposed concept should be reviewed critically before application.

2. Monitoring

The main objective of drinking water quality monitoring programme is to effectively observe that the water of all potable supplies complies with the accepted drinking water standards and that any problem area within a water supply system is identified in order that immediate corrective measures can be taken to restore the original quality of water. Ideally the monitoring programme should cover the whole water supply system, that is the source – be it surface or ground water – the treatment plant, the distribution system and the consumer's tap for maximum protection. Unfortunately, due to high cost of monitoring, only the minimum required number of representative points are evaluated.

2.1. Programme Design

2.1.1. General

Because of the diversity of water supply systems, it is very difficult to lay down hard and fast specifications for the designing of a drinking water quality monitoring programme. A practical monitoring programme should aim at discovering the multitude of hypothetical situations that may cause pollution in the water supply system and should make only the minimum neccessary evaluation. The following factors should be taken into account while designing such a programme:

(i) past experience; the frequency of outbreak of diseases or pollution, water-works efficiency etc.;

(ii) existing problems; the availability of manpower, funding and laboratory facilities and also social economic, legal and administrative limitations;

(iii) potential trouble areas; densely populated areas with poor sanitation, industrial areas with heavy pollution, low pressure areas, dead ends in pipe lines, etc.;

(iv) climatic conditions; droughts and flood for example place stress on the water-works. Therefore the programme should provide for more stringent monitoring during these times. This is also true for wells which are likely to be contaminated by flood waters.

(v) population distribution and geography; the population is normally not evenly distributed in a particular geographical area, therefore the sampling points should be selected based on population distribution rather than purely geographical.

2.1.2. Sampling Station Location and Construction

For the purpose of drinking water quality monitoring, sampling points should be sited at representative points in the water supply system so that the contamination can be isolated. Ideally the points should be located to trace the course of water right from the source, to treatment plant, to the prime conduit then through the major and minor arteries till consumers' taps (especially at public places such as school, hospital, restaurant, ice making plants etc.).

The most accurate evaluation of water quality is obtained when samples are drawn directly from the mains. Permanent sampling stations may be installed but they must be easily accessible and free from the possibility of contamination.

The principle features in the design of a sampling station are:

i) the station be directly connected to the main, with the shortest possible length of pipe;

ii) the connecting pipe, tap etc. must be made of corrosion and heat resistant material;

iii) the sampling tap should be within an enclosed metal or concrete cabinet which can withstand tampering. The cabinet must be tightly sealed to avoid possible contamination of the water supply through cross connection and, the unit must be self draining;

iv) the entire unit should be located in the street close to the tapped main. It should be accessible at all times.

2.1.3. Frequency of Sampling, Number of Samples

Generally, the frequency of sampling for drinking water quality monitoring depends on; (i) population served, (ii) relative importance of parameters concerned, (iii) relative importance of sampling station involved, (iv) whether water supplied with or without disinfection and (v) complexity of water supply system (vi) past experience.

The approach here is to specify the interval for sampling for each of the parameter based on its health significance and possible variation in concentration. This is as shown in Table 1 Column III and Table II Column IV in the National Guidelines for Drinking Water Quality (NGDWQ). As regards to the total number of samples required per month per population, the United States Public Health Service (USPHS) Drinking Water standards recommendation is adopted as shown in figure 1. (See NGDWQ).

2.1.4. Number of Sampling Points

Estimation of the number of sampling points necessary for a public water supply can be calculated as follows:

(a) The number of samples from a public water supply system required for monthly examination can be obtained from the graph in figure 1 (NGDWQ) which depends on the population served by the water supply system.

(b) This number divided by the interval of sampling per month should yield the number of sampling points required.

Assuming official samples are to be examined weekly (usually requirements for bacteriological samples)'(see Table 1 & 2 NGDWQ). therefore, the total number of sampling points per public water supply system should approximately be one quarter of the monthly total samples required.

Based on the above considerations and assuming the water consumption per head per day to be 200 litres, (50 gal.) a water treatment plant of 20 million litres per day (5 mgd) capacity should have at least 25 sampling stations.

2.2. Model of a District Drinking Water Quality Monitoring Programme

To establish a district drinking water quality monitoring programme, the first step is to take an inventory of all the water supply systems. The following information is required for each system:

(a) the plans of the complete water supply system serving the community, including the intake, treatment works, transmission and distribution systems;

(b) the plans of the sewerage collection system in the vicinity of the water supplying area;

(c) particulars of the areas covered by the water supply system;

(d) the type of water source and its quality;

(e) a description of the treatment system;

(f) the capacity of the intake;

(g) the treatment plant capacity;

(h) the peak amount supplied per day, per month and

(i) the population served.

Note: (i) information from a, b, c helps to determine the location of sampling stations;

(ii) information from h, i helps to determine the total number of sampling stations required;

(iii) information from d, e, f, g helps to determine the parameters required and their frequency of sampling.

Based on the above information, the following details were established:–

(i) determination of the total number of samples to be collected each month, (see figure 1 – NGDWQ);

(ii) the total number of sampling stations required (see Sec. 2.1.4);

(iii) the frequency of sampling (see Sec. 2.1.3);

(iv) the parameters to be monitored at each station (Table 1 & II – NGDWQ);

(v) the location of sampling station (see Sec. 2.1.2) and

(vi) the equipment and procedure for sampling (see Sec. 3 – MDWQS)

2.2.1. **Urban Public Water Supply**

To illustrate the above points, the following is an example of an urban district drinking water quality monitoring programme:–

(1) Assuming a water treatment plant serves 100,000 people. From (figure 1 – NGDWQ) the number of samples required is 100 per month.

(2) Assuming that sampling is required on a weekly basis (universal practice for bacteriological sampling), hence 25 sampling stations are required throughout the water supply system.

(3) Having established the total number of samples and total number of sampling stations for a particular drinking water quality monitoring programme, we then try to site these sampling stations in the appropriate location. Ideally, sampling stations should cover extensively over the whole water supply system, namely the source, the intake, the treatment plant outlet, the service reservoir outlet and the distribution system (as shown in Table 1 and map 1). Moreover sampling stations in the distribution system should include:

(a) areas of poor previous records;

(b) low pressure zones;

(c) areas with high leakage rates;

(d) densely populated areas with inadequate sewerage;

(e) dead ends on pipe lines;

(f) periphery of the system furthest away from treatment works;

(g) public places e.g. school, hospital, station, airport;

(h) food and beverage industries – e.g. ice-factory, bottled water manufacturer.

Sampling Station No.	Total No. of Samples
Source (DOE)	1
Intake	1
Treatment Plant Outlet	1
Service Reservoir	1 at each S.R. (3)
Distribution System (variable)	= 19

Table 1 : Sampling station and the respective number of samples.

(4) A map of the whole water supply system should be sketched with all the sampling stations (basic and auxiliary) well defined (as shown in the schematic map of an urban public water supply system – map 1).

(5) Next, we have to decide which parameters are to be monitored at each station and the frequency of monitoring. This is presented in the following Table 2 and 3.

Table 2 : Frequency of Sampling of the various parameters at the respective sampling stations

Stations / Parameters*	Source	Intake	Treatment Plant Outlet	Storage Reservoir Outlet	Distribution System
	001	002	003	004–008	009–025
GROUP I	W/M/2	W/M/2/M	W/M/2	W/M/2	M
GROUP II	M	M	M	M	M/Y/2
GROUP III	Y/2	Y/2	Y/2	Y/2/Y	Y/2/Y
GROUP IV	Y/2	Y	Y	WN	WN

W = weekly   D = daily   Y = yearly

WN = when necessary   M = monthly   Y/2 = semi-anually

(6) Draw up a sampling schedule (Table 4) indicating the name of each station and the date sample is to be taken and by whom (category and name of staff) as illustrated in Table 4.

(7) After having done that, a sampling frequency/cost diagram should be worked out taking into account the man hours and travelling costs involved.

(8) Equipment and procedures for sampling. Sample collection, handling and preservation should be performed according to the procedures described in this manual

TABLE 3 PARAMETERS GROUPING

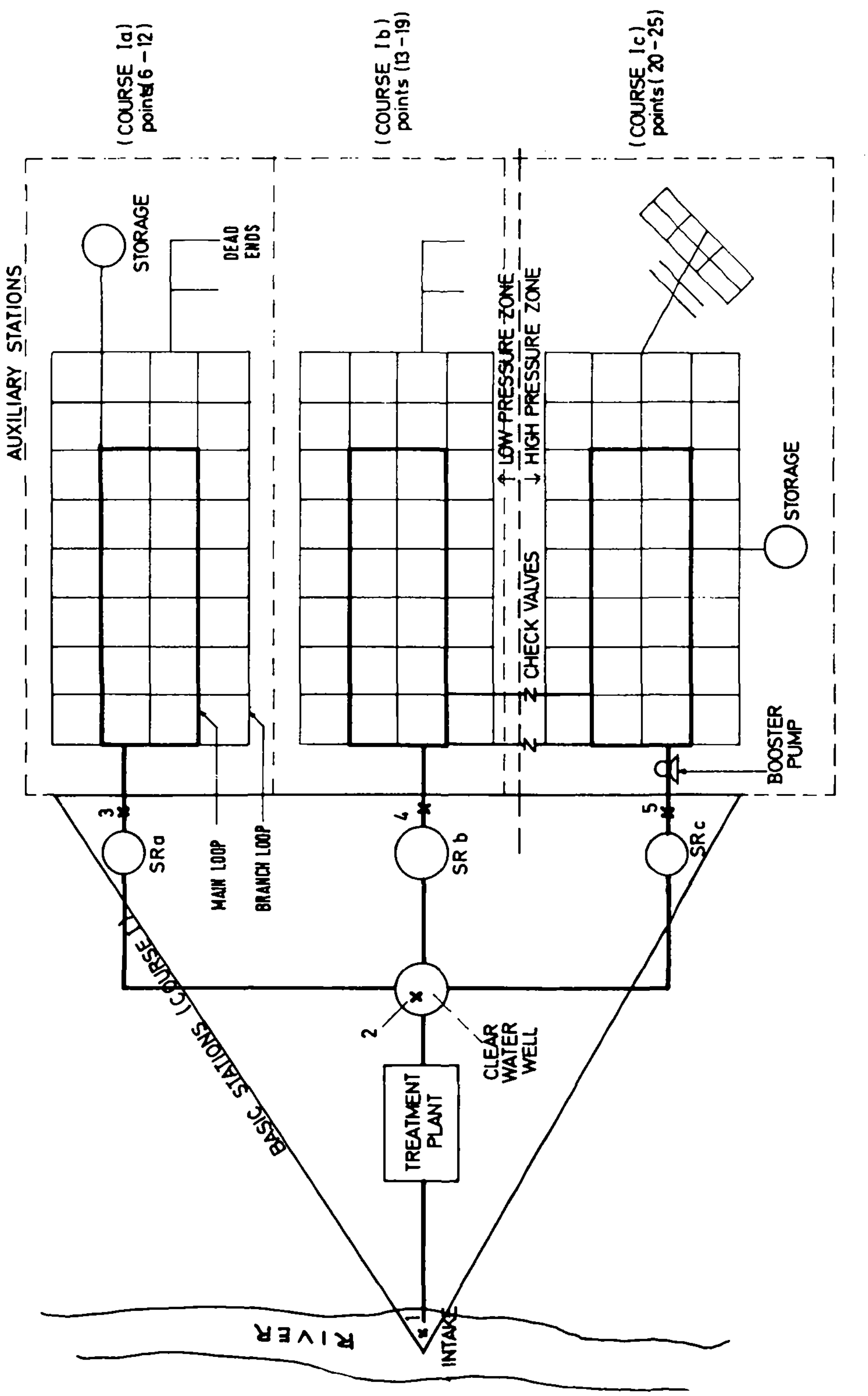
Parameters	Group I	Group II	Group III	Group IV	Group V
Coliform E. Coli Turbidity Colour pH Residual Cl_2	▨				
Total dissolved solids Carbon chloroform extract BOD } for plant intake only COD } Detergent (MBAS) Ammonia (N) Nitrate (N) Fluoride Iron Manganese Aluminium Alkalinity ($CaC0_3$) Hardness ($CaCo_3$) Chloride		▨			
Mercury Selenium Arsenic Cyanide Silver Magnesium Sodium Sulphate Phosphate Hydrogen sulphate Oil Phenol Chloroform			▨		
Biocide				▨	
Radionucleides					▨

(Sec. 3). In addition the following are some useful references:

(i) International standards for drinking water 3rd., edition 1971.

(ii) Standard methods for the Examination of water and waste water, 15th or latest edition A.P.H.A.

MAP 1 SCHEMATIC OF A MODEL URBAN PUBLIC WATER SUPPLY SYSTEM



SAMPLING SCHEDULE/STATIONS/PARAMETERS

BORANG KMA 2

WATER SUPPLY SYSTEM : ______________________

COURSE : ______________________

STATION			WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			DATE																										
TYPE	NAMES	NO	PARAMETERS GROUP	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V	I II III IV V
B	INTAKE	001																											
A	T. P. O	002																											
S	SERVICE RES. 1	003																											
I	SERVICE RES. 2	004																											
C	SERVICE RES 3	005																											
A	DISTRIBUTION SYSTEM 1a	006																											
U		007																											
X		008																											
I		009																											
L		010																											
I		011																											
A		012																											
R	DISTRIBUTION SYSTEM 1b	013																											
Y		014																											
		015																											
		016																											
		017																											
		018																											
		019																											
		020																											
	DISTRIBUTION SYSTEM 1c	021																											
		022																											
		023																											
		024																											
		025																											
		026																											
		027																											
		028																											
		029																											

2.2.2. **Rural Public Water Supply**

Example of a rural water quality monitoring programme (wells)

(1) An inventory of all the wells in the village are taken with the following information:

(i) a brief description of all wells, as regards to:–

(a) well identity : (well no.)
(b) location : (address of kampong)
(c) type of well : (shallow/deep)
(sanitary/unsanitary)
(drug well/tube well)
(with/without piping facilities)
(with/without pumping facilities)

(ii) a map of the location and topography of all wells in the said village;

(iii) the plan of the sewerage collection system and drainage in the vicinity of the wells;

(iv) a description of its water quality;

(v) a description of treatment if any;

(vi) the number of people served by each well.

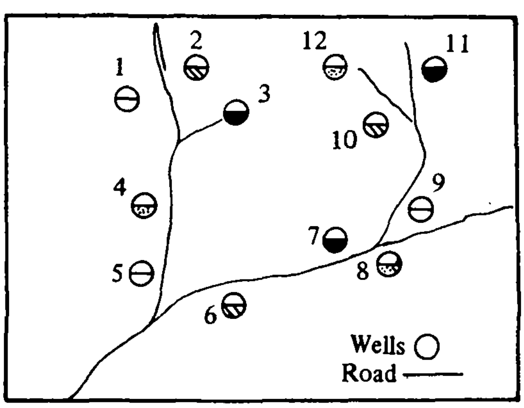
(2) Unlike urban public water supplies, for rural wells, we are observing the following guidelines on frequency of sampling:

(i) every public well has to be sampled at least once every two years.

(ii) For a village, sampling interval will be half yearly.

Thus assuming an average sized village of 50 houses having 12 wells, the field staff need to sample 3 distantly located wells per visit, and should endeavour to sample all the wells over a two year period.

The following is a map illustrating the manner the wells should be sampled at each visit by the field staff.



Map 2: Sampling map for rural public water supply (wells)

A sampling schedule (Table 5) showing the wells, date of sampling, parameters to be tested and their frequency should be established as follows:–

Table 5 : Sampling Schedule

Village : ....

District : ....

State : ....

Well Identity	Sampling Date	Parameters & their respective frequency
Well reference No. 1 No. 5 No. 9		as showed in Table I – (NGDWQ)
No. 2 No. 6 No. 10		
No. 3 No. 7 No. 11		
No. 4 No. 8 No. 12		

2.2.3. **Other Systems**

The following is a description of other system of public water supply. Similar monitoring programmes must be set up for such systems following the guideline given in Sec. 2 and the example described for urban drinking water quality monitoring.

(i) **Production Wells for Public Water Supply System**

The use of ground water for human consumption requires monitoring of (i) levels and (ii) trends of certain hazardous constituents. This is especially important in areas where large potential polluters are situated, such as sanitary landfills, animal feed lots, industrial waste dumps and storage places for fertilisers etc.

Where a large production well is utilised for public water supply, it should be protected from aquifer contamination, hence one or more observation wells have to be installed "up stream" of the abstraction point. These observation wells should be of sufficient number and of suitable distance to cover the ground water basin which drains to the production well to allow for timely warning, if any contamination is detected. Physical, chemical and microbiological examination of production well water should be conducted two to four times per year for small waterworks while large ground supplies may require more frequent analysis (as with treated supplies – refer Table 1, 2 – (NGDWQ).

(ii) **Gravity Feed Water Supply System**

These are small public water supply systems, providing untreated water to the rural communities, using spring water from uninhabited catchment areas which are relatively free from contamination. The parameters and frequency to be monitored are as specified in Table (1, 2 – NGDWQ).

It should be noted that the recommended frequencies may have to be increased because of local conditions. Frequencies may have to be altered to meet new conditions such as epidemics, when new sources are selected, when water mains are chlorinated following installation or repair and when consumer complains or laboratory analysis suggests that contamination of the system may have occurred.

3. Sampling

Sound sampling techniques is one of the basic requirements of a drinking water quality surveillance programme. It involves the transferring of water from the original collection point to another location without causing any change in its properties.

It is useless to make a highly accurate analysis of an improperly collected or handled sample. Hence for meaningful water quality data, great care must be taken in the collection, transport and storage of these samples to ensure that such samples are representative of the water to be examined.

There is no perfect standard procedure for sampling and the ingenuity of the investigator in sample collections may be more important in many instances. General guidelines on the proper collection, transport and storage of samples using appropriate sampling apparatus are given in the succeeding paragraphs.

3.1. Sample Containers

Plastic (polyethylene) or glass containers should be used depending on the tests to be assayed. Generally plastic containers are more desirable, being non-breakable and lighter in weight than glass bottles, however they are unsuitable when sampling for bacteria, organics and pesticides.

3.2 Sampling Device

Sampling devices are necessary when sampling is to be carried out on surface water, reservoir, and wells. The simplest form of a water sampling device is a bottle attached to a string. A holder of sufficient weight may be necessary to overcome the buoyance of the bottle and allow it to sink as rapidly as desired. Such a holder designed to contain one or two litre plastic bottles is illustrated in fig. (1).

When water from a particular depth is to be collected, Meyer's Sampler bottle (fig. 2) or Dussart Sampler (fig. 3) may be used. In both of these devices, a closed container is lowered to the desired depth and than by means of a jerk of the suspending cord, the container is opened.

For greater accuracy and for water depths greater than 50 meters, special samplers such as Kemmerer (fig. 4) or Friedinger (fig. 5) may be used. These essentially consist of bottles, open at both ends which are lowered to the desired depth in the open position in order to allow water to stream through the bottle. Closure is affected by a drop weight which slides down the supporting cord.

