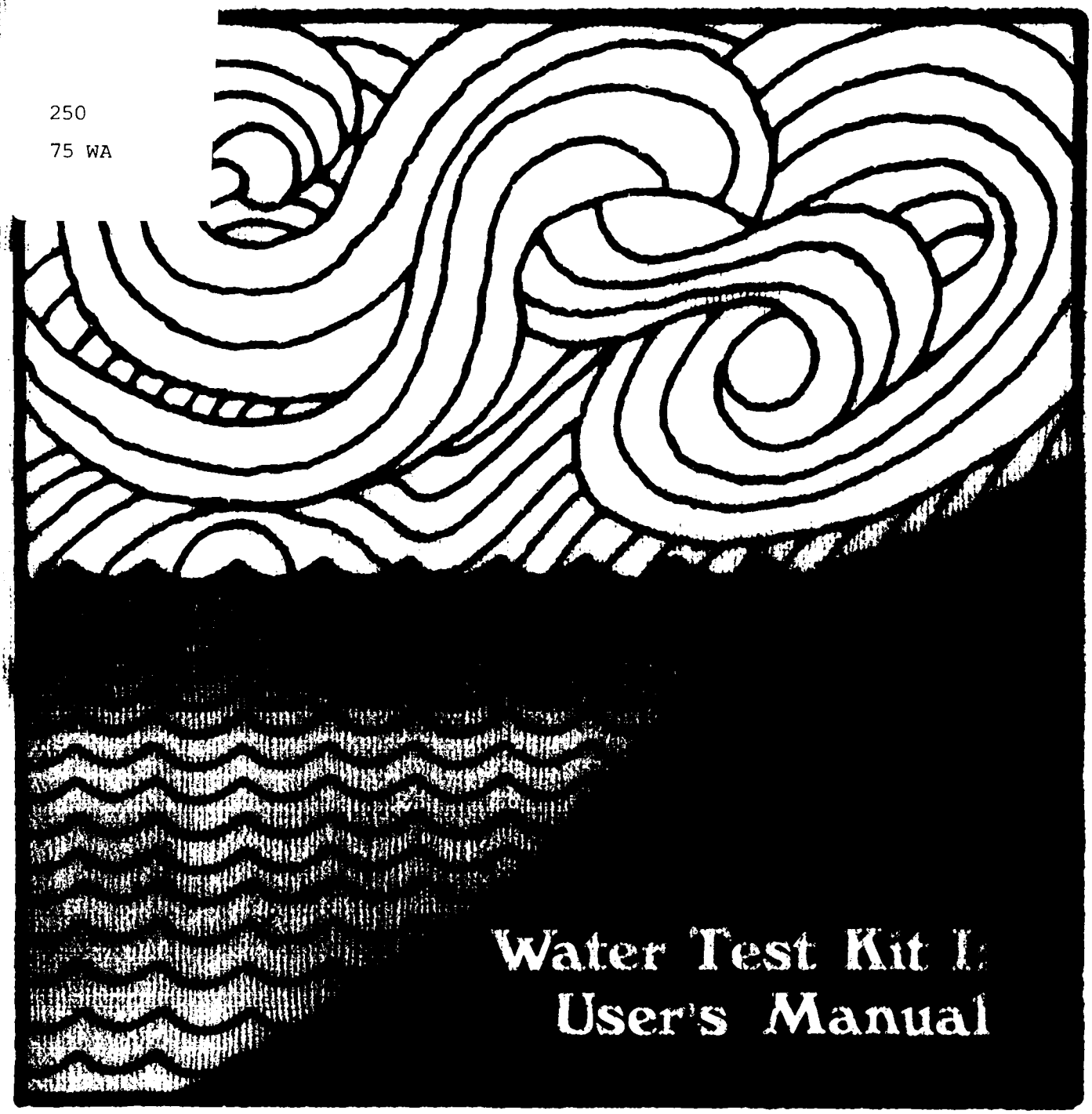

APPROPRIATE METHODS OF TREATING WATER AND WASTEWATER IN DEVELOPING COUNTRIES

THE UNIVERSITY OF OKLAHOMA
BUREAU OF WATER AND ENVIRONMENTAL RESOURCES RESEARCH
Sponsored by: U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTO

WATER TEST KIT I: USER'S MANUAL

Submitted to

Office of Health
Agency for International Development
Department of State
Washington, D. C. 70523

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TABLE OF CONTENTS

INTRODUCTION

The field kit is designed to provide quality checks on the water and sewage facilities. Seven tests were defined as being appropriate to provide an adequate health index of the water. These tests are pH, chlorine residual, turbidity, coliform bacteria, relative stability (biochemical oxygen demand), dissolved oxygen and temperature.

Objectives of the kit were that it be: (1) economical and rugged; (2) responsive to data needs; (3) available for mass distribution; (4) usuable by in-country skills; and (5) that expendables are replaceable in-country.

Commercially available test kits, such as La Motte or Hach, are accurate. However, they require knowledgeable operators. The chemicals had to be ordered out of the country and the cost was well over $250. The kit presented here consists of materials available locally and can be made fresh each day before going into the field. Results are adequately accurate and require no special skills or specific knowledge. The cost is under $100 for the entire kit.

This manual provides pictures of all operations and equipments needed for each test. Measurement in the manual are given in grams and milliliters. However, all weighings are substituted by the measuring spoons provided. The appendices provide alterative methods for performing each test, along with information on references, sterilization and distilling, and conversion tables.

SUMMARY OF METHODS

1. pH - Simple application of two indicators - bromcresol purple and phenolphthalein.

2. Turbidity - Basically, a comparison of water sample with prepared standards made up of precipitated Fuller's Earth.

3. Chlorine Residual - Potassium iodide and starch solution are added to the water sample. Clear sample reflects absence of chlorine. When chlorine is present, water sample will turn to a blue color, the intensity of which is proportional to the amount of chlorine in the sample.

4. Coliform - Application of normal MPN (most probable number) coliform test. A series of culture bottles are prepared using media that can be made up by locally available ingredients. An indicator, bromcresol purple is then added to the bottles. When coliforms are present, pH decreased which induces change of indicator color from purple to yellow will occur after 48 hours of incubation. The number of coliform present (coliform/100 ml.) can be correlated by the use of MPN table provided.

5. Biochemical Oxygen Demand - B.O.D. is measured by the relative stability method which replaces the "overly complicated" standard B.O.D. test. The number of days that are required to use up the oxygen is visually shown by the use of methylene blue indicator which change from blue to clear upon depletion of oxygen. Concentration of oxygen is determined by using a K-rate of 0.171 per day.