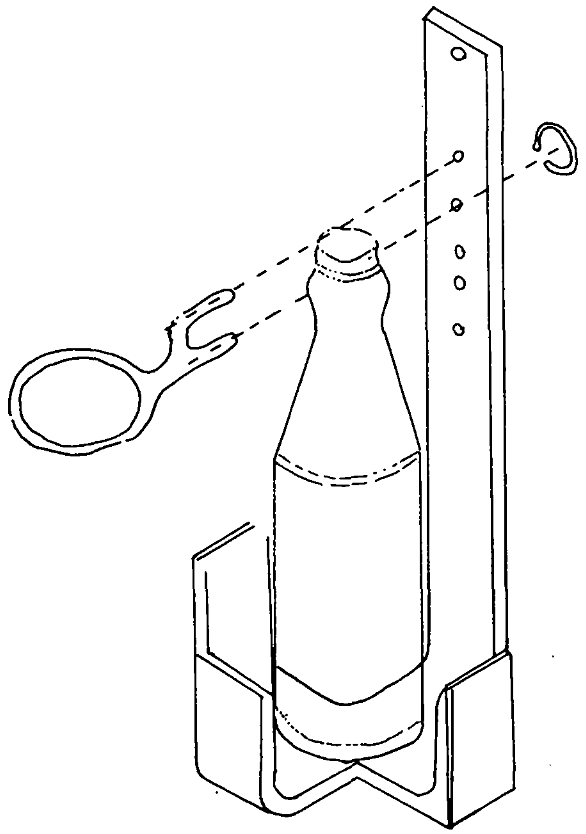


Fig. 1 – Sample bottle holder for sampling

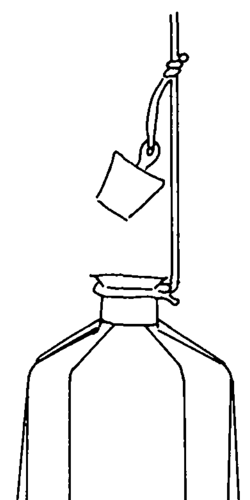


Fig. 2 – Meyer's sampling bottle

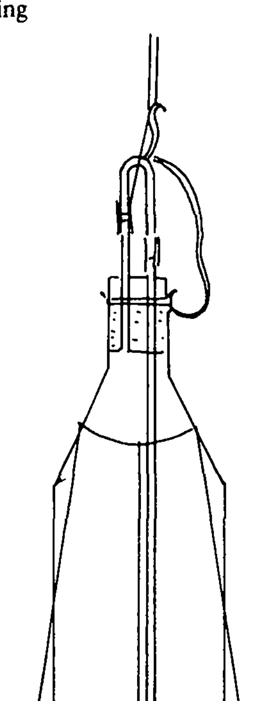


Fig. 3 – Dussart Sampler

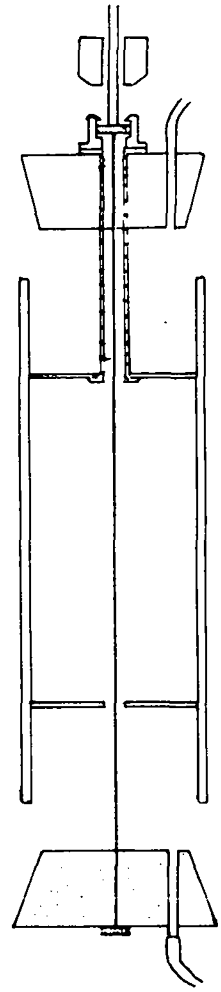


Fig. 4 – Kemmerer Sampler

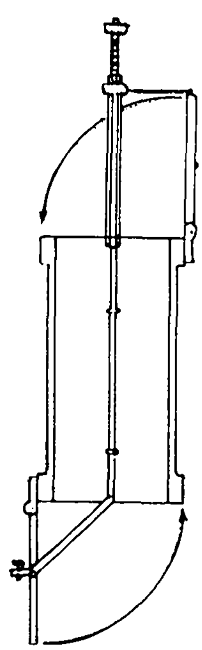


Fig. 5 – Friedinger Sampler

3.3. **Sampling Procedure**

3.3.1. **Sample identification**

Each water sample must be completely identified as to:

(i) the type of water (ref. to 3.3.4 (I))
(ii) the location being sampled (ref. to 3.3.4 (II – VI))
(iii) the date and time collected (ref. to 3.3.4 (II – VI))
(iv) the date and time arrived at the laboratory.

The sample label shown on figure (6) must be adhered firmly to each bottle.

Figure (6) : SAMPLE LABEL

Sample Part	Type of water	State	District	Treatment plant	Sampling pts.	Sequential No.
Collec-ted	Year	Month	Date	Time	am/pm	
Arrived	Year	Month	Date	Time	am/pm	

Name, Address, Tel. No. of Sender: ....

....

Note: Obtain the following volumes for examination:

i)	bacteriological	–	100 ml
ii)	chemical & physical	–	2 litres
iii)	radiochemical	–	1 litre

3.3.2. **Sample Collection**

(1) **For Bacteriological Examination**

(i) Bacteriological samples should be collected first.

(ii) Sterilised glass bottles containing 0.1 ml of 3% sodium thiosulphide and with proper stopper and cap should be obtained from DOC.

(iii) Sampling bottles must be capped at all times except during sampling. When sampling the stopper and neck of bottle should not be in contact with anything. The bottle should be held near the bottom, filled without rinsing and the stopper replaced immediately.

(iv) Samlpes should be taken from a sampling pipe directly connected with the mains (not from a roof cistern). The tap should be clean and sterilised by flaming. The water should be allowed to run to waste from the tap for at least 3 to 5 minutes before the sample is collected (see Annex 1 – 1). The standard design of the sampling pipe is given in Annex 1 Fig. 1.

(v) When samples are to be taken from source (that is spring, river, stream, lake, well) or reservoir, care must be taken to ensure that the sample is representative of the water for the particular purpose. Example, sample from river, stream, lake, reservoir can often be taken by holding the bottle near its bottom and plunging the neck downwards, below the surface. The bottle should be turned until the neck points slightly upwards, with the mouth facing the direction of the current. If no current exists as in reservoir, one should artificially create one by pushing the bottle horizontally forward (see Annex 1 – 2).

(vi) For samples to be taken from wells; samples can be collected directly using a sterilised bottle fitted with a weighted foot. Care should be taken to avoid contamination by surface scum. For wells fitted with pumps, the pump outlet should be sterilised by flaming. Water should be pumped to waste for about 5 minutes before collection (see Annex 1 – 3).

(vii) Samples should be transported in ice and examined within 24 hours after collection.

(2) **For Physical and Chemical Examination**

(i) Chemically clean glass or polyethylene bottles may be used. The bottles should be rinsed out at least three times with the water to be sampled before the sample is taken.

(ii) The general recommendations for bacteriological examination should be followed (except the requirement to sterilise taps or pump outlets).

(iii) Samples should be analysed within seventy-two hours after collection.

(iv) Parameters such as pH, residual chlorine, and dissolved oxygen (DO) should be analysed on site. If DO cannot be determined in the field, a separate sample should be collected. A 200–300 ml narrow neck bottle with a close fitting glass stopper should be used. The temperature should be recorded on the spot. If the sample is collected from a tap, the water should be directed through a glass tube to the bottom of the bottle and allowed to overflow for 2-3 minutes before the sample is taken. When samples are taken from a stream or reservoir, suitable apparatus should be used to ensure that the water in the sampling bottle is displaced several times.

(3) **For Radiological Examination**

(i) Use polyethylene bottles only.

(ii) Samples must be examined as soon as possible after collection, to avoid missing radioisotope with a short half life.

3.3.3. **Complete the Appropriate Forms**

(i) Three forms have been developed for the National Surveillance Programme. Each is to be used for requesting the particular analysis and for recording and reporting the results.

Form S–1	–	bacteriological examination of water
S–2	–	is for periodic short chemical examination of water.
S–3	–	is for the complete chemical examination of water.

(ii) Complete the appropriate form (see Sec. 3.3.4) and send to DOC together with the samples.

3.3.4. **Coding system**

The recording and storage of data collected in the drinking water quality surveillance programme adopt the following codes.

I) **Type of Water**

at source	code
i) ground	01
ii) surface	02
iii) pound/lake	03
iv) spring	04
v) others	05

at distribution system	code
i) untreated water	11
ii) only disinfection	12
iii) treated water	13

II) **States**

STATE	CODE
Perlis	PS
Province Wellesly	PY
Kedah	KH
Perak	PK
Selangor	SR
Negeri Sembilan	NN
Malacca	MA
Johore	JE
Pahang	PG
Terengganu	TU
Kelantan	KN
Wilayah Persekutuan	WN
Sarawak	SK
Sabah	SH

III) **Districts**

DISTRICT	CODE
Perlis	01
Pulau Langkawi	02
Kubang Pasu	03
Kota Setar	04
Kuala Muda/Yen	05
Padang Terap & Sik	06
Baling	07
Kulim/Bandar Baru	08
Pulau Pinang	09
Seberang Prai Utara	10
Seberang Prai Tengah	11
Seberang Prai Selatan	12
Hulu Perak	13
Larut/Matang/Selama	14
Kerian	15
Kuala Kangsar	16
Kinta	17
Manjung	18
Batang Padang	19
Hilir Perak	20
Perak Tengah	63
Ulu Selangor	21
Gombak Petaling	22
Ulu Langat	23
Sabak Bernam	24
Kuala Selangor	25
Kelang	26
Kuala Langat	27
Sepang	28
Seremban	29
Jelebu	30
Port Dickson	31
Kuala Pilah	32
Rembau/Tampin	33
Melaka Utara	34
Melaka Tengah	35
Melaka Selatan	36
Segamat	37
Muar	38
Batu Pahat	39
Kluang	40
Pontian	41
Johor Bahru	42
Kota Tinggi	43
Mersing	44
Pekan	45
Temerloh	46
Bentong	47
Raub	48
Cameron Highland	49

DISTRICT	CODE
Lipis	50
Jerantut	51
Kuantan	52
Kemaman	53
Dungun	54
U. Terengganu/Marang/K. Terengganu	55
Besut	56
Ulu Kelantan	57
Machang	58
Bachok	59
Pasir Puteh	60
Pasir Mas	61
Kota Bharu/Tumpat	62
Tanah Merah	64
Kota Kinabalu	
Tuaran	
Beaufort	
Keningau	
Kudat	
Sandakan	
Tawau	
Labuan	
Kuching	
Bau/Lundu	
Serian	
Simunjan	
Sri Aman/Lubok Antu	
Saribas/Kalaka	
Sibu	
Kanowit	
Mukah/Oya/Dalat	
Miri	
Bintulu	
Baram	
Limbang/Lawas	
Sarikei/Binatang/Julau/Matu Daro	
Kapit/Belaga/Song	

IV. **Treatment Plant**

Two alphabets should be used to identify each water treatment plant, such that no two treatment plants should have similar alphabets in the same district.

V. **Sampling Point**

For each district, numbers starting from 001 to 999 should be assigned to the respective sampling points as they are established.

VI. **Sequential Number**

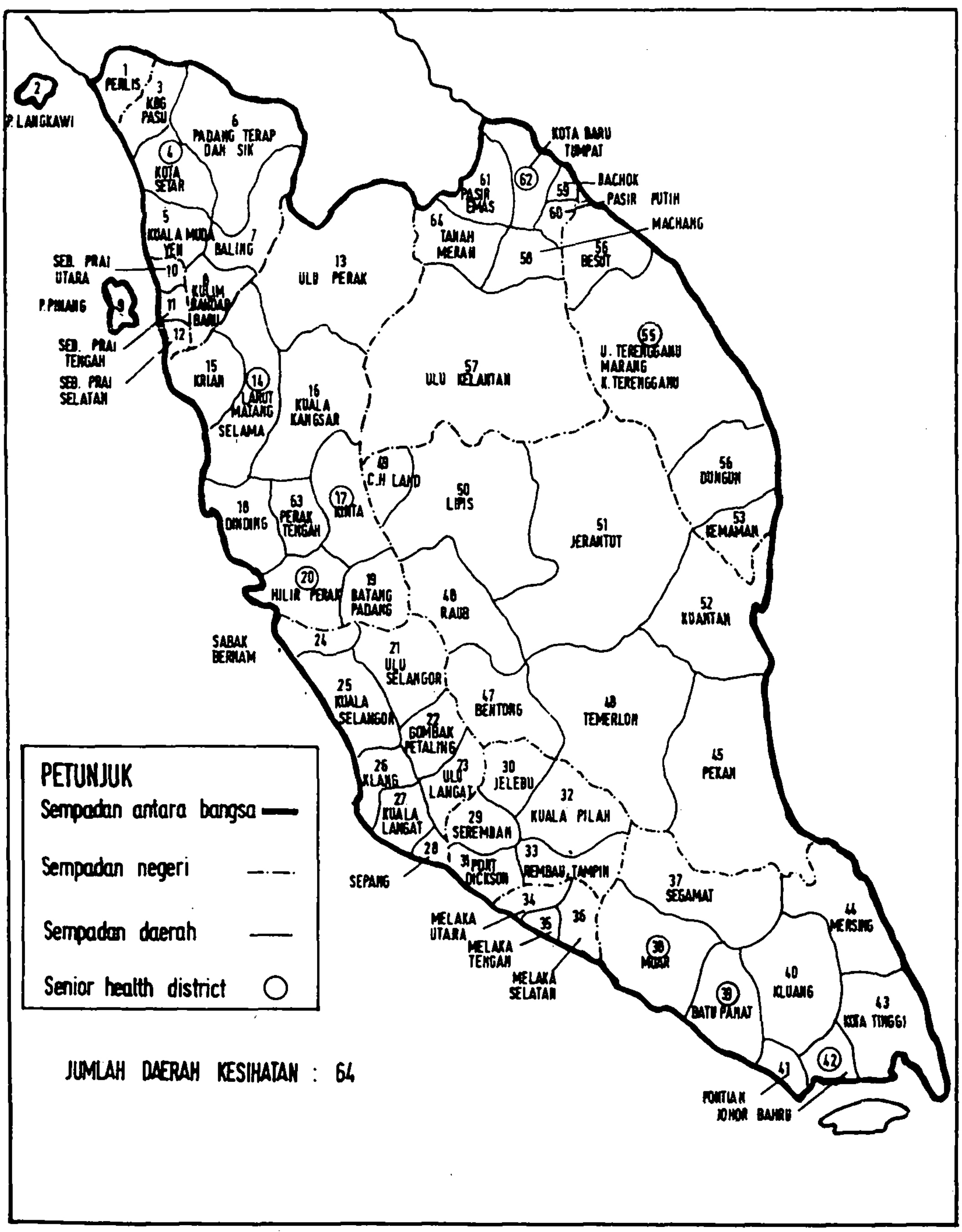
There are numbers in sequence assigned to every sample collected from a particular sampling point for a year.

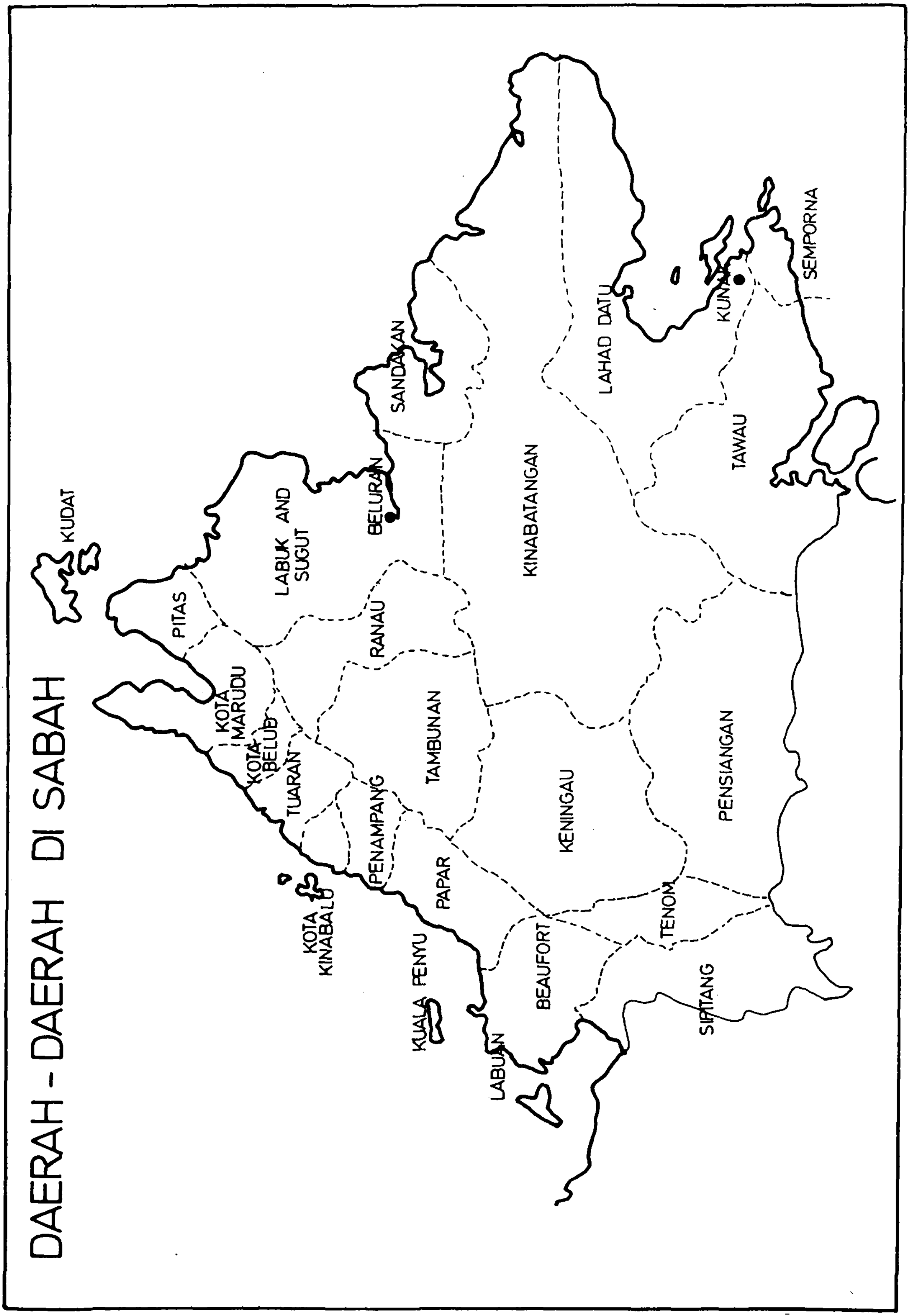
VII. **Laboratory**

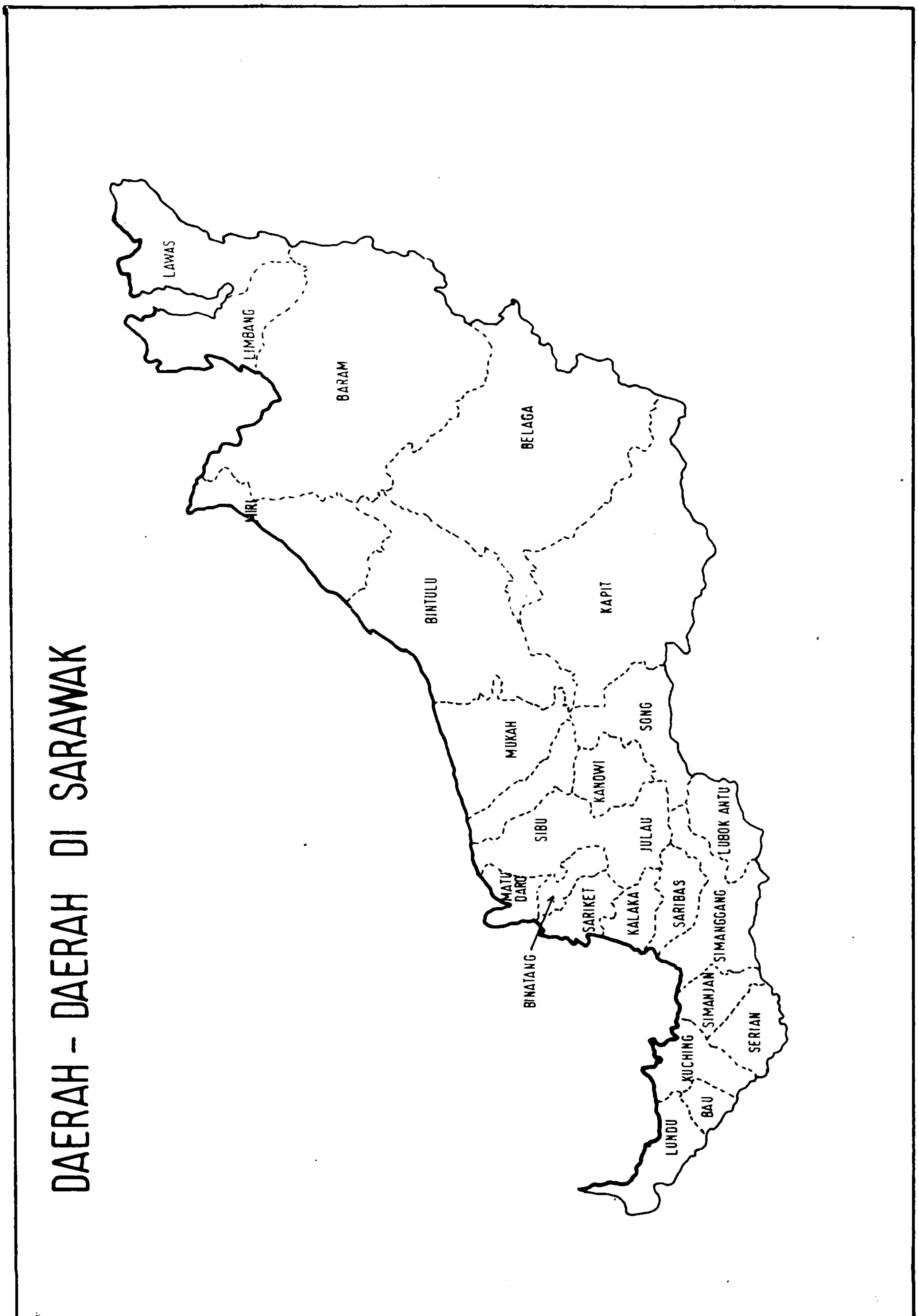
Analytical laboratory should be identified as follows:–

Laboratory	Code
Government	01 – 49
Private	50 – 99

DAERAH-DAERAH KESIHATAN SEMENANJUNG MALAYSIA




DAERAH - DAERAH DI SABAH
KUDAT
PITAS
KOTA MARUDU
KOTA BELUD
TUARAN
LABUK AND SUGUT
BELURAN
SANDAKAN
RANAU
TAMBUNAN
PENAMPANG
KOTA KINABALU
PAPAR
KUALA PENYU
LABUAN
BEAUFORT
KENINGAU
KINABATANGAN
LAHAD DATU
KUNAK
SEMPORNA
TAWAU
PENSIANGAN
TENOM
SIPITANG


DAERAH - DAERAH DI SARAWAK
LAWAS
LIMBANG
BARAM
BELAGA
MIRI
BINTULU
KAPIT
MUKAH
SONG
KANOWI
SIBU
JULAU
LUBOK ANTU
MATU
DARO
SARIKET
KALAKA
SARIBAS
BINATANG
SIMANGGANG
SIMANJAN
SERIAN
KUCHING
BAU
LUNDU

3.3.5. **Transport and Storage**

(i) Sturdy boxes are provided by the DOC (see fig. 7) so that the samples are adequately protected against breakage during transport.

(ii) The samples should be packed in ice and kept in a dark environment at a constant temperature.

(iii) The sample box should be forwarded to the DOC as quickly as possible. It must reach the laboratory within 24 hours of sampling.

(iv) The sampling box must be attended to immediately when it reaches the DOC.

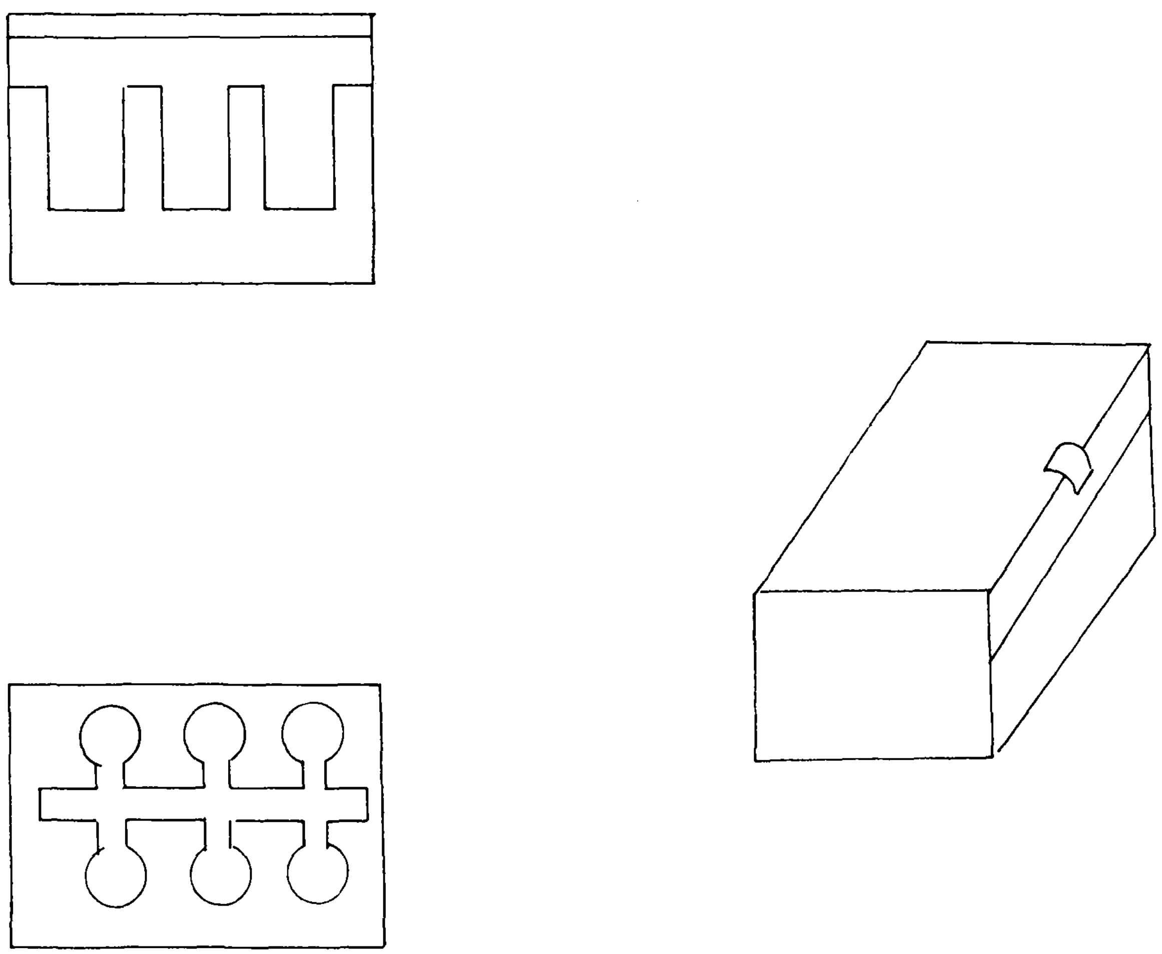


Fig. 7 – Box for dispatch of water samples.

4. Testing

Different methods of testing for the same analyte may yield different readings. It is important to specify the method used for a particular analyte in order to be able to compare or interprete the values meaningfully.

4.1. Laboratory Testing

The methods recommended in "Standard Methods of Examination of Water and Waste Water" by the American Public Health Authorities and American Water Works Association must be adopted. Every Water Testing Laboratory must possess a latest edition of the book; and with copies of each method easily accessible on the work bench.

DOC; through its regional laboratories will assist in analysing water samples from public water supplies operated by FWD and WB;

The laboratories are also required to provide proper containers with the appropriate treatment to the water sampler for sampling.

4.2. Field Testing

Because of chemical changes that occur in water samples during transit and storage, certain parameters should be measured on site, immediately after the sample is taken. These are temperature, pH, residual chlorine and dissolved oxygen.

In some areas where samples cannot be forwarded to the DOC within the stipulated time, it is also necessary to carry out the examination of E. coli in water on site. The other parameters will be carried out as usual by the DOC.

Similarly, for rural water supply schemes (public wells, gravity-feed scheme) assisted by MOH, bacteriological, physical and chemical testing are to be carried out by field staff using portable kits. Such tests are mainly for screening purposes (except bacteriological) and any positive findings must be confirmed with DOC.

All field testing kits must be standardised with the DOC before putting into wide use. The detailed method for field testing kits can be obtained from the respective manufacturer, and should be followed closely.

4.3. In-Plant Testing (primary control tests)

In addition to the complete laboratory examination of water quality, simple "primary control tests" are designed for in-plant testing. These tests are aimed at controlling each step in the water treatment process and usually includes: pH, colour, turbidity, residual chlorine, alkalinity, jar tests etc.

These tests can be carried out by trained plant operators who are to be supervised regularly, by a chemist or a qualified laboratory staff. The number of water samples examined each day will depend upon the quality of the raw water, the rapidity with which the raw water characteristics change, the multiplicity of processes employed in the treatment and the number of processing units involved. Generally all plants should collect water samples hourly for primary control testing to ensure that the water has been properly prepared for each major step of treatment process and has proceeded according to plan such that the finished product is aesthetically pure and safe for human consumption.

For in-plant laboratory, the various tests can be consolidated into one room, with the various functions allocated to different sections of the room. It should be well lighted, clean, comfortable and safe. Adequate laboratory control presupposes a well equipped and properly staffed laboratory. Therefore instruments like the pH meter or comparator, turbidimeter, weighing balance, Chlorine comparator or titrator, colorimeter, reagents and glass-wares must be available and well maintained. Details of the testing procedures are described in Annex (3).

5. Sanitary Survey

5.1. Elements of a Survey

Sanitary Survey is an on the site inspection of the conditions, devices or practices of a water supply system.

Sanitary Survey if carried out routinely allow an overall appraisal of the water supply system and serve to identify any deviation from norms that may sooner or later affect the optional production or distribution of safe drinking water.

Sanitary Surveys carried out during a remedial action plan, complement the results obtained through monitoring, help in identifying the cause as well as the source of sanitary deficiencies.

5.1.1. Sanitary Survey of Source

This is a systematic inspection of the source of a water supply made by a qualified personnel. For surface source it generally involves the survey of the whole watershed, including every stream and riverlet which feeds into the river or reservoir leading to the water-works. The drainage of the inhabited areas, cultivated land or any other land use should also be examined to discover whether these pollute the source directly. For ground source (wells) it generally requires the examination of the apron, the scaling between casing and surrounding soil, the arrangement of conveying waste water away, the position of all drains, privy pits or the wastes within the drainage area of the well.

Table 6 outlines some principle features of a sanitary survey for the different types of source, with respect to the sanitary defects likely to be present, and the remedial measures that may be used to correct them.

Table.6 – Sanitary Survey of Water Supply Sources

Source	Possible Sanitary Defects	Suggested Rectification measures
Dugwells	Contamination by nearby waste discharges; surface water-pollution through lining, cover slab or manhole.	Sanitary conservation of nearby area, sealing of leaks, chlorination of supply.
Tube Wells	Entry of polluted drainage around pipe, damaged casing, improper sealing at top, liquid waste discharges in the vicinity.	Sanitary conservation of the area, sealing of the top and at ground level with a concrete apron, emergency chlorination, surface run-off.
Natural streams and springs	Access near point of intake for men and animals; pollutional discharges up-stream;	Sanitary conservation of the area, emergency chlorination.

Source	Possible Sanitary Defects	Suggested Rectification measures
	irrigation works or cultivation nearby.	
Infiltration wells and galleries in river beds.	Raw water access through leaky lining and cover slabs, short circuiting through deep scour.	Closing holes and grouting leaks, provision of collecting well at scour-point and chlorination of the supply.
Lake or reservoir.	Drift of pollution by wind; access to intake point for men and animals; fishing, boating, swimming activities; picnics on margins and shores, habitations, manure pits and agricultural operations in the nearby catchment area.	Restrictions and treatment to be decided by the bacterial purity of the water at the point of intake; sanitary conservation of the nearby watershed area; routine post chlorination treatment.
River	Liquid waste discharges up-stream of the intake point and also at near points downstream; sewage farms, dumping grounds, the growing of crops in the riverbed above the intake point during periods of reduced flow; fares and festivals near the river margin; laundry and washing and other human activities just above the intake point.	Corrective steps to avoid, to mitigate or to minimise the pollutional load at the point of intake depending on discharges into the river and the extent of contamination in the nearby water-shed-prechlorination during emergency; routine post chlorination treatment.
Raw-water transmission	Route and mode of conveyance should be chosen to avoid additional pollution during transmission.	Open canals should be protected in accessible reaches against contamination; cross drainage systems if any should be diverted.

5.1.2. Sanitary Survey of the Intake

The function of the plant intake is to withdraw continously adequate quantities of the best available grade of raw water for the treatment plant at all times. Ideally the location of the intake should be at the up-stream sources where the watershed is uninhabited or sparsely inhabited with no source of pollution. If this is not possible then the intake location should be as far down-stream as possible from any potential source of contamination to allow self-purification of the stream. It should also be as far upstream from such similar sources of contamination in order to avoid contamination through counter flow.

The intake structure should be designed and built to permit raw water withdrawal at various levels or locations or both. Also dual facilities should be provided for mechanical equipment. Pump priming must not create a cross connection between the finished and raw water. The intake facilities should also be constructed to avoid chance contamination of the raw water, be inaccessible to trespass and contain adequate toilet facilities and waste-water drainage.

5.1.3. **Treatment Plant Appraisal**

The purpose of a treatment plant appraisal is to verify and improve the functional efficiency of the plant components. The following are some general guidelines in making such an appraisal:

(i) **Presettling Reservoirs**

Presettling reservoirs are for removing turbidity by plain sedimentation, supplemented in special cases by the addition of coagulants, chlorine or both (usually coagulation at the inlet and prechlorination at the inlet or outlet). Presettling reservoirs should be designed to provide sufficient retention time for the removal of turbidity and harmful organisms. Provision should be made for rapid, convenient removal of sludge from reservoir and a bypass to avoid interruption during such cleaning.

(ii) **Chemical Dosing**

Dosage should be in accordance with laboratory tests (jar test, alkalinity, pH, turbidity, colour, residual chlorine etc.) chemical preparation, storage and feeding must conform to standard directives.

Treatment plants should be provided with devices for accurately measuring and adding to the water each chemical used for a specific purpose, with at least one reserve unit for all chemical feed equipment. The chemical feed equipment should have continuous recording devices and alarm devices to ensure continuity of treatment and should be capable of ready adjustment to variations in the flow of water being treated. Where flows vary considerably throughout a 24 hour period, the chemical feed adjustment should be automatic.

Sufficient chemicals should be stored (a minimum of 30 days supply) to prevent shortages of unforeseeable interruption of chemical supply. An up-to-date inventory of chemical stock should be kept.

(iii) **Coagulation and Flocculation**

Coagulation and flocculation are generally accomplished by flash mixing of the coagulant followed by gentle agitation to promote flocculation. Dosing efficiency, flash mixing efficiency and floc formation should be verified. Points of excessively high or low velocity or bad short circuiting in the flocculation chambers and raw water channel should be investigated.

(iv) **Sedimentation**

Sedimentation basins should be sized and arranged to ensure the settling of the floc developed and the delivery of relatively clear water to the filters. Basins should be of sufficient number and hydraulic flexibility to ensure the continuous operation of the treatment plant. Provisions should be made for satisfactory removal of sludge. The critical displacement velocity of the floc must not be exceeded by water flowing through the sedimentation basins.

(v) **Filtration**

(a) **Slow Sand Filters**

Slow sand filters are suitable for the treatment of relatively clear raw water (influent turbidity should be less than 30 NTU). Preferably they should be covered and operated at rates of about 4 million gallons per acre per day. The filter area should consist of several independent units so that the quality and quantity of water required at times of maximum draft can be supplied when some units are out of service for cleaning (normally done every 20-60 days) or for repair works.

(b) **Rapid Sand Filters**

Rapid sand filter should preferably be the open, gravity type to permit ready and continuous inspection. The depth, effective size and uniformity coefficient of the media should meet the requirements of adequate yield and filter efficiency. Rapid sand filters are operated at 1.5 - 3.0 gallons per square foot per minute. Cleaning is normally done once in every 12-40 hours or when sufficient head lost has been established or when there seems to be danger of a breakthrough.

In general rapid sand filters should be designed and operated to maintain high efficiency in particulate removal and to keep the filtering medium free of mud balls, cracks and other hindrances to efficient filtration.

(vi) **Chlorination**

Chlorination should be continuously applied to the water being treated in a manner that ensures rapid and thorough dispersion of the chlorine throughout the water. The proper dosage of chlorine should be determined by regular and frequent chlorine residual tests: both at the plant and at various points in the distribution system. In general, a minimum free residual chlorine of 0.1 ppm at distant points in the distribution system helps maintain a system free of bacteria growths. If total residual chlorine is used, the desirable level is 1-2 ppm at distant points in the distribution system. In cases where the source is badly contaminated, a free residual chlorine of 0.2 – 0.5 ppm is required to maintain a system free of bacteria growths.

Chlorination equipment should be selected, installed and operated to achieve continuous and effective disinfection under all possible conditions, with enough stand-by units to ensure uninterrupted operation. Chlorination enclosures should be adequately ventilated to permit exhaust by gravity or mechanical means from the lowest point of the enclosure. The chlorinator installation and the handling and storage of chlorine containers should conform to safety requirements.

5.1.4. Sanitary Survey of the Distribution System

Before making the sanitary survey, a study must be made on the plans of a distribution system and the sewerage system of the area concerned. The survey must be able to provide information on the following:

(i) areas supplied by the distribution system;

(ii) population served, number of house taps, number of public taps;

(iii) nature of supply system – pump or gravity type (continuous or intermittent, single or dual system);

(iv) total plant capacity and average rate of supply;

(v) operating pressures, high and low;

(vi) potential trouble areas such as slums and low pressure regions;

(vii) areas of risk for cross-connection between water mains, service piping and sewers, sewer-line connections, or waste water drains and ditches, hydrant drain lines connected to sewer or drain courses;

(viii) location of recent sewer lines on top of, crossing or near old water mains or house service pipes;

(ix) household plumbing and practices such as misuse and improper location of house taps, back siphonage etc.;

(x) risk of pollution at public stand pipes as from improper usage, damaged taps, open and leaky valve chambers, valve chambers under water of filth.