6. Dissolved Oxygen - A ferrous sulfate method is being introduced in this kit. Commercially available, ferrous sulfate capsules (iron anemis) are dissolved in water. Methylene blue and sodium hydroxide are added to each bottle containing the water sample. Different amounts of iron solution are then introduced into each bottle. The color of the indicator will turn from blue to straw upon consumption of oxygen.

7. Temperature - Thermometer.

STANDARDS AND FREQUENCY OF TESTS

Two lists of tests, for testing water from the domestic water supply and from the waste water treatment plant, with their respective recommended standards and suggested frequency for testing are compiled in the following charts.

1. Domestic Water Supply: Effluent

	Test	Frequency	Standards
A.	pH	once/week	7 - 9
B.	Turbidity	once/week	5 JTU most desirable 25 JTU max. permissible
C.	Chlorine Residual	once/week	0.15 - 0.2 ppm.
D.	Coliform Bacteria	once/week	2 MPN/100 ml.

2. Waste Water: Effluent

	Test	Frequency	Standards
A.	pH	once/week	6 - 10
B.	Turbidity	once/week	Less than 50 JTU
C.	Coliform Bacteria	once/week	240 MPN/100 ml.
D.	Relative Stability	once/week	30% reduction*
E.	Dissolved Oxygen	once/week	No less than 4 ppm.
F.	Temperature	once/week	Not more than 10°F over surrounding's water temperature.

The influent water (either domestic water supply or waste water treatment plant) should be tested once every three months. All listed tests should be performed. This is to check if the condition of the water entering the plant has changed and also to compare and see if the treatment is effectively improving the water condition after treatment.

If the effluent water (water coming out of the treatment plant) is not meeting (exceeds) these standards, then the treatment plant is perhaps not functioning properly and adjustments should be made in order that these standards can be achieved.

* See page 13 for determination of reduction.

DATA SHEET OF "OU-AID WATER & WASTE-WATER TESTING KIT 1"

SITE: ______________________________ TIME PERIOD: From ___/___/___ to ___/___/___

SOURCE OF TESTING WATER: Domestic Water Supply ------------ (1) _____ Influent (2) _____ Effluent

Waste-Water Treatment Plant ------ (3) _____ Influent (4) _____ Effluent

NAME OF KIT 1 USER: ______________________________.

Test / Date	pH*#			Turbidity* (JTU)			Chlorine Residual* (ppm)			Coliform Bacteria (MPN/100ml)					Dissolved Oxygen# (ppm)				Relative Stabil-ity #	Temperature# (^oF)
										Domestic			Waste							
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	
/	<6	6-9	>9	<25	25-50	>50	0	0.15	>0.2	<2	2	>2	<240	>240	<4	4	≥ 4	>4	%	

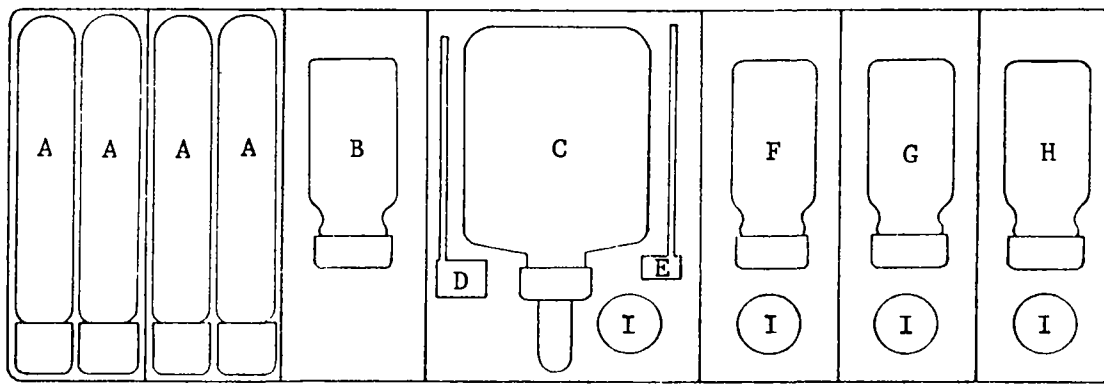
* - Tests for Domestic Water Supply

- Tests for Waste Water Treatment Plant

KIT SET UP

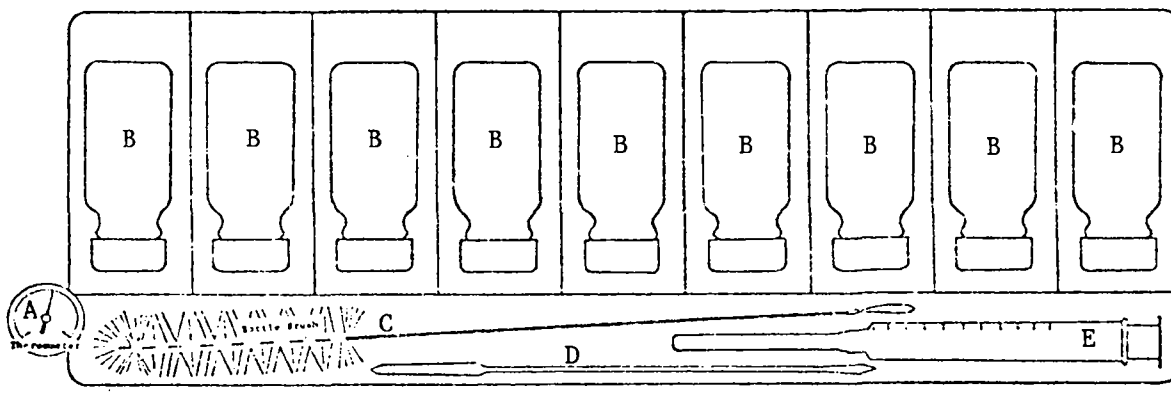
The kit is divided into three levels. The following figures show the set-up of top, middle and bottom levels.