5.2 Model of a District Sanitary Survey Programme

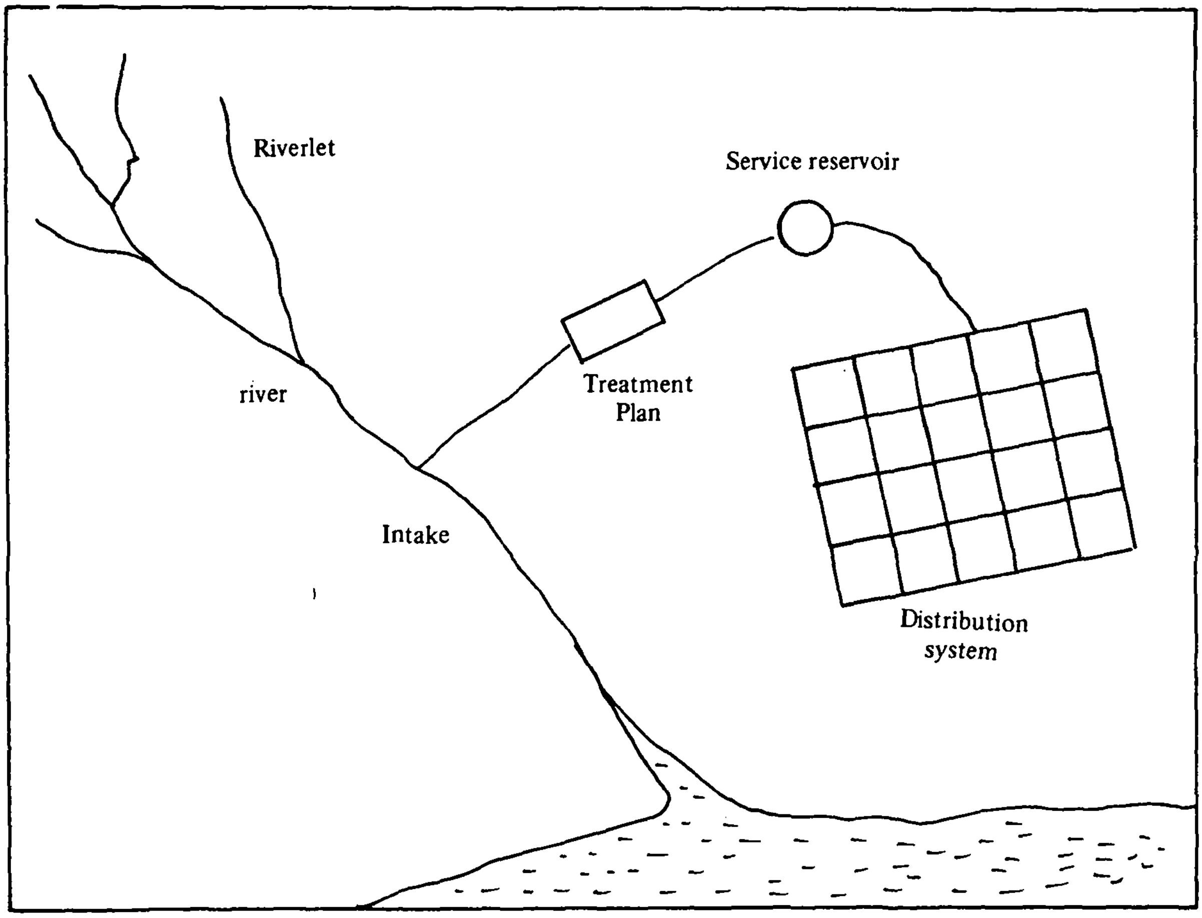
5.2.1 Programme Establishment

(i) Insert the names of all public water supply systems of the district in form (SSP) (see fig. 8).

(ii) Decide on the frequencies (see NGDWQ) and the dates of sanitary surveys to be made for each system covering the source, intake, treatment plant and distribution system respectively.

(iii) Fill in the category of staff (e.g. Engineer, Technical Assistant, Technician or Health Inspector) and their respective names, who will be responsible to carry out such sanitary surveys.

(iv) For each public water supply system, prepare a map showing the flow of water in the sequence : source – intake – treatment plant – service reservoir – distribution system (see Map 3).



Map 3 : Sanitary Survey Map

Form (SSP)

Fig. 8 : SANITARY SURVEY PLAN FOR PUBLIC WATER SUPPLIES

State : ....

District : ....

Name of Public Water Supply System and Location	Part of the Supply	Sanitary Survey Frequency	Date for S. S.	Personnel to make S. S.			
				Water Purveyor		Surveillance agency	
				Category of Staff	Name	Category of Staff	Name
	Source			E/TA		E/HI	
	Intake						
	Treatment Plan						
	Distribution System						

5.2.2 **Making the Survey**

5.2.2.1 **Routine Survey**

For routine sanitary inspection, the inspector (Technical Assistant/Technician/Health Inspector) shall jointly carry out the survey and complete the routine sanitary survey form (RSS – 1, RSS–2), (Fig. 9a, 9b). The form includes common information and checks common to all systems. The questions or checks are of the Yes – No type and are drafted in such a way that the answers yes signifies absence of risk and vice-versa. The inspector should read Sec. 5.1 carefully before completing such forms.

Form (RSS–1)

Fig. 9a : Routine Sanitary Suvey Form – 1

A. General

(1) Date of Survey: ☐ day ☐ month ☐ year

(2) Survey of: ☐ source ☐ intake ☐ treatment ☐ distribution

made by: ____________________ (Waterworks) ____________________ (Surveillance agency)

(3) Name of Supply: ____
(State) (district) (treatment plant)

(4) Address: ____

(5) Person-in-charge: ____

(6) Capacity of intake : ____

(7) Population served: ____

(8) Number of house connection: ____

(9) Number of standpipes: ____

(10) Water demand (from plant records):

average/day : ____

maximum/day : ____

maximum/month : ____

B. Source

Type of source: ☐ reservoir ☐ stream ☐ river ☐ well ☐ others

Is the source adequate with respect to:

		Yes	No
(i)	quantity	☐	☐
(ii)	bacteriological quality	☐	☐
(iii)	chemical quality	☐	☐
(iv)	physical quality	☐	☐
(v)	adequate protection	☐	☐

(vi) adequate sampling ☐ ☐

C. **Intake**

Is the intake adequate with respect to:

	Yes	No
(i) location	☐	☐
(ii) structure	☐	☐
(iii) maintenance	☐	☐

D. **Treatment**

Type of treatment:

☐ presedimentation

☐ precoagulation

☐ pre-disinfection/oxidation ☐ chlorine ☐ ozone

☐ powder activated carbon treatment

☐ aeration

☐ coagulation & flocculation ☐ lime ☐ coagulant aid

☐ sedimentation

☐ filtration ☐ slow ☐ rapid ☐ granular carbon

☐ disinfection

☐ others

Is treatment adequate with respect to :

	Yes	No
(i) presedimentation	☐	☐
(ii) precoagulation	☐	☐
(iii) predisinfection	☐	☐
(iv) powdered activated carbon treatment	☐	☐
(v) aeration	☐	☐
(vi) coagulation and flocculation	☐	☐
(vii) sedimentation	☐	☐
(viii) filtration	☐	☐
(ix) disinfection	☐	☐

(x) others

Chlorination was interrupted ______ times in the last 12 months.

Interruptions were due to:

- chlorinator failures
- feedwater pump failure
- lack of chlorine/hypochlorite
- changing cylinders
- power failure
- others

Laboratory for operation control	Yes	No	
Test			frequency
alkalinity			
jar test			
pH			
residual chlorine			
colour			
turbidity			
E. Coli			
flouride			

Are the following adequate

(i) records for:

(a) disinfection		
(b) filter run		
(c) Chemical consumption		
(d) operation control tests		
(e) bacteriological examination		
(f) residual chlorine		

(ii) Maintenance:

(a) general cleaniness

(b) equipment

(iii) Partition exist between treatment and untreated water

E. Distribution

Type of distribution system :

grid

branched

mixed

Source = single dual multi

Is distribution adequate with respect to:

	Yes	No
Storage		
booster chlorination		
residual chlorine		
booster pumping		
pressure		
continuity of supply		
leakage		
cross connection		
back siphonage		

F. Personnel

(i) What is the academic level of the most senior personnel (full time) of the treatment plant.

university

college

others

secondary

primary

(ii) Level of formal training in water treatment.

	length of time
university	___________
college	___________
school	___________

☐ short courses ______

☐ others ______

(iii) Length of time in present water treatment plant ______

(iv) Total experience in water treatment ______ years.

(v) Present staff is adequate

	Yes	No
(a) in number	☐	☐
(b) in experience	☐	☐
(c) in qualification	☐	☐
(vi) Budget is adequate	☐	☐
(vii) Management is adequate	☐	☐

(viii) Operators major complaints ______________________________

____

____

(ix) Managements' complaints ______________________________

____

____

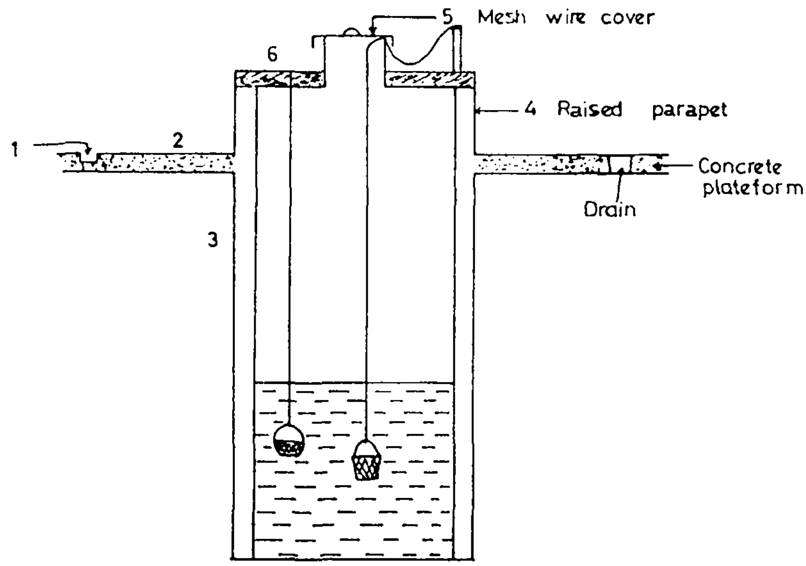
(x) Consumer's complaints ______________________________

____

____

Fig. 9b : Sanitary Survey Form – 2

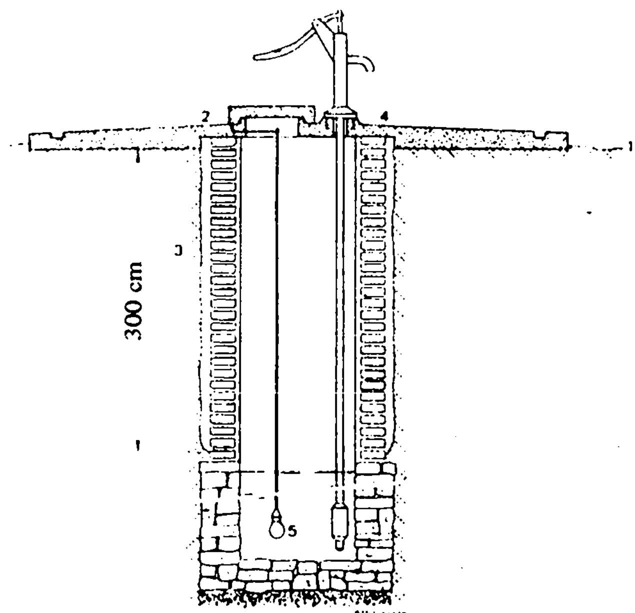
(1) **Dug Well**



Check List :

	Yes	No
(1) Is the nearby area free from wastes and privies?		
(2) Is there an impervious apron to exclude surface water?		
(3) Are the sides of well sealed watertight for 3m. below ground level?		
(4) Is there a parapet with cover to prevent animal users from entering the well?		
(5) Are the ropes and buckets permanently installed?		
(6) Is the well water chlorinated?		

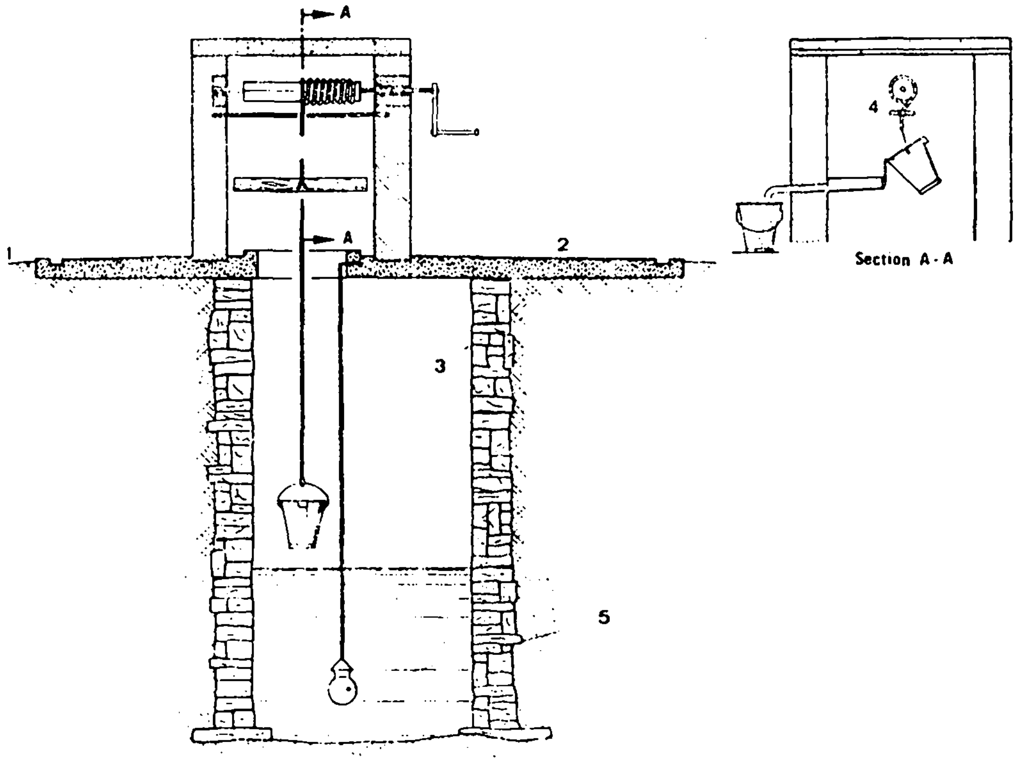
(2) **Dug well with pump**



Check List :

	Yes	No
(1) Is the nearby area free from liquid wastes & privies?	▱	▱
(2) Is there an impervious apron to exclude surface water?	▱	▱
(3) Are the sides of well sealed watertight for 3m. below ground level?	▱	▱
(4) Is the suction pipe to pump sealed in apron at exit?	▱	▱
(5) Is the well water chlorinated?	▱	▱

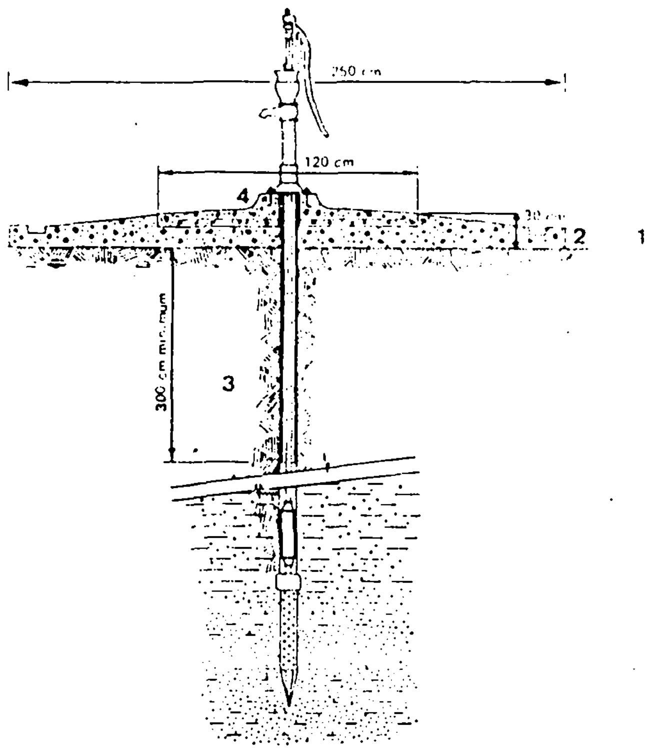
(3) **Dug well with Windlass**



Check List :

	Yes	No
(1) Is the nearby area free from liquid wastes & privies?		
(2) Is there an impervious apron to exclude surface water?		
(3) Are the sides of well sealed fro 3m below ground level?		
(4) Are the rope and bucket inaccessible to the users?		
(5) Is the well water chlorinated?		

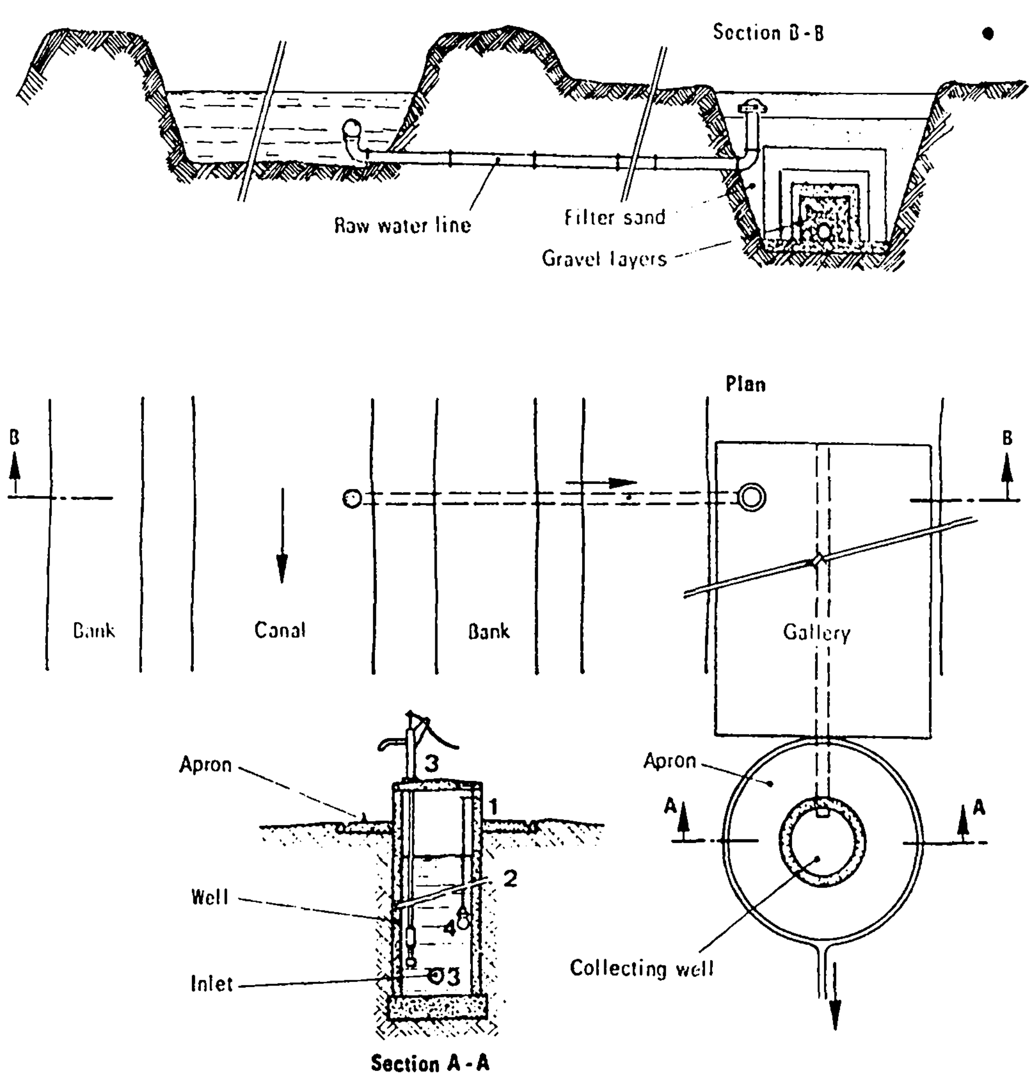
(4) **Tube Well**



Check List :

	Yes	No
(1) Is the nearby area free from liquid wastes and privies?	☐	☐
(2) Is there a watertight concrete apron and is drainage provided?	☐	☐
(3) Is there watertight tubing for 3m below ground level?	☐	☐
(4) Is the suction pipe to pump sealed in apron at exit?	☐	☐

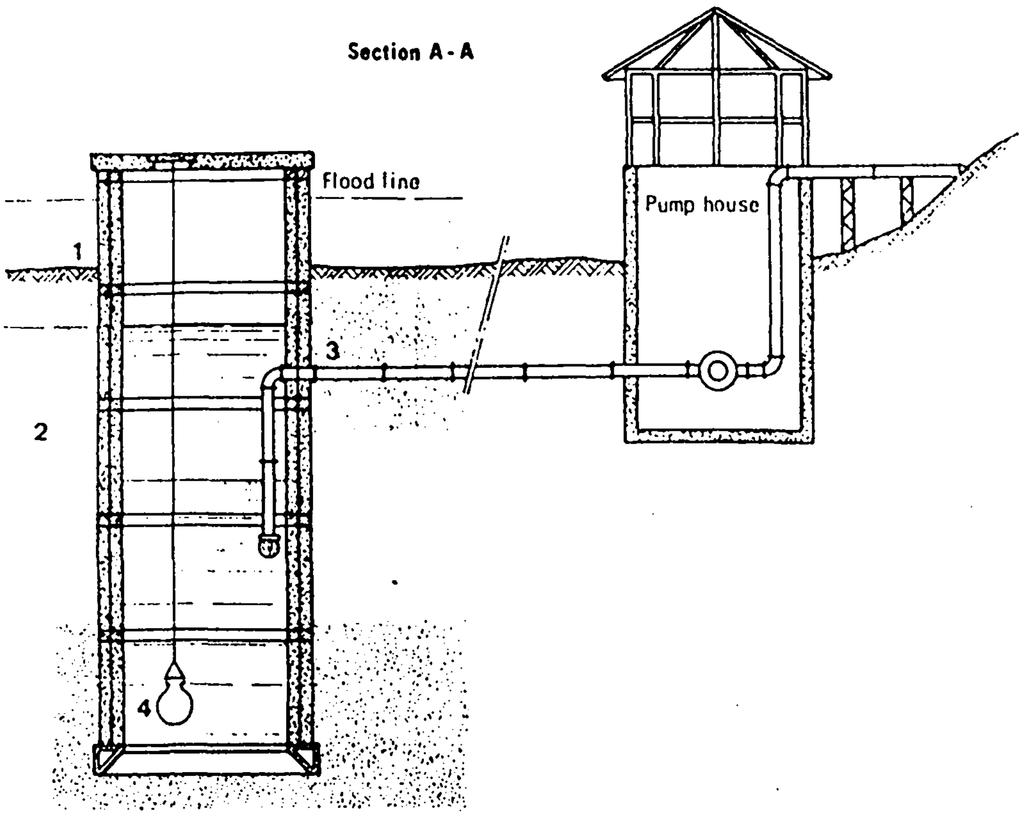
(5) **Gallery for Canal**

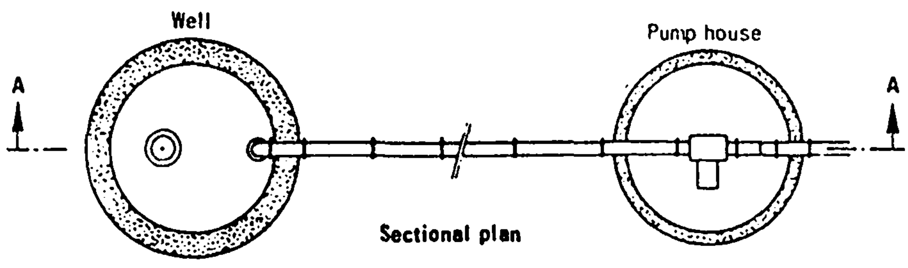


Check List :

	Yes	No
(1) Does the collecting well extend 1m above ground?		
(2) Is the collecting well sealed watertight throughout?		
(3) Are the inlet and outlet pipes well sealed in?		
(4) Is the water chlorinated?		

(6) **Infiltration well in river bed**





Check List :

		Yes	No
(1)	Does the infiltration well extend above mean flood level?		
(2)	Are the sides of well sealed watertight top to bottom?		
(3)	Is the outlet pipe of well sealed in?		
(4)	Is the water chlorinated?		

5.2.2.2 **Violation Survey**

Sanitary survey to be carried out as a result of sanitary deficiency in public water supply system detected through monitoring or other means should aim at discovering the cause and the source of such deficiency. The survey should be made by more experienced and qualified personnel (Engineer/Technical Assistant/Sanitarians). The sanitary survey and report should be carried out according to the following guideline:

(1) **Source**:

(i) Label all the names of the streams and riverlets flowing into the river before the intake point (see Map 3).

(ii) Identify and locate on the map the potential areas or sources of pollution and the type of pollution (e.g. effluents from industrial, agricultural or domestic activities) being discharged upstream.

(iii) Describe their relative distance from the intake, the dilution and evaluate the relative impact on the raw water quality at the intake.

(2) **Intake**

(i) Identify and describe the nearest possible pollution sources at the intake i.e. one upstream and the other downstream of the intake.

(ii) Describe the general conditions at the intake and its vicinity.

(iii) Comment on the location of the inlet port, conditions of the screen, strainer, flow control device, flow measuring device, pumping aids etc.

(iv) Record down whether the intake is accessible to trespassers; contain adequate toilet facilities and waste-water drainage.

(3) **Treatment Plant**

(i) Aeration Tower:

(a) record the type of aerator (spray/trays/cascades);

(b) describe the general conditions of the aerator, such as colour of water, any smell or excessive foaming, scum etc.

(ii) Coagulation and Flocculation:

(a) note down whether flash mixing flocculation is done mechanically or hydraulicly;

(b) verify dosing efficiency, flash mixing efficiency and floc formation;

(c) note down any point of excessive high or low velocity or bad short circuiting in the flocculation chamber and raw water channel;

(d) note down the frequency of jar test, alkalinity and pH measurement and whether dosing of coagulant is in accordance to laboratory tests mentioned;

(e) describe the coagulant used, the dosage, the physical condition of coagulant solution and storage tank, dosing equipment, material of pipes carrying coagulant solution etc.;

(f) name the coagulant aid (e.g. polyelectrolyte, or lime) added if any and the respective dosage. Describe the manner in which such chemicals are added;

(g) observe chemical storage and handling, report on any problem of corrosion and

(h) observe floc formation (weak/satisfactory) the colour, size and its settleability.

(iii) Sedimentation:

(a) name the type of sedimentation tanks (upward flow/horizontal flow);

(b) observe the shape and size of the basin, the method of influent entry, the range of diffusion, short circuiting or direct currents between inlet and outlet, sludge removal arrangement, etc.

(c) it is also necessary to note the displacement efficiency as between theoretical detention period and actual flow through period;

(d) describe the clarity of settled water, any "roll over" of water, characteristic of sludge from sedimentation tank.

(iv) Filtration

(a) describc the type of filters (slows sand filters/rapid sand filters);

(b) observe influent and filtrate turbidity;

(c) observe rate of filtration, initial headloss, final head loss, length of filter runs, duration of filter cleansing and overhauling, the depth and texture of the sand layer in the filter and the condition of the filter gravel and underlying system;

(d) for rapid sand filter, obtain additional information on wash water consumption, the duration of washing, the hydraulics of filter washing, the reliability and efficiency of surface wash and air wash aids;

(e) at the time of back washing operation observe the uniformity of air agitation, degree of sand expansion, quality of wash water at the end of back wash, clearance between wash water trough and expanded sand bed and physical condition of bed for presence of cracks, craters and undulations;

(f) note also the condition of filter appurtenances and problems (if any) with rate settler rate controller, flow indicator, head loss indicator, valves, etc.

(v) Chlorination

(a) describe the type of chlorination (chlorinator/dosing tower);

(b) record the frequency of test for chlorine demand or break point chlorination;

(c) if bleaching powder is used, record the frequency of test for available chlorine;

(d) record the strength of solution used and the actual dose of chlorine applied;

(e) describe the working condition of the dosing equipment (chlorinator or dosing tower) type and condition of material used for carrying chlorine solution.

(f) if chlorinator is used, observe if there is a separate chlorine room, provision of ventilation, safety equipment, alarm system, any chlorine gas leaking, whether chlorine gas tanks are connected in parallel and in series, etc.

(4) **Distribution**

Look for the following common sanitary defects:

(i) intermittent service resulting in reduced or negative pressures in distribution system; sizes of mains and laterals inadequate for preventing negative pressures; presence of dead-ends resulting in reduced or negative pressures; lack of provision for maintaining continuity of pumping service under all conditions;

(ii) repumping on consumer premises when pressure is low causing negative head;

(iii) existence of cross connection between the primary supply and a secondary supply of questionable safety;

(iv) presence of a secondary non-potable water system on premises where a public system exists in the absence of adequate regulation or enforcement procedures to prevent the occurrence of cross connections;

(v) lack of or inadequate enforcement of plumbing regulations designed to protect the water supply against the possibility of backflow from plumbing fixtures;

(vi) connection of new pipelines to the system without prior disinfection of pipes;

(vii) unauthorized operation of water supply facilities by persons other than waterworks employees – e.g. unregistered plumbers;

(viii) existence of leaky pipes in the distribution system;

(ix) improper location of water pipes in relation to sewers and storm drains;

(x) return to the system of water used for cooling purposes;

(xi) connection to sewers and sewer flushing chambers, and improperly located blowoffs in the distribution system;

(xii) inadequate wash-out points to permit distribution mains to be flushed or swabbed, insufficient valves to permit the isolation of different parts of the distribution system.

(xiii) poorly designed valve, blow-off and meter boxes, hydrants and "pit taps" that may permit puddles or groundwater to accumulate with consequent risk of back siphonage, spread of helminthic diseases and breeding of mosquitoes;

(xiv) poorly drained and protected street fountain;

(xv) defective service reservoir.

6. Remedial Action

6.1 Purpose

The purpose of drinking water quality surveillance is not just to monitor the quality of the water alone but also to ensure that appropriate measures are taken to restore the water to its original quality if found to be unsatisfactory.

Monitoring programme and sanitary survey programme provide the detection mechanisms to identify sanitary deficiences in public water supply system, while remedial action plan provides the mechanism for prompt and effective corrective measures to be taken in rectifying such deficiencies.

6.2 Establishing the district remedial action plan

Basically the remedial action plan consists of two parts:

(i) an outline of a response mechanism in the event of an unsatisfactory condition in public water supply system identified through the detection mechanism (see fig. 10, 11, 12, 13 & 14).

(ii) an outline of the procedures necessary depending on the urgency of the problem (see Sec. 4.7 National Guidelines for Drinking Water Quality).

As for the monitoring programme and sanitary survey programme, personnels of the District Health Office and the District Public Works Department shall jointly establish such plan as follows:–

(i) construct diagrams similar to those shown in fig. 10, 11, 12, 13 & 14 for each detection and response mechanism respectively, and

(ii) insert the names of the personnel responsible on the diagram.

6.3 Surveillance detection and remedial action (response) mechanisms

This section describes the two separate but equally important mechanisms employed in the National Drinking Water Quality Surveillance Programme. They are namely, the detection mechanisms which serve to identify sanitary deficiencies in public water supply system and the response mechanisms, which are being activated or triggered off by the detection mechanisms, in carrying out remedial measures to correct such deficiencies.

The three detection and response mechanisms are as follows:–

(i) laboratory detection and response
(ii) in-situ test detection and response
(iii) sanitary survey detection and response.

6.3.1 Laborary detection and response

Monitoring, if carried out on a regular basis will be able to detect deficiencies or potential deficiencies in the public water supply system within a reasonable period of time. This would act as an early warning system to alert health and waterworks authorities in taking prompt corrective action before any adverse impact on consumer health can occur.

(I) Non-violation report and response (see fig. 10)

(1) In the instance of a laboratory report having results within the limits stipulated in the national drinking water quality standards (see Sec. 3.2 – NGDWQ), the analyst shall send a copy of the report (form S1, S2 & S3) by post to the following:–

(i) the Engineer of the DPWD concerned and

(ii) the Medical Officer of Health of the DHO.

The report shall be properly filed for future reference.

(2) The Senior Health Inspector (DHO) shall compile all such reports in his district and prepare a monthly summary report (form MSR) in triplicate, with 2 copies forwarded by post to the Deputy Director of the SMHSD.

(3) The Chief Health Inspector (SMHSD) shall compile the monthly summary reports of all the districts in the State and forward them monthly by post to the Research Officer (UDWQS) Ministry of Health. He shall also retain a copy of the monthly summary report and filed for future use.

(4) The Scientific Officer (UDWQS) Ministry of Health shall process and evaluate the monthly summary reports of all the States for the purpose of making recommendations and in preparing the annual report.

(II) Violation report (exceeding recommended level and mandatory level but not including those parameters described under health investigation level) – See fig. 11.

(1) The analyst upon discovering that the water sample having a test result exceeding the recommended levels and mandatory levels in the national drinking water quality standards, shall send a copy of the report (form S1, S2, S3) to the following within 14 days of sample collection:

(i) the Engineer of the DPWD
(ii) the Engineer of the SPWD
(iii) the Medical Officer of Health of the DHO
(iv) the Deputy Director of the SMHSD

(2) The Medical Officer of Health shall immediately discuss the problem with the Engineer of the DPWD and instruct the HI to liaise with the DPWD for remedial action.

(3) The Engineer (DPWD) after discussing with the Medical Officer of Health shall instruct the TA/T to investigate the problem together with the HI and to take whatever remedial action deemed necessary – (refer to Sec. 4.7.1. in the NGDWQ). The TA/T and HI shall then present a report (form CR) in duplicate to their respective supervisor (Engineer/Medical Officer of Health) within one month of receipt, one copy of the report shall then be sent to the respective State Departments (SPWD, SMHSD).

(4) The SMHSD AND SPWD shall ensure that (through correction report) the sanitary deficiencies detected through the violation report (exceeding recommended levels) and mandatory levels are adequately taken care of by their respective district offices (DHO, DPWD).

(III) Violation report (exceeding health investigation levels)

(1) The analyst upon discovering that the water sample having test results exceeding the health investigation levels in the National Drinking Water Quality Standards, shall immediately inform the following by telephone:

(i) the Engineer of the DPWD concerned
(ii) the Deputy Director of the SMHSD

(2) The Engineer of the DPWD upon receiving such information shall:–

(i) immediately contact the Medical Officer of Health by telephone informing him of the situation and brief him on the remedial actions to be taken. He shall also either investigate the problem personally or instruct the TA/T together with the HI to take whatever remedial action deemed necessary (refer to Sec. 4.7.2. in the NGDWQ);

(ii) send a copy of the recorded telephone message (form TMR) to the following:

(a) the Engineer (SPWD)
(b) the Engineer (FPWD)

(3) After being informed by the Engineer of the DPWD about the incidence, the Medical Officer of Health shall immediately instruct the H.I. to liaise with the DPWD for remedial action (See Sec. 4.7.2. – NGDWQ).

(4) Deputy Director of the SMHSD after receiving such telephone message from the analyst, shall send a copy of the telephone massage record form TMR to the Scientific Officer UDWQS Ministry of Health.

(5) Within one month after receiving the violation report, the TA/T and HI shall prepare a correction report (form CR) in triplicate to be sent to the following:–

(i) the respective immediate supervisor (Engineer (DPWD), Medical Officer of Health DHO);

(ii) the Engineer, Deputy Director of the respective State Department (SPWD, SMHSD);

(iii) the Engineer, Scientific Officer of the respective federal department (FPWD, UDWQS Ministry of Health).

(6) From the remedial action report the SMHSD and SPWD shall ensure that the sanitary deficiencies detected through the violation report (exceeding health investigation levels) are adequately taken care of by their respective district offices (DHO, DPWD).

6.3.2 **In-situ test detection and response mechanism (see fig. 13)**

In-situ testing of residual chlorine is being carried out routinely during sampling of water from the public water supply systems as scheduled in the District Monitoring programme or auxiliary programme. Auxiliary programme here refers to the proposed independent assessment of drinking water quality by the DHO. Only pH, residual chlorine and E. coli shall be evaluated (the pH and residual chlorine can be measured on site by HI while the E. coli can be tested either by the use of millipore kit or at the medical laboratory in the State Hospitals.) The absence of residual chlorine can serve as an early indicator of possible bacteriological contamination of the drinking water. (For contaminated sources the residual chlorine level should be 0.2 – 0.5 ppm).

(I) **Non-violation report and response**

In the event that the HI/T have detected free residual chlorine level of not less than 0.2 ppm at all the sampling points scheduled, then they only have to file up the results for future reference.

(II) **Violation report and response**

(1) If the HI/T were unable to detect free residual chlorine level of 0.2 ppm or more at any one point, the HI, upon completion of his sampling schedule shall report the incidence to the Medical Officer of Health who shall then immediately inform the engineer (DPWD) concerned by telephone.

(2) The engineer upon receiving such information shall instruct the TA/T to investigate the problem and attempt to initiate remedial measures. After the problem has been rectified, the TA/T shall report the whole incidence in report form CR to his engineer and a copy sent to the Medical Officer of Health of the DHO.

6.3.3 **Sanitary survey detection and response mechanism** (see fig. 14)

Regular sanitary surveys conducted on the source, treatment plant and the distribution system may help in the detection of existing or potential problems involving conditions, devices practices etc. in the public water supply system which may result in further deterioration if early attention is not received.

(I) **Non-violation report and response**

Upon completing the sanitary survey and if the findings are found to be acceptable, the H.I. and T.A. shall complete the sanitary survey report (form SSR) and file them for future reference.

(II) **Violation report and response**

(1) If any of the conditions, devices; practices etc are found to be unsatisfactory during the sanitary survey the HI shall record such matters in the sanitary survey report (form SSR) and shall send them to the Medical Officer of Health who shall in turn inform the Engineer of the DPWD.

(2) Upon receiving such information, the Engineer shall instruct the TA/T to investigate the problem and attempt to correct them. A report on the actions carried out and the outcome shall be made by the TA/T concerned in (form CR) and reported to the Engineer. A copy of the report shall be sent to the Medical Officer of Health of the DHO.

Fig:10 NON - VIOLATION REPORT —— DATA FLOW.