1. Top Level



A. Test tube
B. Square bottle
C. Phenolphthalein solution
D. Spoon A
E. Spoon B
F. Square bottle for turbidity test
G. 50 JTU standard storage bottle
H. 25 JTU standard storage bottle
I. Hole for holding test tube when doing the test

2. Middle Level



A. Thermometer

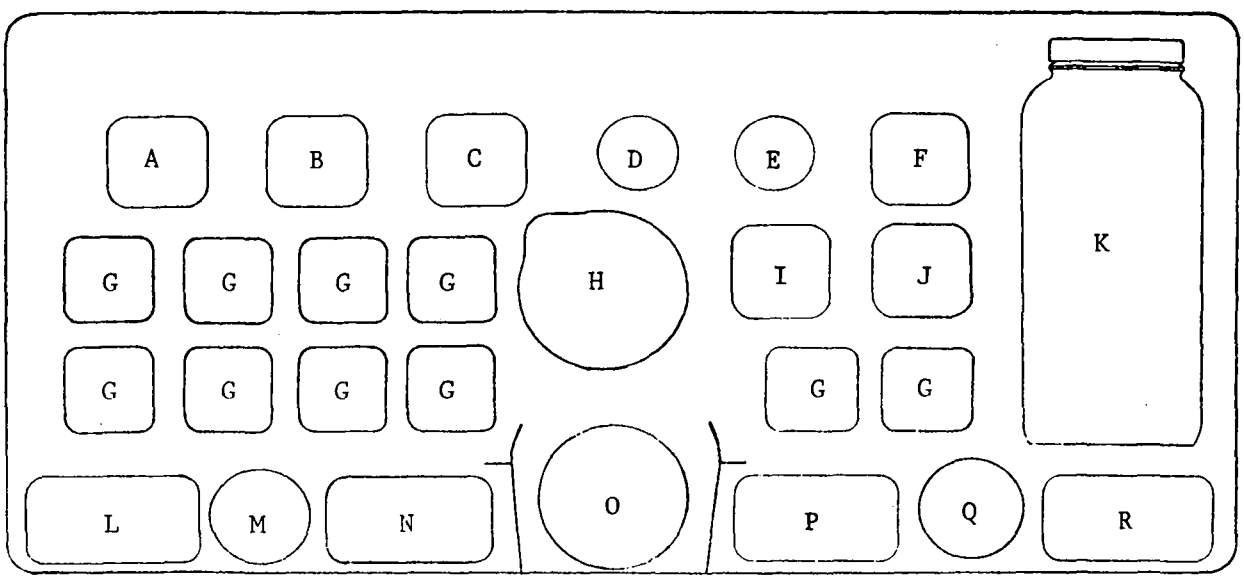
B. Square bottle

C. Bottle brush

D. Spatula

E. Syringe

3. Bottom Level



A. Methylene blue

B. $FeSO_4$ capsules

C. Sodium Hydroxide (NaOH)

D. Fuller's earth

E. Starch

F. Bromcresol purple

G. Square bottle

H. 100 ml beaker

I. Phenolphthalein

J. Potassium Iodide (KI)

K. Dry Milk

L. Methylene blue solution

M. Mineral oil

N. $FeSO_4$ solution

O. Glass bottle for relative stability

P. Sodium hydroxide solution

Q. Starch solution

R. Bromcresol purple solution

For ease of identification of apparatus and chemicals, a color code system is used as follows:

Color Code		Test involved
Blue		pH
Yellow		Turbidity
Green		Chlorine Residual
Orange		Coliform Bacteria
Brown		Relative Stability
Red		Dissolved Oxygen

CHECKLIST BEFORE GOING TO FIELD

1. pH -	A.	Bromcresol purple and phenolphthalein indicator solutions.
	B.	One clean bottle.
2. Turbidity	A.	25 JTU and 50 JTU standards* (be sure they are securely capped and not leaking).
	B.	One clean bottle (same as those containing the standards).
3. Chlorine Residual -	A.	Potassium iodide crystals
	B.	Starch solution * in dropper bottle
	C.	Two clean bottles
4. Coliform -	A.	Fifteen sterilized screw-capped bottles, each contains 15 ml. of media* and five drops of bromcresol purple indicator solution*.
	B.	One clean 10 ml. syringe
	C.	One clean 100 ml. beaker for sample collection
5. Relative Stability -	A.	One clean glass-stopper bottle
	B.	Methylene blue indicator solution.*
6. Dissolved Oxygen -	A.	Four clean test-tubes
	B.	One clean 10 ml. syringe with clean needle
	C.	One clean 100 ml. beaker for sample collection
	D.	Sodium hydroxide solution* in dropper bottle
	E.	Methylene blue indicator solution.*
	F.	Ferrous sulfate solution* preserved under a layer of mineral oil.
7. Temperature -	A.	Thermometer.

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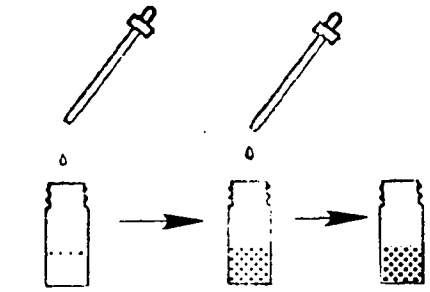
* See the section about preparation of reagents.

TEST METHODS

1. pH
   A. Use a square bottle, take 15 ml of water sample. Add 1 drop of bromcresol purple solution and 1 drop of phenolphthalein indicator solution.
   B. Observe closely the color of colution.

TABLE 1

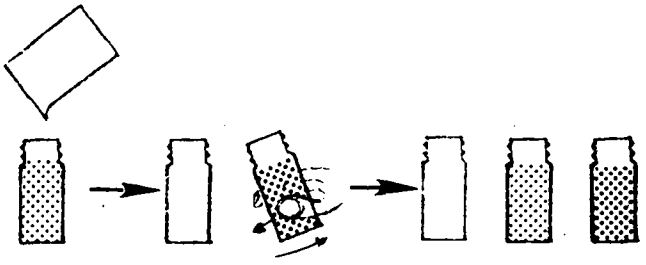
Color of solution	pH range	Comment on pH
Yellow	< 6.0	too low
Blue	6.0 - 8.5	OK
Purplish-blue	8.5 - 9.5	Still OK
Red	> 9.0	Too high

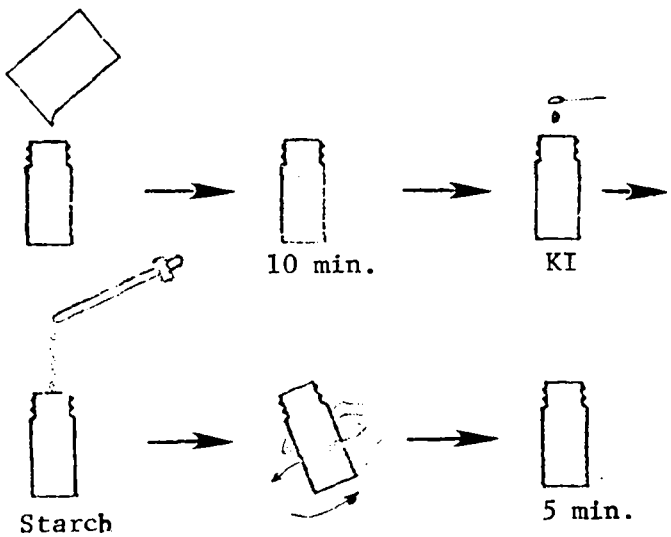


Bromcresol purple Phenolph-thalein

   C. Record result in data sheet.
   D. If having difficulty in identifying the red color, the following standard red solution may be prepared: Repeat step A, but in addition, add 5 drops of NaOH solution. This should give a standard red color solution for comparison.

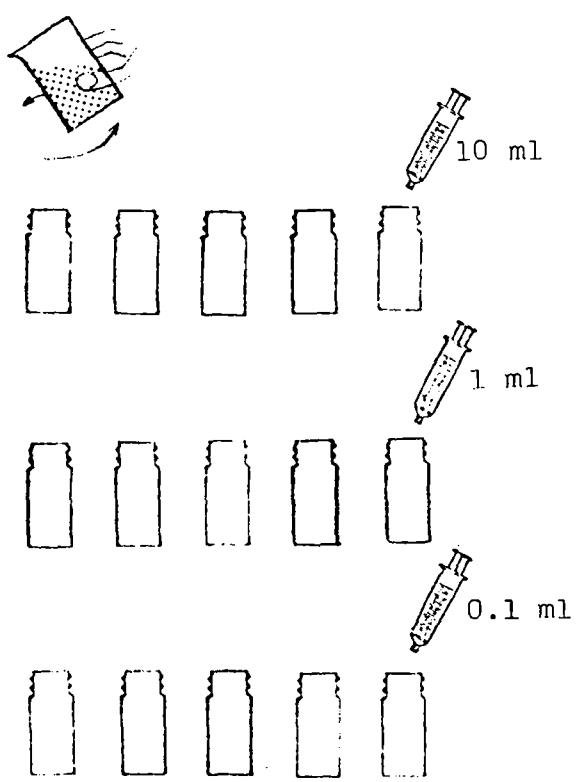
2. Turbidity
   A. Fill the sample bottle completely full with water sample.
   B. Shake the standards by inverting them.
   C. Compare the sample with the two standards and determine if the sample is less than 25 JTU, between 25-50 JTU, or greater than 50 JTU (Observe movement of particles in solution).
   D. Record result in data sheet.





3. Chlorine Residual

A. Fill a clean bottle with water sample up to the bottle-neck. (If water sample is turbid with color, fill a second bottle as with the first bottle. This is for comparison of color in later steps.)
B. Let the water sample(s) stand for ten minutes.
C. Add two crystals of potassium iodide. (DO NOT ADD THIS TO THE SECOND BOTTLE.)
D. Add five drops of starch solution. (TO BOTH BOTTLES)
E. Shake the sample(s) vigorously and let it stand for five minutes.
F. Observe the solution for change of color. Any change of color intensity upon longer standing should be disregarded.
G. Record result in data sheet.
No color -------- absence of chlorine (0 ppm)
Faint blue color --------- correct amount of chlorine (0.15 ppm)
Dark blue color --------- too much (>0.2 ppm.)



4. Coliform

A. To get better results, water sample should be thoroughly swirled before use.
B. To the first group of five bottles (with correct amount of media and indicator solution) introduce 10 ml of water sample into each, by using the syringe. BE SURE to record the amount of water sample introduced into each bottle.
C. To the second group of five bottles, introduce 1 ml of water sample into each.
D. To the third group of five, introduce 0.1 ml of water sample into each.
E. Incubate the bottles at 35°C (or 95°F) for 48 hours.

F. After 48 hours, observe for color change in the bottles. Bottles that have changed from purple to yellow color indicate a positive test. Record the number of bottles in each concentration that give positive results.

G. MPN Index (most probable number) and most positive results.
   (i) Domestic water supply - see Table 2
   (ii) Waste water - see Table 3

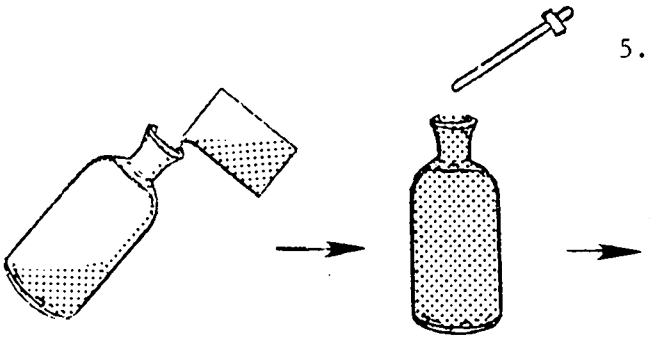
H. Record result in data sheet. (If MPN is greater than 2 for domestic water supply rerun the test the next day or sooner, if possible.)

Table 2. MPN Index for Various Combination of Positive Results (For Domestic Water Supply)

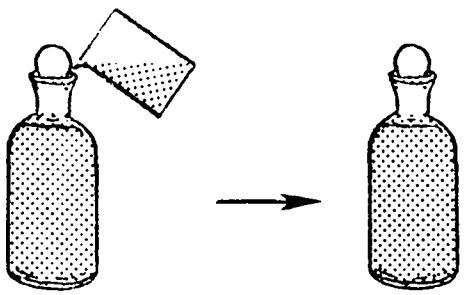
Number of bottles giving positive results			MPN Index
10 ml water sample	1 ml water sample	0.1 ml water sample	per 100 ml
0	0	0	<2
0	0	1	2
0	1	0	2
1	0	0	2
1	0	1	>2
1	1	0	>2

Table 3. MPN Index for Various Combination of Positive Results (for wastewater)

Number of bottles giving positive results			MPN Index per 100 ml
10 ml. water sample	1 ml. water sample	0.1 ml. water sample	
	↑		<240
5	4	2	<240
5	4	3	>240
5	4	4	>240
5	5	0	240
5	5	1	>240
	↓		>240



4 drops
Methylene blue



5. Relative Stability

A. Fill the glass stoppered bottle (or BOD bottle) with water sample, and avoid trapped air bubbles by letting water in along one side of the bottle and tap gently when it is full to get rid of any trapped air bubbles.