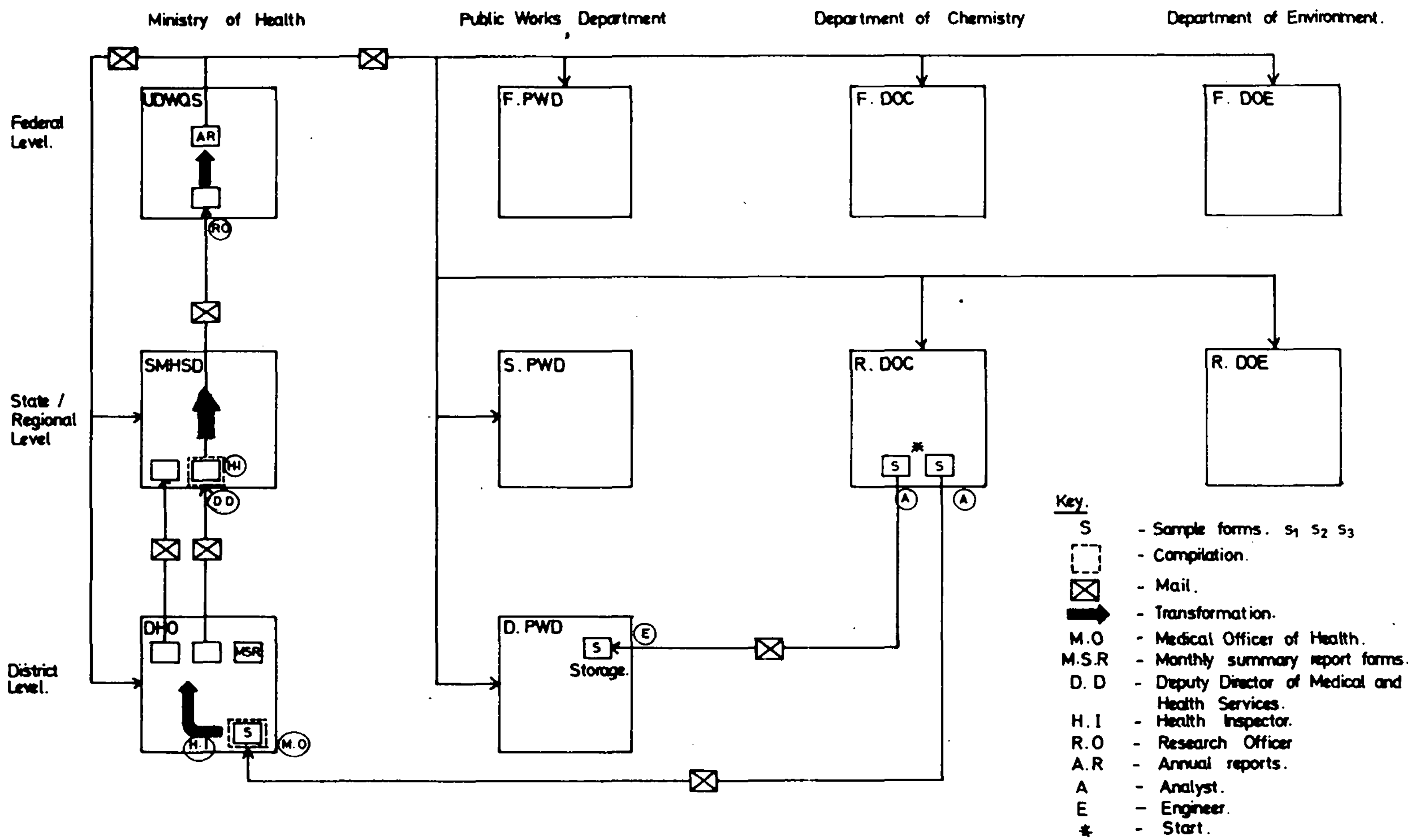


Fig – II – VIOLATION REPORT DATA FLOW. (Exceeding recommended levels and mandatory levels but not including those parameters described under health investigation levels.)

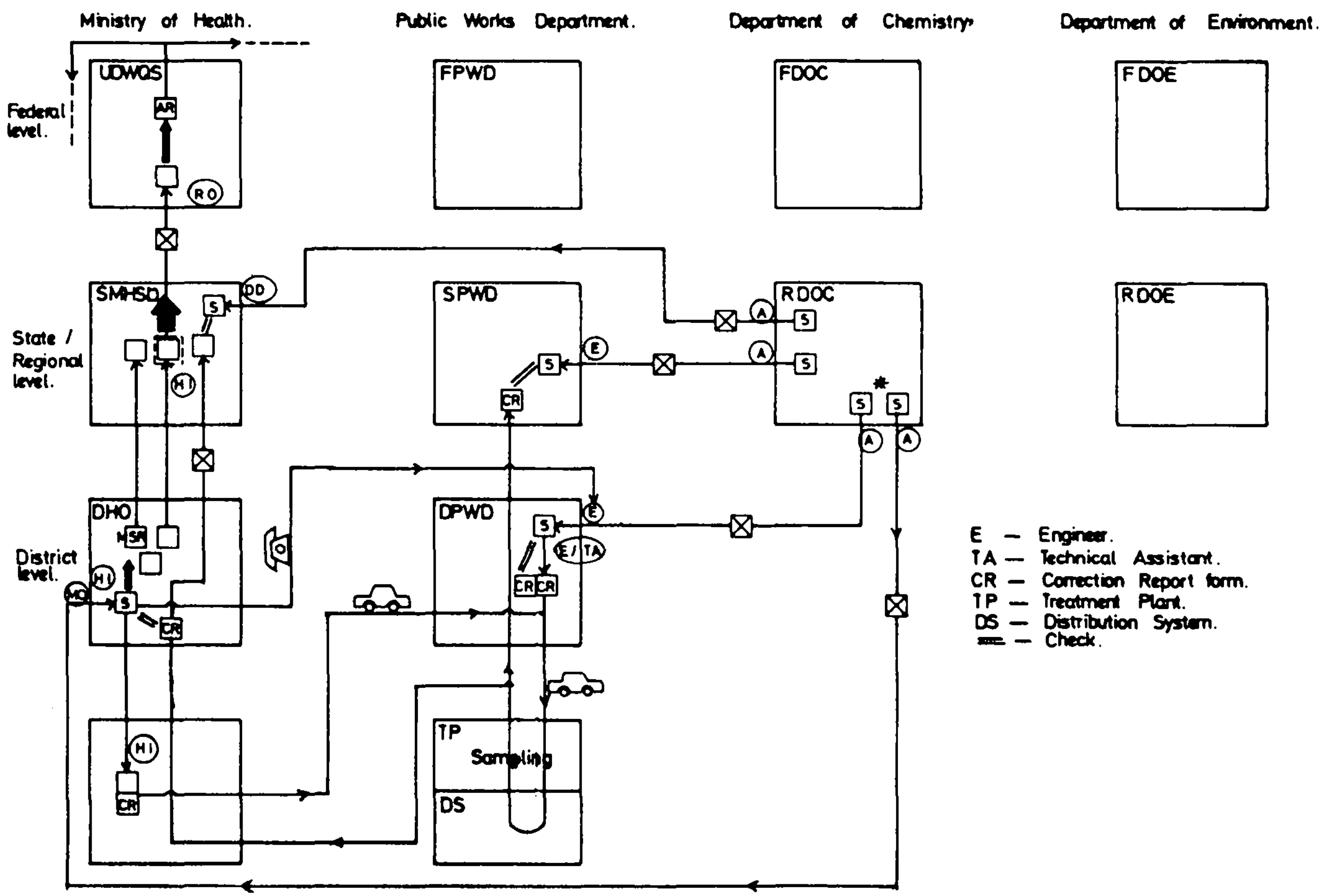
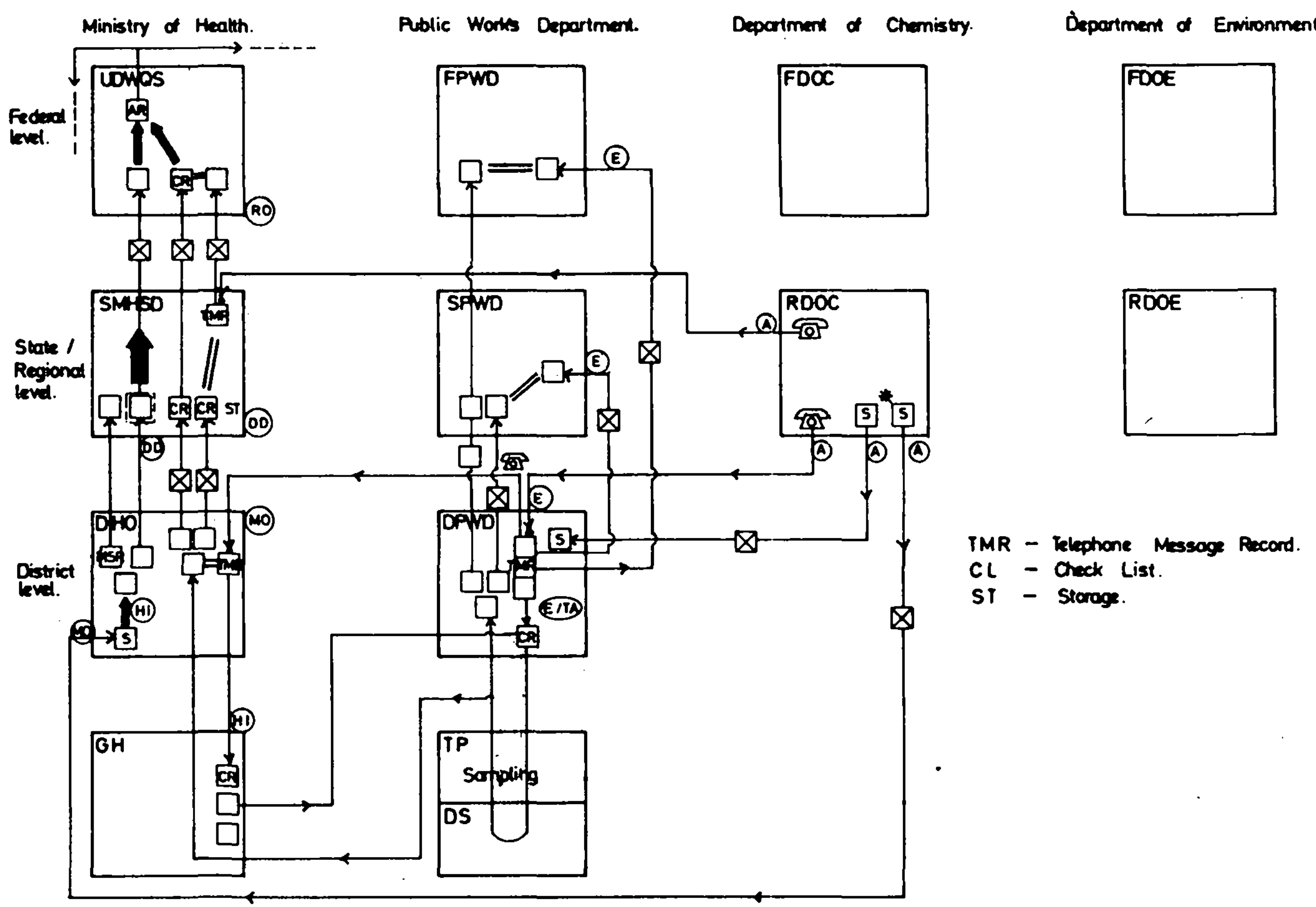


Fig. 12 VIOLATION REPORT DATA FLOW. (Exceeding Health Investigation levels).



TMR – Telephone Message Record.
CL – Check List.
ST – Storage.

Fig13 RESIDUAL CHLORINE DETECTION MECHANISM

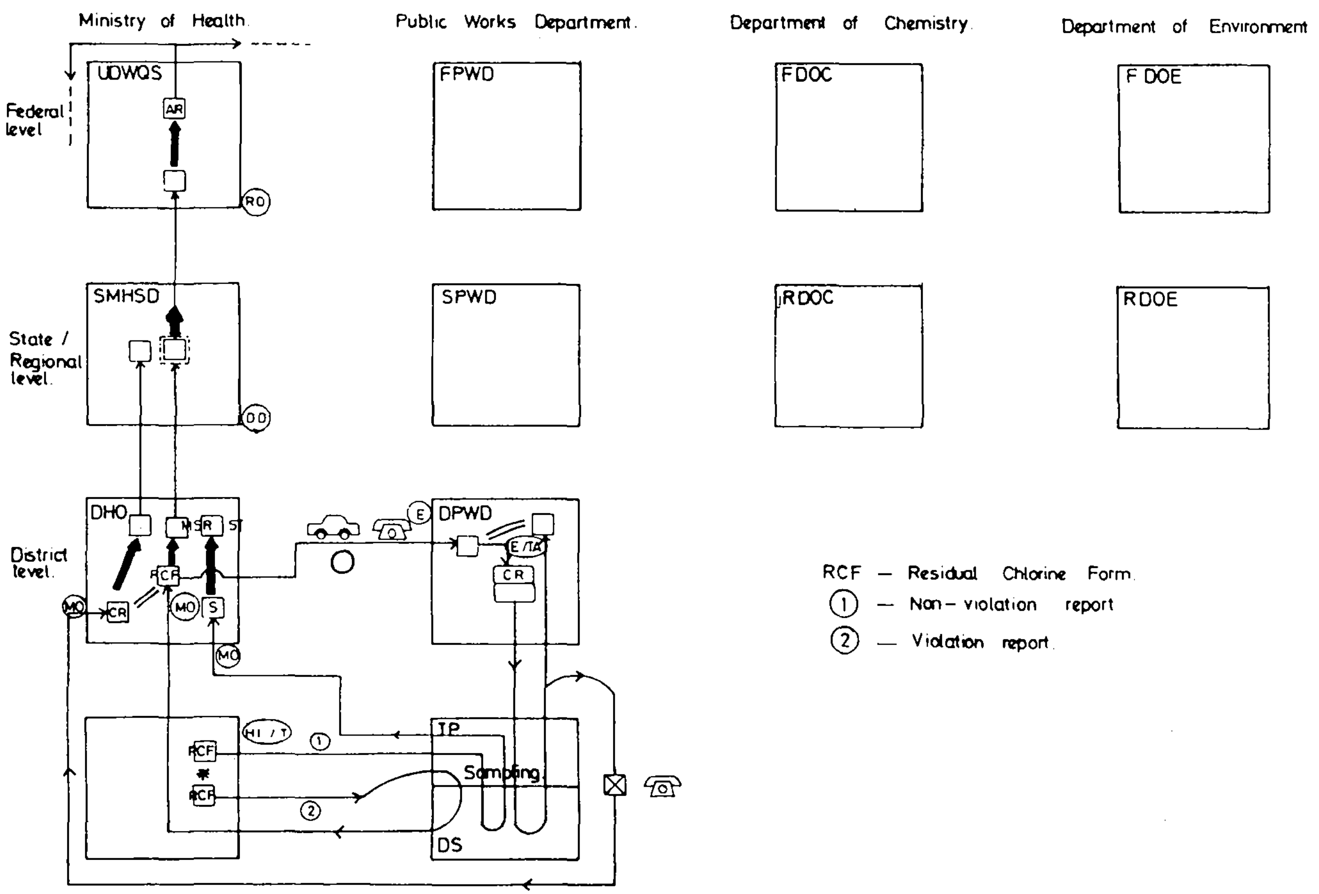
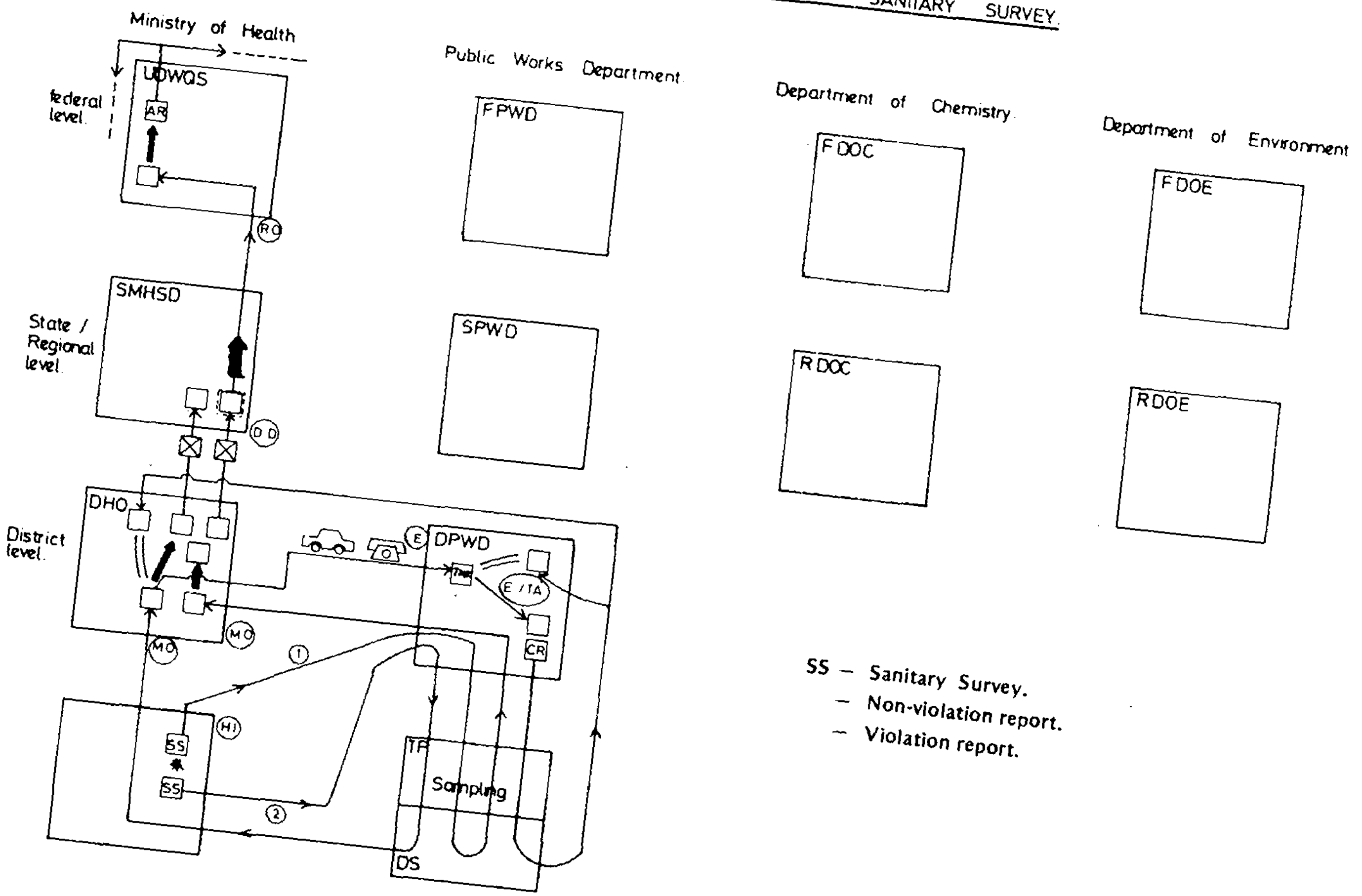


Fig 14 DETECTION MECHANISM THROUGH SANITARY SURVEY.



SS – Sanitary Survey.
– Non-violation report.
– Violation report.

BORANG MSR 1

MONTHLY SUMMARY REPORT

NAME OF WATER SUPPLY SYSTEM : ______________________

PARAMETERS / STATION NUMBER / DATE / TYPE			GROUP I						GROUP II													
TYPE	DATE	STATION NUMBER	Coliform	E. Coli	Turbidity	Colour	pH	Residual Chlorine	Total Dissolved Solid	Carbon Chloroform Extract	BOD	COD	Detergent (MBAS)	Ammonia (N)	Nitrate (N)	Fluoride	Iron	Manganese	Aluminium	Alkalinity ($CaCo_3$)	Hardness ($CaCo_3$)	Chlorine

MONTHLY SUMMARY REPORT

BORANG MSR 2

NAME OF WATER SUPPLY SYSTEM : ______________________

PARAMETERS			GROUP 3																		GROUP 4									
TYPE	DATE	STATION NUMBER	Mercury	Cadmium	Selenium	Arsenic	Cyanide	Lead	Chromium C^{6+}	Silver	Copper	Magnesium	Zinc	Sodium	Sulphate	Phosphate	Hydrogen Sulphide	Oil	Phenol	Chloroform	Biocide (Total)	Pesticides Aldrin	Dieldrin	Chlorolane	2,4—D	DDT	Heptachlor and Heptachlor Epoxide	Hexachloro-benzene	Lindane	Methoxychlor

CORRECTION REPORT

BORANG CR

NAME OF WATER SUPPLY SYSTEM : DISTRICT : STATE :	____________ ____________ ____________	Report no : Information (problem identified) from :	______ ______
Problem identified :	____________ ____________ ____________		Date :
Action recommended : Recommendation made by :	____________ ____________ ____________ ____________ (Name) ____________ (Position) (Dept)		
Action taken : Action taken by :	____________ ____________ ____________ ____________ (Name) ____________ (Position) (Dept)		
Results :	☐ No change ☐ Slight improvement ☐ Back to normal ☐ Others,please specify ____________ ____________ ____________		
Comments : Comments made by :	____________ ____________ ____________ ____________ (Name) ____________ (Position) (Dept)		

TELEPHONE MESSAGE RECORD

BORANG TMR

NAME OF STATION:	______________	Report no:	______
NAME OF WATER SUPPLY SYSTEM:	______________		
DISTRICT:	______________		
STATE:	______________		
Problem identified:	______________ ______________ ______________ ______________		Date:
Call made by:	______________ (Name) ______________ (Position) (Dept)		
Telephone message received by:	______________ (Name) ______________ (Position) (Dept)		

BORANG RCF

RESIDUAL CHLORINE FORM

State : ______________________________ Date: ____________

District : ______________________________

Name of Water
Supply System : ______________________________

'YPE	STATION NUMBER	pH	RESIDUAL CHLORINE

NB : Please enter in red for violation results.