B. Add 4 drops of methylene blue indicator solution, stopper the bottle and mix by inverting the bottle.

C. Let the bottle stand at room temperature ($20 \pm 2^{o}C$, or $64 \pm 3^{o}F$).

D. Observe the solution twice a day (morning and evening) until the blue color disappears.

E. Record the number of days required for the color to disappear and then read off the corresponding relative stability percentage shown in Table 4.

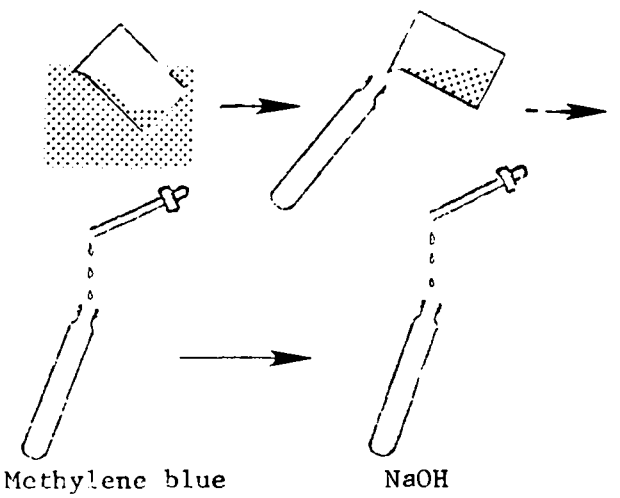
Table 4. Relative Stability Percentage and Days Required for Color Disappearance

Days	Relative Stability Percentage
0.5	17.56
1.0	32.40
1.5	44.40
2.0	54.30
2.5	62.40
3.0	69.10
3.5	74.60
4.0	79.10
4.5	82.80
5.0	85.90
5.5	88.40
6.0	90.50
6.5	92.15
7.0	93.50
7.5	94.65
8.0	95.60
8.5	96.40
9.0	97.00
9.5	97.57
10.0	98.00
11.0	98.70
12.0	99+

F. To determine percentage reduction, he following equation can be used:

$$\frac{\text{Effluent \% - Influent \%}}{\text{Effluent \%}} \times 100\% = \text{\% reduction}$$

G. Record result in data sheet.

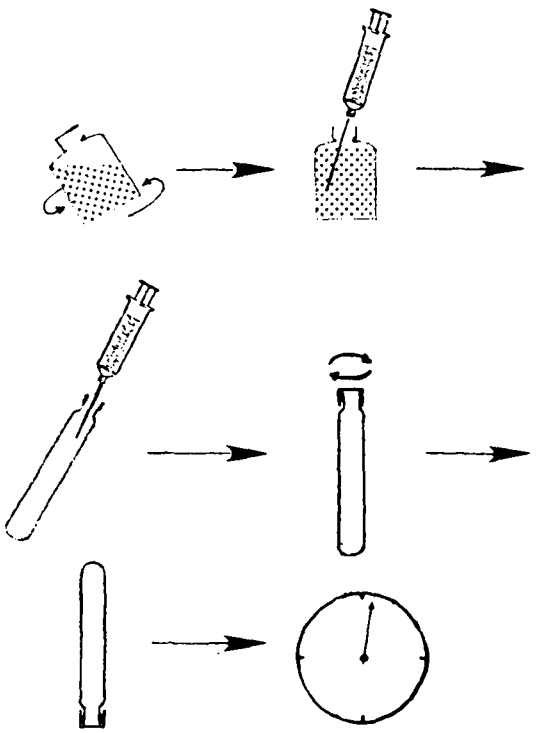


6. Dissolved Oxygen

A. Fill the beaker with water sample by carefully and slowly submerging it completely in water.

B. Fill the four test tubes by pouring, from the beaker, 15 ml water sample along the slanted side of the tube to avoid getting oxygen into the water. (All possible means must be exercised to avoid trapping excess air!)

C. To each test tube, add five drops of methylene blue indicator solution and five drops of sodium hydroxide solution.



D. Swirl the iron solution gently to mix it evenly.
E. With the needle tip placed underneath the oil layer, fill the syringe with the iron (ferrous) solution. Wipe any oil droplet off the needle-tip.
F. Discharge the iron solution slowly down the side of the test tube so as not to introduce additional oxygen into the solution: 4 ml of the iron solution into the first bottle; 5 ml of the iron solution into the second bottle; 6 ml into the third, and 7 ml into the fourth.
G. Recap the test tube securely; invert each test tube gently to mix the solution.
H. After two minutes, observe the color change of these test tubes (color change from blue to straw).
I. Refer to the Table 5 for approximate dissolved oxygen reading. Record result in data sheet.

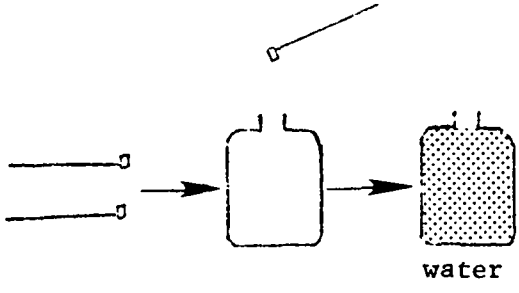
Table 5. Dissolved Oxygen Concentration and Color Change

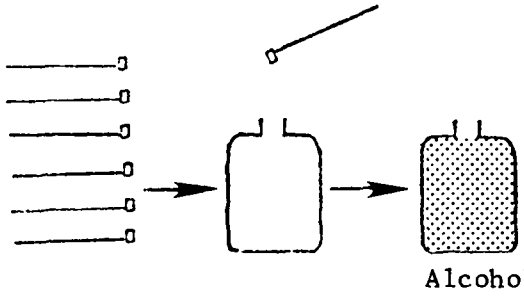
Change of Color from Blue to Straw	Dissolved Oxygen (ppm)	Comment
1st	<4	Slightly low
1st and 2nd	4	OK
1st, 2nd and 3rd	≥4	Good
1st, 2nd, 3rd and 4th	>4	Good

7. Temperature
   A. Submerge 1/3 of thermometer stem into the water sample for a min.
   B. Record result in data sheet.

PREPARATION OF REAGENTS

Important: Label all containers that has reagents in them!





1. pH

   A. To prepare bromcresol purple indicator solution:
   Dissolve 2 spoons* (use spoon B, about 0.05 gm) of bromcresol purple indicator in the dropper bottle with distilled water and fill the bottle to the neck.