7. **Data handling, evaluation and interpretation**

Data obtained through monitoring, sanitary survey, etc. should be filed in an orderly and systematic manner to assure rapid access to the data when required. The purpose of such a system is to :

(i) provide a rapid warning system;

(ii) provide data input for statistical computation such as time series analysis, water quality trends andforecasting,physical, chemical and biological correlations, etc.

For the initial stages of the National Drinking Water Quality Surveillance Programme, the volume of data is likely to be "small" hence a manual data storage and processing system is sufficient. Nevertheless in the designing of such a system, considerations have been given to the possible case of computerised systems in the future.

7.1 **Data Handling**

7.1.1. **Water Sample Information**

Sec. 3.6 describes the identification and coding system used in this programme for differentiating water samples. The sampler shall insert such sample information as :

(i) the type of water;

(ii) the location being sampled (State, district, treatment plant, sampling station);

(iii) the date and time collected, and

(iv) the date and time arrived at the laboratory.

On the sample label and (form S1, S2, S3) – (See Sec. 3.3.1, 3.4).

7.1.2 **Analytical Results**

The water sample entering the laboratory for analysis is accompanied by form S1, S2, S3 which contain information about the sample and a list of parameters for which the sample is to be analysed. The forms follow the sample throughout the laboratory.

If the analyst performing a certain test choose to record his results in a laboratory book, he should then transfer these results to the form S1, S2, S3 at the end of the analyses.

7.1.3 **Monthly Summary Report**

All the analytical results in form S1, S2, S3 from each sampling point in the district drinking water quality monitoring programme shall be entered into the monthly summary report (form MSR) with the sampling points tabled in chronological order.

7.1.4 **Storage and Retrieval**

Data obtained through laboratory analyses (form S1, S2, S3), sanitary surveys (form SSR) must be filed and stored in such a manner that they are easily retrievable and in a format suitable for interpretation, report writing, graph plotting etc.

The proposed filing system for the storage and data system are as follows:

(i) Station file – for filing of the (form S1, S2, S3) from the various sampling points of a public water supply.

(ii) Project file – for filing of all the monthly summary reports (form MSR) of a public water supply system in a district.

(iii) Violation file – for filing of the telephone messages record (form TMR) or violation report (form S1, S2, S3) and the corresponding correction report (form CR).

(iv) Sanitary Survey file – for filing of all the sanitary survey reports (form SSR). Other files may be required depending on circumstances.

7.2 Data Evaluation

Evaluation of data should be carried out continuously during data collection to ensure that:

(i) information on each sample is properly recorded;

(ii) analytical results are properly recorded such as the use of significant figures, detection units, etc. to make sure that they remain consistent throughout the programmes;

(iii) analytical results are compared with previous results. This will help catch any abnormal values immediately and alert the analyst to re-examine the sample if necessary;

(iv) analytical results are indeed correct values (through examination of the quality control programme).

The above should be carried out at the various stages of data handling and by the respective relevant personnel, namely the sampler, the analyst, the official receiving and using such data.

7.3 Data Interpretation

Once data have been collected and assembled in data storage systems the next step is to interpret the data with respect to specific questions, problems or requirements. The following are some of the commonly asked questions.

(i) Whether it is necessary to review the raw water criteria or drinking water quality standards of the country in view of increased pollution or improved knowledge on toxicity.

(ii) Whether it is necessary to improve on certain water treatment methods or to introduce new ones for more effective removal of water pollutants.

(iii) Whether it is necessary to review the existing monitoring programme, sanitary survey programme, remedial action plan to ensure their effectiveness to act as an early warning system.

(iv) To answer the above questions; the statistical approach is used rather than just by scanning long columns of tabulated data. Statistical analysis of the data will provide a deeper understanding of data and enable the user to arrive at a better decision in drinking water quality management.

There are several well known statistical techniques for examining water quality data; some of which are:

1. Mean values
2. Standard deviation
3. Cumulative frequency distribution
4. Mass loadings
5. Trend analysis
6. Frequency (harmonic) analysis
7. Power spectum analysis.

8. Institutional Examination

Institutional examination is a study of those elements of operation and management of the various relevant agencies which may result in health hazards to the consumer.

Periodical surveys and field visits by personnel of the Unit of Drinking Water Quality Surveillance, Ministry of Health serve to identify:

(i) technical and methodological gaps in the drinking water quality surveillance programmes;

(ii) problems of implementation such as:

  (a) lack of staff
  (b) lack of training
  (c) lack of budget and
  (d) lack of inter-agency coordination etc.

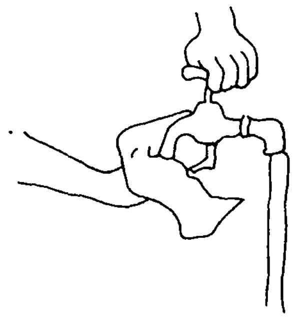
Some of the common surveillance problems experienced by other countries are listed in the succeeding paragraph. Many of these failures reflect lack of capital and human resources, but some are compounded by complacency and apathy on the part of the relevant authorities.

(1) Lack of awareness of the danger of outbreaks of water-borne disease.
(2) Lack of established surveillance policies and procedures.
(3) Failure to make sanitary surveys.
(4) Failure to collect samples of raw and delivered water.
(5) Failure to enforce correction of deficiencies and remedial measures.
(6) Failure of laboratories to notify waterworks, surveillance agency of results of analysis.
(7) Inadequate approval programme for new sources.
(8) Failure to adopt and enforce drinking water quality standards.
(9) Failure to protect watersheds, wells and springs from surface contamination.
(10) Failure to maintain positive continuous hydraulic pressure throughout the distribution system.
(11) Failure to maintain a continuous chlorine residual in distribution systems.
(12) Inadequate or non-existent cross-connection and back-siphonage control programmes.
(13) Lack of standard testing procedures.
(14) Failure to maintain plant operation records and other records.
(15) Failure to maintain surveillance records.
(16) Samples taken from fixed locations unrepresentative of the water supply system.
(17) Failure to disinfect new construction and repair work.
(18) Lack of adequate legal authority.
(19) Inadequate budget and manpower.
(20) Inadequate numbers of suitably trained and qualified personnel.
(21) Inadequate laboratory facilities and support.
(22) Inadequate maintenance programmes.

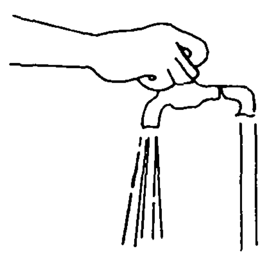
Annex 1

Sampling Techniques

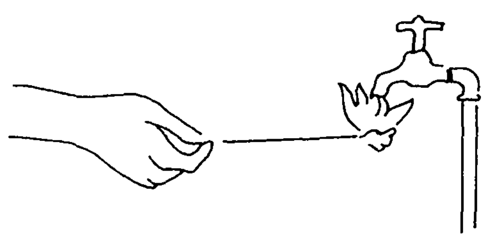
(1) Sampling from Taps



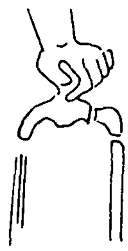
(i) Remove from the tap any attachments that may cause splashing and clean the mouth so as to remove any dirt.



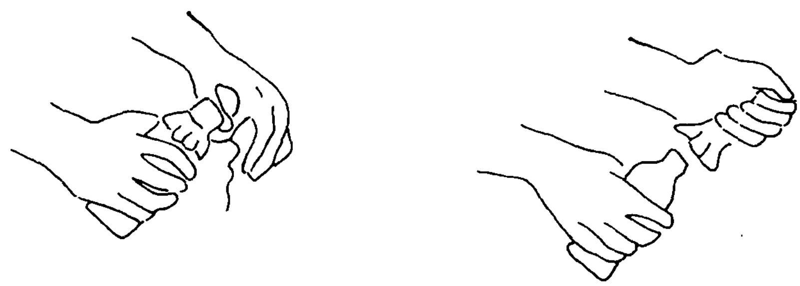
(ii) Turn on the tap and let the water flow for one or two minutes.



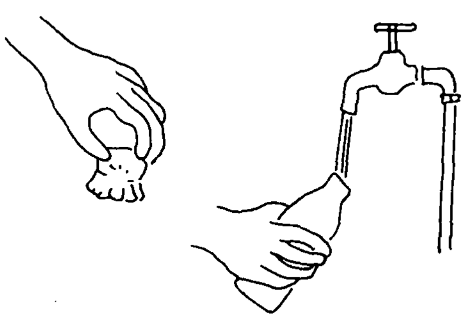
(iii) Sterilise the tap for a minute by swabbing with a piece of cotton wool soaked in alcohol and then flaming.

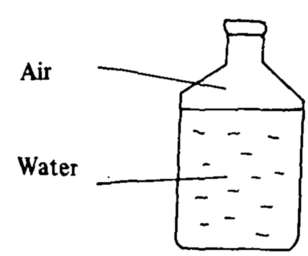


(iv) Carefully turn on the tap and allow the water to flow out at a moderate rate.



(v) The string fixing the protective cover is untied and the stopper removed.

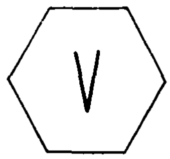




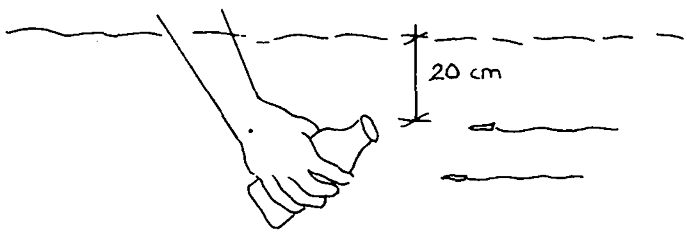
(vi) While holding the cap and protective cover facing downwards so as to prevent entry of dust that might carry micro-organisms, the bottle is brought under the water jet without loss of time and filled leaving a small air space to facilitate shaking at the time of innoculation.

(vii) The bottle is stoppered and the protective sheet fixed in place with the string.

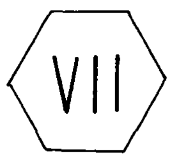
(2) **Sampling in a water course or reservoir**



(i) Proceed as in (v) above.

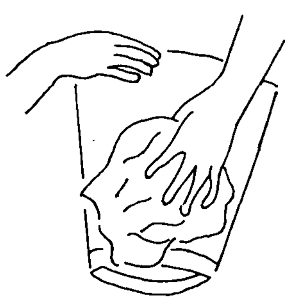


(ii) Holding the bottle by the lower part submerge it to a depth of about 20 cm in water, with the mouth facing towards the current. If there is no current, create an artificial current by moving gently forward.

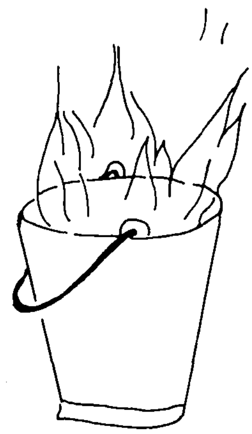


(iii) Proceeds as in (vii) above.

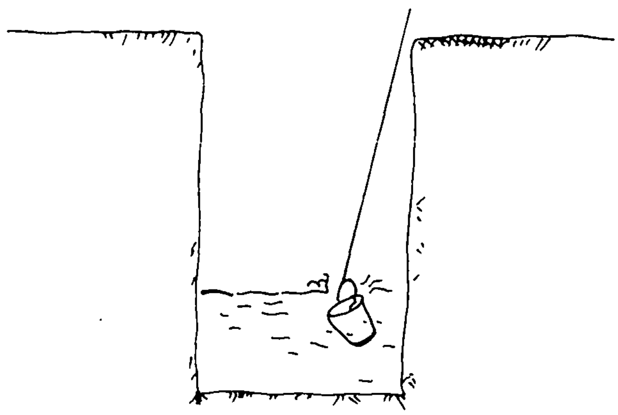
(3) **Sampling from a Dug Well**



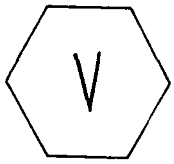
(i) Clean a metal bucket until it is free from earth and rubbish.



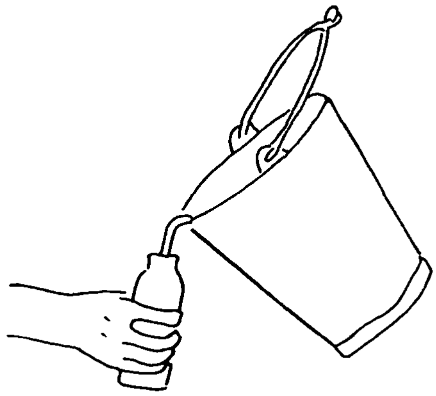
(ii) Pour a little methylated spirit into the bucket, light it and allow the burning alcohol to run over the walls of the bucket so as to sterilise the inner surface.



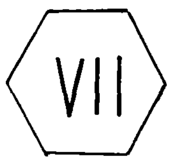
(iii) Lower the bucket into the well making sure that the rope does not enter the water nor the inside of the bucket, and also the bucket should not touch the side of the well. When the bucket is full of water, it is carefully raised.



(iv) Proceed as in (v) above.



(v) Fill the sample bottle with water from the bucket.



(vi) Proceed as in (vii) above.

DEPARTMENT OF CHEMISTRY, MALAYSIA
REPORT ON BACTERIOLOGICAL EXAMINATION OF WATER

Lab. No. . . . .

Supply: . . . .

Date Received: . . . ., Time: . . . . am/pm . . . . 19 . . . .

Sender: Sender/Lorry/Bus/Railway*

No.	Sampling Point	Type of Water	Date	Time	Residual Chlorine**	pH**	MPN/100 ml		
			Collected				Coliform	E.Coli	
1									
2									
3									
4									
5									

* Delete whichever is inapplicable ** As reported by the sampler.

Telephone report was made to: 1. Name of Officer: . . . .

P.W.D. . . . .

2. Name of Officer: . . . .

SMHSD Office: . . . .

1. Water Works Engineer,

. . . . District P.W.D.

. . . .

2. Medical Officer,

. . . . District Health Office.

. . . .

Chemist,
For Director-General of Chemistry,
Malaysia.

DEPARTMENT OF CHEMISTRY, MALAYSIA
REPORT ON SHORT CHEMICAL EXAMINATION OF WATER

Lab. No. ....

Supply: ....

Date Received ...., time: .... am/pm. .... 19 ....

Sender: Sender/Lorry/Bus/Railway*

Sample Particulars / Analytical Results			
	Sampling Point		
	Type of Water		
	Sampling Date		
	Sampling Time		
GROUP I **			
Residual Chlorine			
pH			
Turbidity (N.T.U.)			
Colour (Hazen Unit)			
GROUP II			
Total Dissolved Solid			
TOC			
COD			
BOD			
Ammoniacal Nitrogen as N			
Nitrate Nitrogen as N			
Total Nitrogen as N			
MBAS			
Total Akalinity as $CaCO_3$			
Total Hardness as $CaCO_3$			
Fluoride as F			
Chloride as C1			
Iron as Fe			
Manganese as Mn			
Aluminium as A1			

* Delete whichever is inapplicable.
** As reported by the sampler.
All results are in mg/1 except for pH or otherwise stated.

COMMENTS

1. Water Works Engineer,
   .... District P.W.D. Office.
   ....
2. Medical Officer,
   .... District Health Office.
   ....

Chemist,
for Director-General of Chemistry,
Malaysia.

DEPARTMENT OF CHEMISTRY, MALAYSIA
REPORT ON LONG CHEMICAL EXAMINATION OF WATER

S–3

Lab. No. . . . .

Supply. . . . .

Date Received: . . . ., Time . . . . am/pm . . . . 19 . . . . . .

Sender: Sender/Lorry/Bus/Railway*

Sample Particulars / Analytical Results			
	Sampling Point		
	Type of water		
	Sampling Date		
	Sampling Time		
GROUP I **			
Residual Chlorine pH Turbidity (N.T.U.) Colour (Hazan Unit)			
GROUP II			
Total Dissolved Solid TOC COD BOD Ammoniacal Nitrogen as N Nitrate Nitrogen as N Total Nitrogen as N MBAS Total Alkalinity as $CaCO_3$ Total Hardness as $CaCO_3$ Fluoride as F Chloride as Cl Iron as Fe Manganese as Mn Aluminium as Al			
Arsenic as As Mercury as Hg Cadmium as Cd Lead as Pb Chromium as Cr^{6+} Silver as Ag			

DEPARTMENT OF CHEMISTRY, MALAYSIA
REPORT ON LONG CHEMICAL EXAMINATION OF WATER

Copper as Cu Zinc as Zn Magnesium as Mg Sodium as Na Selenium as Se Sulphate as SO_4 Phosphate as PO_4 Hydrogen Sulphide as H_2S Oil and Grease Cyanide as CN Phenol Chloroform		
GROUP IV		
PAH Aldrin Dieldrin Chlordane DDT Endrin Heptachlor Lindane Methoxychlor Toxophene 2, 4 – D 2, 4, 5 – T		
GROUP V		
GROSS α (Bq/1) GROSS β (Bq/1)		

* Delete whichever is inapplicable
** As reported by the sampler.
All results are in mg/1 except for pH or otherwise stated.

COMMENTS

Chemist,
for Director-General of Chemistry,
Malaysia.

1. Water Works Engineer,

   .... District P.W.D.

   ....

2. Medical Officer,

   .... District Health Office.

   ....

WELL HISTORY AND WATER QUALITY RECORD

BORANG KMA 1

STATE:	____________	LOCATION OF WELL (TOPOGRAPHY)	____________
VILLAGE:	____________	DATE OF CONSTRUCTION:	____________
WELL IDENTIFICATION NO:	____________	NO. OF USERS:	____________

GENERAL DATA

- [ ] Dug well
- [ ] Tube well
- [ ] Shallow
- [ ] Deep
- [ ] Sanitary
- [ ] Unsanitary

- [ ] Without pumping facilities
- [ ] With pumping facilities
- [ ] With piping facilities
- [ ] With pumping facilities
- [ ] Without any form of treatment
- [ ] With treatment, describe.

TECHNICAL DATA

Inner wall diameter ____________ m.

Depth of well ____________ m.

Average depth of water during

wet season ____________ m.

dry season ____________ m.

WATER QUALITY

Date Sample	Date Tested	Parameters	Result	Possible source of contamination	Improvement Remarks
		E. Coli			
		Turbidity			
		Colour			
		pH			
		Chloride			
		Ammonia			
		Nitrate			
		Fluoride			
		Iron			
		Others			

Report on sanitary condition (see sanitary survey form – Manual On Drinking Water Quality Surveillance)

Annex 3

Laboratory Procedures for Water Treatment Plant:

(1) Colour
(2) Turbidity
(3) pH
(4) Residual Chlorine
(5) Alkalinity
(6) Jar Test
(7) Bacteriological examination

I. Colour

1. Visual comparison method

Colour is determined by visual comparison of the sample with known concentrations of coloured solutions. The unit of colour is that being produced by 1 mg/1 platinum in the form of the chloroplatinate ion. The ratio of cobalt to platinum may be varied to match the hue in special cases.

1.1 Reagents

(a) Dissolve 1.246 gm potassium chloroplatinate K_2PtCl_6 (equivalent to 500 mg metallic platinum) and 1 gm crystallised cobaltous Chloride $CoCl_2\ 6H_2O$ (equivalent to about 250 mg metallic Cobalt) in distilled water with 100 ml conc. H Cl. and dilute to 1,000 ml with distilled water. This stock standard has a colour of 500 units.

(b) Prepare standards having colours of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60 and 70 by diluting 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0 and 7.0 ml stock colour standard with distilled water to 50 ml in Nessler tube. These standards, protected from contamination and evaporation are stable for 6 months.

1.2 Equipments

(a) clean glass sample bottles
(b) 6" glass funnel
(c) funnel support
(d) filter paper, whatman #30, 180 mm diameter
(e) Pipette, 10 ml capacity graduated in $\frac{1}{10}$ ml.
(f) 18 colour comparison tubes, Nessler high form 50 ml
(g) colour tube support for high form Nessler tubes

1.3 Procedures

(a) Fill a Nessler tube to the 50 ml mark with sample and compare with standards by looking vertically down-ward through the tubes towards a white surface placed at such an angle that light is reflected upward through the columns of liquid. This is the apparent colour.

(b) To determine the "true" colour if suspended matter turbidity is present, filter the sample through filter paper* and compare the filtrate in a 50 ml Nessler tube with standard as above.

(c) Water having colour greater than 70 units are diluted with distilled water before comparison.

Turbidity

1. Nephelometric Method

Turbidity is the optical effect caused by dispersion of an interference with light rays passing through water containing small particles in suspension. The method present below is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions.

1.1 **Reagents (1) stock turbidity suspension**

(a) Solution I – dissolve 1 gm hydrazine sulphate $(NH_2)_2H_2SO4$ in distilled water and dilute to 100 ml in a volumetric flask.

(b) Solution II – dissolve 10 gm hexamethylenetetramine (CH_2) 6NH in distilled water and dilute to 100 ml in a volumetric flask.

(c) In a 100 ml volumetric flask, mix 5 ml solution I with 5 ml of Solution II. Allow to stand for 24 hours at 25 ± 3° C then dilute to the mark and mix. The turbidity of this suspension is 400 NTU.

1.2 Turbidity free water – pass distilled water through a membrane filter having a pore size, no greater than 100 um. If such water shows a lower turbidity than the distilled water, discard the first 200 ml collected. If filtration does not reduce turbidity, used distilled water.

Standard turbidity suspension:

(a) Dilute 10 ml stock turbidity suspension in 100 ml volumetric flask using turbidity free water. The turbidity of this suspension is defined as 40 NTU (prepare weekly).

(b) Dilute turbidity standards – dilute portions of the standard turbidity suspension with turbidity free water as required (prepare weekly).

1.3 **Procedures**

(a) Turbidimeter calibration – follow the manufacturer's operating instructions. In the absence of a precalibrated scale, prepare calibration curves for each range of the instrument.

(b) Check the accuracy of any supplied calibration scales on a precalibrated instrument by the use of appropriate standards.

(c) Measurements of turbidity less than 40 NTU – thoroughly shake the sample, wait until air bubbles disappear and pour the sample into the turbidimeter tube. Read the turbidimetry directly from the instrument scale or from the appropriate calibration curve.

(d) Measurements of turbidity above 40 NTU – as above, but the sample is diluted before measurement, and compute the turbidity of the original sample from the turbidity of the diluted sample.

Hydrogen ion concentration – pH

1. **Glass electrode method**

The hydrogen glass electrode in combination with the saturated calomel electrode (as reference electrode) is recognised as primary standard. The glass electrode system is based on the fact that a change of 1 pH unit produces an electrical change of 59.1 mv at 25° C.

1.1 **Reagents**

(a) Buffer solution pH 4.02 at 30° C – dissolve 10.21 gm anhydrous potassium biphthalate $KHC_8H_4O_4$ in distilled water and dilute to 1000 ml.

(b) Buffer solution pH 6.85 at 30° C – dissolve 3.40 gm anhydrous potassium dihydrogen phosphate KH_2PO_4 and 3.55 gm anhydrous disodium hydrogen phosphate Na_2HPO_4, both of which have been dried for 2 hours at 110° C to

130° C. Use distilled water which has been boiled for 15 min. and cooled to room temperature. Dilute to 1,000 ml.

(c) Buffer solution pH 9.14 at 30° C – dissolve 3.81 gm sodium borate decahydrate (borax) $Na_2B_4O_7\ 10H_2O$ in distilled water that has been boiled for 15 mins. and cooled to room temperature. Dilute to 1,000 ml.

1.2 **Equipment**

(a) pH glass electrode
(b) pH meter

1.3 **Procedure** (follow manufacturer's instructions)

note:

(a) The glass electrode and the calomel electrode should be thoroughly wetted (6–8) times with portions of the sample before measurement.

(b) The instrument must be standardised against a buffer solution with pH approaching that of the sample.

(c) Linearity of electrode response can be checked against at least one additional buffer of a different pH.

1.4 **Calculation**

Read the pH value from the pH meter.

IV. Residual Chlorine

1. Orthotolidine – arsenic test (OTA)

This method can measure free, combined and total chlorine residuals. The method is based upon the fact that free chlorine residuals react instantaneously with orthotolidine to produce a yellow compound, whereas combined chlorine reacts much more slowly, requiring 5 minutes at 20°C for full colour development. Also the addition of a reducing agent (sodium arsenite) will neutralise any residual chlorine either free or combined without affecting any colour initially formed.

1.1 **Reagents**

(a) Orthotolidine (OT) reagent
(b) Arsenite reagent

1.2 **Equipments**

(a) Chlorine test kits with permanent standards
(b) Cells
(c) Timer

1.3 **Procedure**

(a) For free chlorine residual – (i) to cell (FC) (free chlorine) add one drop of OT reagent, fill to the mark with water sample and immediately add dropperful of arsenite reagent, mix. (ii) to cell (B) blank add one dropperful of arsenite reagent, fill to mark with sample and add one dropperful of OT reagent, mix. (iii) place cell (FC) in left hand slot of camparator and cell (B) in right hand slot of comparator (i.e. in line with colour disc or permanent stds) rotate disc until colour matches on both sides of field when viewed through eye piece.

(b) For total chlorine residual : to cell (tc) total chlorine – add one dropperful of OT reagent and fill to mark with water sample, use timer and set aside for 5 minutes at room temperature (25° C). (i) place cell (tc) in left hand slot of comparater and cell (B) in right hand slot as in 1.3(iii) rotate disc until colour matches on both sides of field when viewed through eye piece.

1.4 **Calculation**

(i) The results are read directly from the disc and reported as mg/l free chlorine residual or total chlorine residual.

(ii) The combined chlorine residual, it is the difference in values of cell (tc) and cell (fc).

V. Alkalinity

1. Methyl orange alkalinity method

Alkalinity is a measure of the "basic" constituents of water i.e. namely hydroxide, carbonate or bicarbonate. For this purpose only total alkalinity as determined with methyl orange indicator, gives sufficient information for the control of coagulation and corrosion prevention when pH also is determined. (Control of lime soda softening of hard waters requires information as to the characteristics of alkaline compounds, hence phenolthelain alkalinity must be determine).

1.1 **Reagents**

(a) Methyl orange indicator solution, 0.5 g/l of distilled water.
(b) 0.02 N sulphuric acid.

1.2 **Equipments**

(a) Burrette, 50 ml
(b) Burrette stand
(c) Two 250-ml Erlenmeyer flasks
(d) 100 ml volumetric flask

1.3 **Procedure**

(1) Using volumetric flask, measure two 100 ml portions of sample and transfer each to a 250 ml Erlenmeyer flask.

(2) Fill burette to mark with 0,02 N sulphuric acid.

(3) To each sample in flasks, add 2 drops of methyl orange solution.

(4) Add the sulphuric acid slowly from burette to one of the test portions in flask, mixing thoroughly by rotating flask.

(5) Continuously compare the colours in the two flasks as the acid is added, and at the first appearance of a permanent faint pink colour in the test flask, stop adding the acid.

(6) Read burette. The amount of 0.02N acid used (in ml) multiplied by 10 will give the alkalinity in parts per million (ppm).

1.4 **Calculation**

Results are reported as ppm $CaCO_3$ as follows:

$CaCO_3$ alkalinity to methyl orange in ppm

$$= \text{ml } 0.02\text{ N acid} \times 10 \times \frac{100}{\text{Volume of sample}}$$

VI) **Coagulation and flocculation or jar test**

Alum and lime are commonly used in the water treatment plant for coagulation and flocculation. The jar tests described below determine the most effective doses of these two chemicals for a specific water in the control of coagulation and flocculation, which cannot be determined from the results of water analysis.

1.1 **Reagents**

(a) Alum – 1000 mg/l
(b) Lime – 1000 mg/l

1.2 **Equipment**

(a) Stirring device to provide controlled agitation equivalent in degree to plant scale flocculators (usually 30–100 rpm)
(b) 6 beakers (2 litres)
(c) Filter funnel
(d) Filter paper
(e) Pipette (100 ml)
(f) Equipment for colour, turbidity, pH and alkalinity.

1.3 **Procedure**:

(a) Determine the colour, turbidity, pH and alkalinity of raw water.

(b) Measure 1l portions of the sample into each of the 6 beakers and place them in the stirring equipment.

(c) Start motor of the stirrer.

(d) Add as quickly as possible graded doses of alum and lime to the six portions being agitated (as shown in table 1 & 2 of the annex).

(e) Agitate for the period of time provided for flocculation at the plant (20 mins). If flash-mixing is practiced on a plant scale, operate the agitator at full speed for 1 min. followed by the selected degree of agitation.

(f) Observe the time of the first appearance of visible floc in each of the six portions of the sample, and also the appearance, size and quantity of floc at the end of the agitation or flocculation period.

(g) Let all portions settle for 1 hour in the beakers.

(h) Observe the extent of sedimentation and the character of the unsettled floc. remaining in the six portions.

(i) Determine the colour, turbidity, pH and alkalinity of the supernatant.

(j) If none of the test portions after 1 hour of sedimentation in step (g) has colour below 10–20 units or turbidity below 5–10 units, discard the six portions tested and start another series of six portions of the sample with another range of chemical doses. Repeat until several portions are shown to be effectively coagulated.

(k) When effective coagulation is secured in one or two portions, filter the supernatant and determine its colour, turbidity, and alkalinity, also determine the pH of the settled water.

1.4 **Interpretation**

(a) The test portion giving the best flocculation and reduction of colour and turbidity by sedimentation and filtration will indicate the optimum doses of alum and lime for the specific sample under test.

(b) Only preliminary trials will disclose whether alum alone or both alum and lime are needed.

(c) Other tests with a constant selected dose but different degree of agitation will disclose optimum degree of agitation.

Table 1 Typical results of coagulation & flocculation test of a turbid alkaline water

Jar No.	Alum dose ppm	Lime dose ppm	Result of ppm	Analysis of settled water			
				Colour	Turbidity	pH	Alkalinity ppm
–	0	0	raw water	10	100	7.6	125
1	10	0	none	10	90	7.4	120
2	20	0	poor	8	50	7.1	115
3	30	0	good	5	8	6.8	110
4	40	0	very good	5	5	6.6	105
5	50	0	good	5	10	6.5	100
6	60	0	poor	7	30	6.2	95

Table 2 Typical results of coagulation and flocculation test of a coloured water of low alkalinity (lime needed for pH correction)

Jar No.	Alum dose ppm	Lime dose ppm	Result of Flocculation	Analysis of settled water			
				Colour	Turbidity	pH	Alkalinity ppm
–	0	0	raw water	80	10	5.6	15
1	20	0	poor	50	10	4.6	6
2	20	3	fair	30	8	5.0	10
3	20	6	good	10	5	5.4	13
4	30	8	good	10	5	5.4	13
5	30	10	fair	25	8	5.8	15
6	30	12	poor	70	10	6.2	18

VI. Bacteriological examination

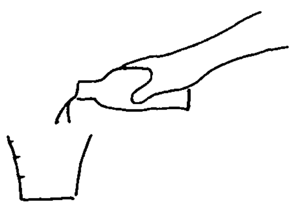
Two basic procedures are normally used for the detection of coliform bacteria in water; the multiple tube method; and the membrane filter method.

For multiple tube method, which is the choiced method for the permanent laboratory, it will only be briefly discussed here. The detailed method can be obtained from Standard Methods of Examination of Water and Waste Water. Aliquotes of a water sample are added to tubes containing suitable culture media; the mixture then incubated at 35° C and after 24 hours is examined for gas production. If a gas is produced it is presumed that coliform bacteria are present. (This is called the positive or presumptive test). The sample is than reincubated with a new fresh medium at 35° C for an additional 24 hours. There after the sample is tested for gas again and if detected it is considered that the test is positive for faecal coliforms.

The number of positive findings of coliform group organisms (either presumptive or confirmed) resulting from multiple-portion decimal dilution plantings should then be computed and recorded in terms of the most probable number (MPN).

The membrane filter technique gives a direct count of total coliforms and faecal coliforms present in a given sample of water. The techniques is based on filtering bacteria from a known volume of water through a membrane filter. The filter (and the trapped bacteria) may then be incubated with medium at 35° C for 24 hours for the detection of total coliforms or at 44.5°C for 24 hours for the detection of faecal coliforms. The outstanding advantage of this method is the speed with which results can be obtained. The number of coliforms both non-faecal and fecal can be determined in approximately 24 hours whereas the multiple tube method requires 48 hours for a negative or a positive test. It is easy to use in the laboratory and it also effects savings in supplies and glassware. However, its biggest advantage is its utility in the field. This enables rapid corrective action to be taken when required. However, the method has physical limitations and these must be recognized. High turbidity waters caused by clay, algae etc. may block the membrane thereby preventing the filtration of adequate volumes of the sample or alternatively the deposit may interfere with the growth of the organisms. In addition waters which are heavily polluted may have to be diluted several times. In the case of waters which contain a large number of non-coliform bacteria in relation to coliform bacteria, there may be interference in the growth rates of the two groups. In fact the coliform group may not survive in this situation. There is then the possibility of obtaining incorrect results. And finally if the waters being sampled contain toxic substances, the membrane filter cannot be used because the coliforms are not likely to survive in such an environment.

DETERMINATION OF FAECAL COLIFORMS – Membrane filter method



1. Pour the volume chosen (according to the type of water) into the stainless steel sample vessel.

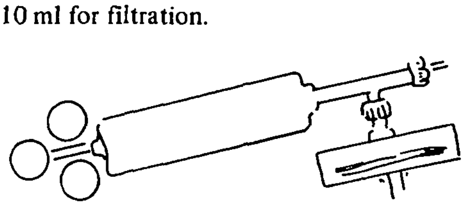
Note :

As the membrane area is relatively small, it can only support the growth of a limited number of colonies, the optimum usually being between 20–80 colonies with a maximum of 200. Above that figure it is difficult to distinguish small isolated colonies. In additon, colonies may grow over others and finally because of the high number of colonies it is possible that the growth of some might be inhibited. Choice of the volume of sample to be filtered will depend on the type of water.

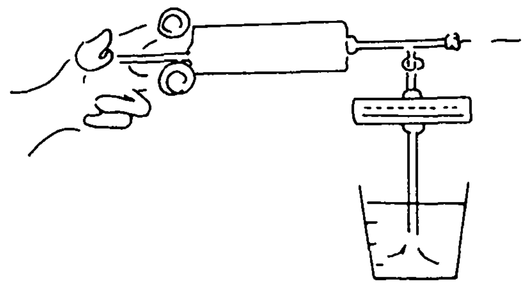
As a general rule the following filtration volumes should be used:–

	Volume of sample to be filtered (ml)
Good quality treated water	50 – 100
Untreated water suitable for drinking	10 – 50
Surface water	1 – 10

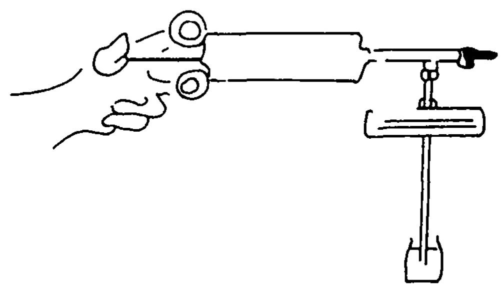
If the volume to be filtered is less than 10 ml the sample should be diluted in sterile dilution water so as to give a minimum of 10 ml for filtration.



2. Connect the vacuum syringe to a Petri dish or a monitor with MF and pad, and with a plastic tube for sucking in the sample.



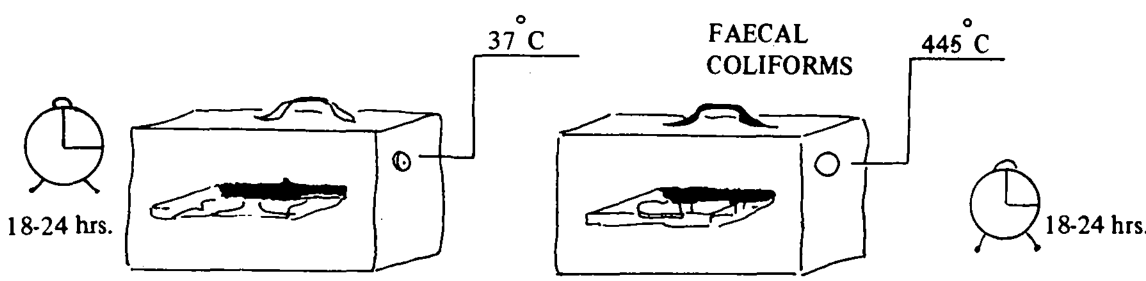
3. Operate the vacuum syringe so as to make the sample pass through the monitor and the MF with pad.



COLIFORM – ENDO – MF

FAECAL COLIFORM M – FC

4. After filtration, depending on the coliform being tested, add an ampoule of culture medium (MF–Endo for coliforms or M–FC for faecal coliforms) to the pad.



5. Place the monitor or Petri dish in the incubator included in the carrying case (the cases are generally suitable for incubating coliforms, but there are also portable incubators for faecal coliforms.)

   For coliforms: 18–24 hours at 35°C, and for faecal coliforms: 18–24 hours at 44.5°C.

Obtaining the results

The detection, counting and calculation of the bacteria is carried out as follows, as in the laboratory technique.

Colonies of faecal coliform bacteria are blue in colour but the total coliform colonies are metallic green coloured.

The colonies are counted with the aid of a magnifying glass and the number of faecal coliforms per 100 ml are determined as follows:–

$$\text{Faecal foliforms/100 ml} = \frac{\text{Faecal coliform colonies counted}}{\text{ml of filtered sample}} \times 100$$

or

$$\text{Total coliforms} = \frac{\text{Coliform colonies counted}}{\text{ml of filtered sample}} \times 100$$

L—J.P.N., K.L.