   B. To prepare phenolphthalein indicator solution:
   Dissolve 6 spoons* (use spoon B) of phenolphthalein indicator in the dropper bottle with 50-60% alcohol and fill the bottle to the neck.

2. Turbidity

   A. To prepare stock solution:
   Add 1 spoon* (use spoon B) of Fuller's Earth to 50 ml of distilled water. This makes a stock solution with a turbidity of 1,000 JTU.

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* One spoon of reagent: Fill the spoon with one level spoonful of reagent, use a sheet of paper to scrap off the excess from the top and the sides. Invert the spoon, tap the end of the spoon handle to release the powder.

B. To prepare 50 JTU solution:
Shake the stock solution well. Take 5 ml of stock solution and dilute to 100 ml with distilled water. This makes the 50 JTU solution standard.

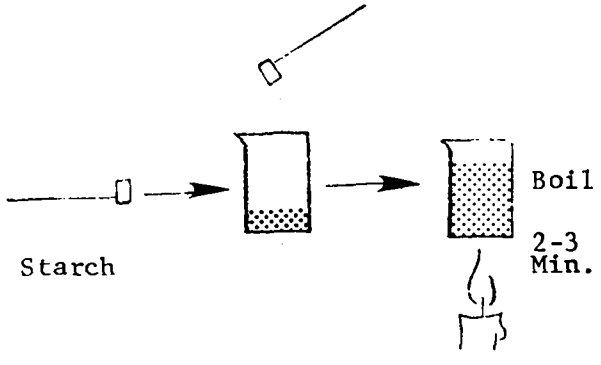
C. Preservation:
Add mercuric chloride (a few specks) or bleach (a few drops) to each standard solution. Standards must be prepared fresh each month.

D. LABEL ALL SOLUTIONS PREPARED.

3. Chlorine residual

To prepare starch solution:

Measure out one spoon of clean starch with spoon A. Add enough cold water and stir to produce a thin paste. Add approximately 100 ml of boiling water and keep stirring. Boil for 2-3 minutes. Add a few drops of chloroform (or formaldehyde) to preserve the solution. Fresh solution should be prepared as often as possible (two weeks or less).

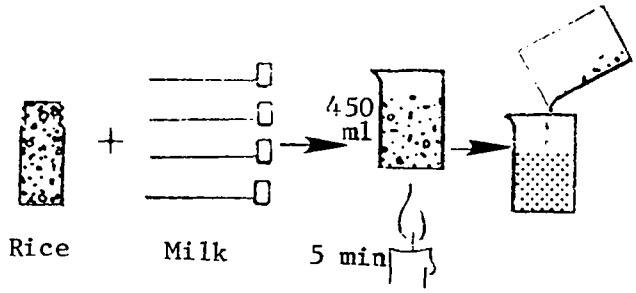


4. Coliform

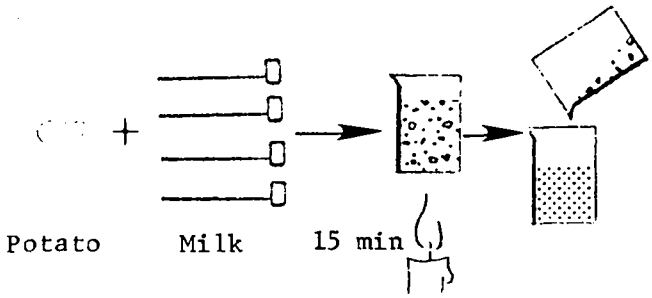
A. To prepare media:

Any of the following four methods may be used:

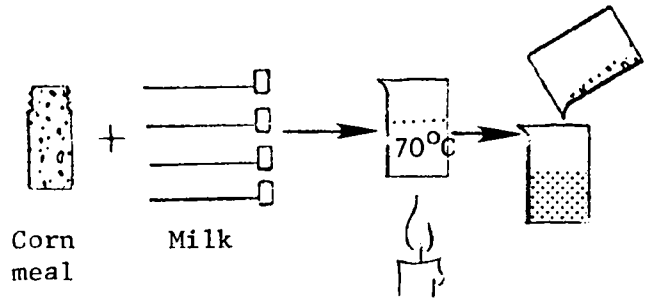
i. Rice Broth: Boil 25 grams (or fill 1 square bottle full) of rice and add 4 spoons (use spoon A, about 1 gram) of powdered milk in 450 ml of water for 5 minutes, stir occasionally. Decant carefully the rice broth into a glass bottle and discard the rice residue.

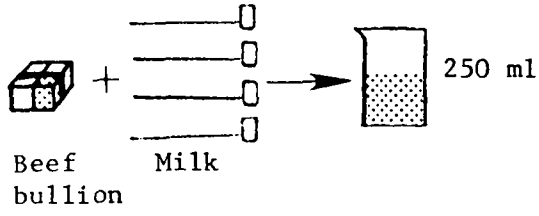


ii. Potato Broth: Peeled or sliced potatoes (or sweet potatoes) may be used. Boil 50 grams of potato (in place of the 25 grams of rice) and 4 spoons (spoon A) of powdered milk for 15 min, then, follow the same steps as with the rice broth.



iii. Corn Meal Broth: Heat 400 ml of water to 70°C (158°F). Add 1 square bottle full of corn meal and 4 spoons (use spoon A) of powdered milk, stir frequently. Decant carefully the broth into a glass bottle and discard the residue.





iv. Lactose Broth: Dissolve ¼ of a beef bullion bar (approximately 1 gram) and 4 spoons (use spoon A) of powdered milk in 250 ml of distilled water. Heat if necessary.

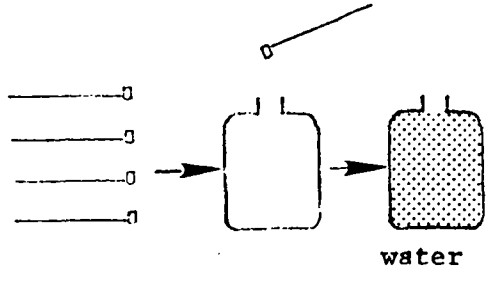
B. To prepare sterilized culture bottles:

Take 15 clean, screw-capped bottles. Introduce 15 ml of media into each bottle. Add 5 drops of bromcresol purple indicator solution to each bottle. Sterilize*, with the cap loosely placed on the mouth of the bottle. Let cool slightly; tighten the cap.

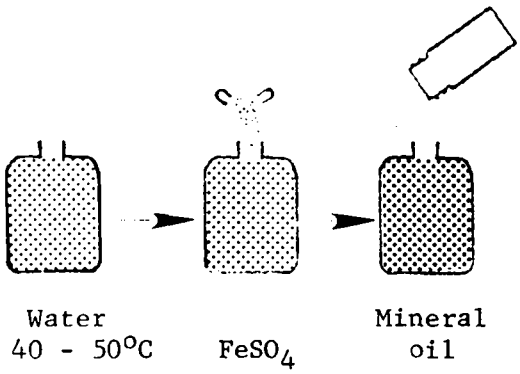
5. Relative Stability

To prepare methylene blue indicator solution:

Place 4 spoons (use spoon B) of methylene blue indicator in the dropper bottle. Fill the bottle with distilled water to the neck. Shake to dissolve the indicator.



* See appendix D for methods of sterilizing or autoclaving.



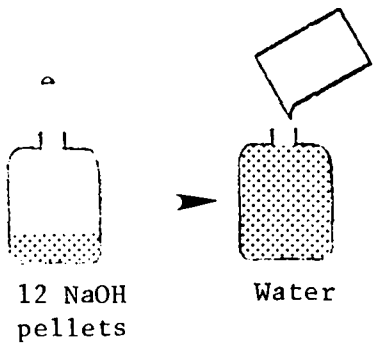
6. Dissolved Oxygen

A. To prepare ferrous sulfate solution:
Dissolve one capsule of ferrous sulfate (sold under the name of "Feosol Spansule") in 125 ml of distilled water. Keep water temperature at 40 - 50°C (100 - 120°F) for effective dissolving. Fill the bottle to the neck with warm water, then pull the capsule apart to let the pellets inside the capsule to go into the water. Cover the prepared solution with a layer of mineral oil.

B. To prepare methylene blue indicator solution:
See relative stability.

C. To prepare sodium hydroxide (NaOH) solution:
Dissolve 12 NaOH pellets in a dropper bottle with distilled water. Fill the dropper bottle to the neck with distilled water. Shake well. BE CAREFUL! NaOH pellets are extremely corrosive; avoid contact, rinse thoroughly with water and consult a doctor if "Burn" persists.

D. Mineral oil used is commercially available.



APPENDIX A

APPARATUS & CHEMICALS

I. Apparatus:

A. Square bottles (30 ml)

B. Test tubes (30 ml)

C. Dropper bottle (125 ml)

D. Dropper bottle (60 ml)

E. Glass-stoppered bottle

F. Beaker (100 ml)

G. Plastic Syringe (10 ml) with needle

H. Measuring spoon, 1.0 g. (spoon A)

I. Measuring spoon, 0.05 g. (spoon B)

J. Spatula, stainless steel

K. Thermometer

L. Brush

II. Chemicals:

A. Bromcresol purple

B. Phenolphthalein

C. 50-60% alcohol *

D. Fuller's earth

E. Starch

F. Potassium Iodide (KI)

G. Rice, potato, corn meal or beef bullion *

H. Powdered milk

I. Methylene Blue

J. Ferrous sulfate capsule ($FeSO_4$)

K. Mineral Oil

L. Sodium Hydroxide (NaOH)

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* To be obtained locally, not provided in the kit.

III. Companies where equipment and chemicals can be obtained:

A. Hach Chemical Company
P, O. Box 907
Ames, Iowa 50010
U. S. A.

B. Hach Chemical Company
Laivsco Mex S. A. de C. V.
Presidenie Masaryk No.17
Apartado Postal 17-519
Mexico 17, D. F., Mexico

C. Sargent Welch International Division
7300 North Linder Avenue
Skokie, Illinois 60076
U. S. A.

D. Curtin Scientific Company
4220 Jefferson Avenue
Houston, Texas 77011
U. S. A.

E. Curtin De Mexico, S. A. de C. V.
Apartado Postal 13265
Mexico 13, D. F., Mexico

F. Fisher Scientific International Division
52 Faden Road
Springfield, New Jersey 07081
U. S. A.

G. Fisher Scientific de Mexico, S. A.
Medellin 43-1402
Mexico 7, D. F., Mexico

APPENDIX B

REFERENCES

1. Standard Methods for the Examination of Water and Wastewater (13th Ed.)
American Public Health Association
1015 Eighteenth Street, N. W.,
Washington, D. C. 20036
U. S. A.

2. Shugar, Shugar and Bauman
Chemical Technicians' Ready Reference Handbook
McGraw-Hill Book Company
Manchester Road
Manchester, Missouri 63011
U. S. A.

APPENDIX C

ALTERNATIVE METHODS

A. pH

1. pH meter

2. Indicators

a. The following liquid indicators can be used for various titrations.

INDICATORS

Name	Transformation Interval	Color change Acid - Alkaline
Thymol Blue	1.2-2.8	red-yellow
Dimethyl yellow	2.9-4.1	red-yellow
Methyl Red	4.4-6.3	red-yellow
Bromcresol purple	5.2-6.8	yellow-purple
Bromthymol blue	6.0-7.6	yellow-blue
Phenol red	6.4-8.2	yellow-red
Neutral red	6.8-8.0	red-brown yellow
∝-Naphtholphthalein	7.8-9.0	rose brown-blue green
Phenolphthalein	8.0-9.8	colorless-red
Thymolphthalein	9.3-10.5	colorless-blue
Tropeolin	11.1-12.7	yellow-orange brown

b. Cop: Cop is the alcoholic blue cabbage extract. This extract exhibits the following colors: red at pH 2, rose at 4-5, blue at 7, green at 8, yellow at 11. The solution is obtained by extracting blue cabbage cop with 50-60% alcohol. The above solution should be stored in orange colored bottles.

c. Universal Indicators

i). methyl red, ∝-naphtolphthalein, phenolphthalein, bromthymol blue and thymolphthalein. Mix equal volumes of

0.1% solutions of the above five. This solution is red at pH of 4.0, yellow at 6, green-yellow at 7, green at 8, blue-violet at 10.

ii). 100 mg. phenolphthalein, 200 mg. of methyl red, 300 mg. of dimethyl yellow, 400 mg. bromthymol blue, 500 mg. of thymol blue in 500 ml. of alcohol, (methyl or ethyl), with sufficient 0.1 N alkali added to produce a yellow colour (pH = 6); orange-red at pH 4, yellow at 6, yellow-green at 7, green at 8, blue at 10.

d. pH paper.

B. Turbidity

1. Jackson candle (refer to Standard Methods)
2. St. Louis or Baylis Turbidimeter (refer to Standard Methods)
3. Turbidity Rod: A calibrated rod, attached to one end is a 1 mm diameter platinum wire which is at right angle to the rod. About 1.2 meters from this wire a wire ring is attached through which the fine wire is observed when the rod is lowered into the water. To obtain the turbidity of a water with this instrument, the rod is lowered vertically into the water being tested. The observer places an eye immediately above the ring and watches the platinum wire as the rod is being lowered into the water. When the wire disappears from sight the position of the surface of the water is read on the calibrated scale of the rod, this is read in parts per million. The rod shall be graduated as follows; mark of 100 shall be placed on the rod at a distance of 100 mm. from the center of the wire, and other graduations made so that:

Turbidity (ppm)	Vanishing depth of wire (mm)
10	794
20	426
40	228
60	158
80	122
100	100
150	72
200	57.4
300	43.2
400	35.4
500	30.9
1,000	20.9
2,000	14.8

C. Chlorine Residual

1. Orthotolidine method (refer to Standard Methods)

D. Coliform: The technique is the same, however, certain materials can be substituted:

1. use durham tubes (inverted vials) to detect gas production instead of bromcresol purple.
2. use pH paper instead of bromcresol purple, should end up with a pH of about 5.
3. instead of plastic syringe, glass syringes or glass pipettes can be used.
4. instead of powdered milk and bullion, the following normally used media can be applied:

    8 grams of peptone and beef extract (nutrient broth)

    5 grams of Lactose

    To be more accurate, you can use the confirmed test or selective media, refer to Standard Methods.

E. Dissolved Oxygen

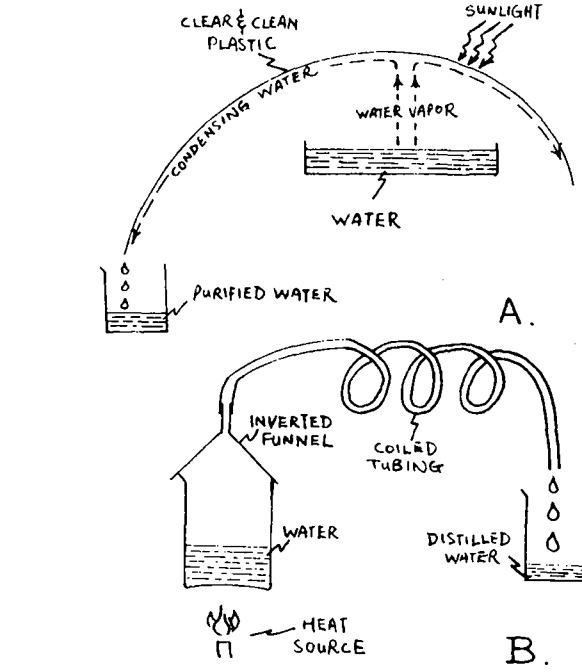
1. Winkler method or its various modifications. See Standard Methods.

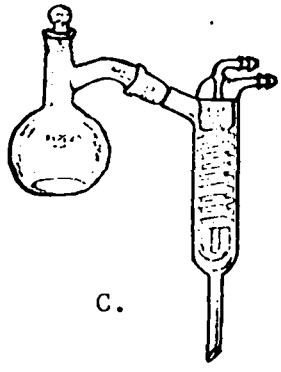
F. Relative Stability

1. BOD test, refer to Standard Methods or to some source of information on water analysis.

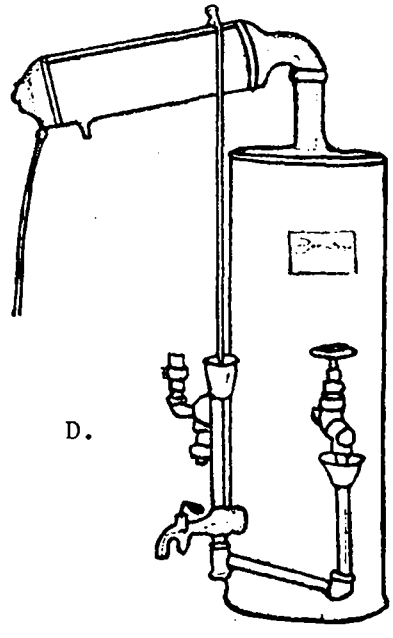
APPENDIX D

DISTILLING & AUTOCLAVING





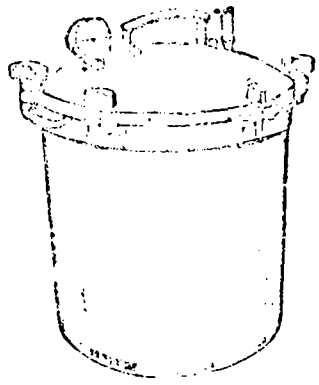
C.



D.

1. Distilling - the basic idea is to heat the water to its gaseous state through evaporation, then, condense it and collect it in liquid state. This causes the water collected to be free of impurities. This can be done in the following ways:

   A. Evaporation and collection.
   B. Heating the water to produce steam and then cool the steam to obtain purified water.
   C. Use of commercially available glass apparatus.
   D. Use of electric or gas model distilling apparatus.
   E. Use of de-ionizing devices also give water of equivalent quality as distilled water.



2. Autoclaving or sterilization -

The idea here is to heat the material to a high enough temperature (using wet or dry heat) to kill or inactivate the micro-organisms.

Glassware can be heated in an oven at 170°C for sixty minutes, or put in an autoclave or pressure cooker as shown in diagram with fifteen pounds of pressure at 120°C for fifteen minutes. Media can be sterilized in an autoclave or pressure cooker as above or it can be boiled for fifteen minutes.

Important:

Be sure to read the operating manual for the autoclaving and sterilizing devices carefully before any attempt is made to use them.

APPENDIX E

CONVERSION TABLES

16 tablespoons = 1 cup or 8 ounces

1 teaspoon = 5 ml

1 tablespoon = 15 ml

1 cup = 1/4 liter

1 pint = .4732 liters

1 gram = 0.0352 ounces

1 ounce (avoir) = 28.35 grams

1 kilogram = 2.2046 pounds

1 pound = 453.6 grams

1 fluid ounce = 29.57 ml

1 quart = 946 milliliters

1 liter = 1.06 quarts

1 liter = 2.113 pints

1 gallon = 3.785 liters

Temperature Conversion

^{o}Kelvin = ^{o}C + 273

^{o}Farenheit = 9/5 ^{o}C + 32

^{o}Centigrade = 5/9 (^{o}F - 32)