

CHAPTER 7: MONITORING OF WATER QUALITY

7.1 INTRODUCTION

Sampling and analysis of sewage is done in the treatment units in STPs to find out whether the organic matters are removed as designed. It is also done in locations of sewage discharge to make sure that the discharge standards are satisfied.

7.2 NEED FOR SAMPLING AND ANALYSIS IN STP

Effective operation and control of a STP requires that the operator possess thorough knowledge of the characteristics of the influent, effluent and internal process streams. To acquire such knowledge, representative samples of various unit operations in a STP should be collected following standard procedures and analysed for both the sewage and sludge.

7.3 SAMPLING

In general, the two categories of samples are to be collected for (a) physical and chemical tests and (b) microbiological tests. In both cases, care should be taken to avoid entry of extraneous materials such as silt, scum and floating matters into sampling bottles.

7.3.1 Overview

Understanding the principles and practices of sampling to obtain a representative sample is important to get at a truly representative sample instead of random collection leading to misleading results. Laboratory analyses will have little value if representative sampling is not done. Sampling points must be located where homogeneity of the sewage with good mixing is available.

7.3.2 Grab Sample

Grab samples are collected when frequent changes in character and concentrations are likely to occur and influence the treatment, undesirable constituents are suspected, the quality is not expected to vary or when samples require on the spot analysis for parameters such as DO, pH and residual chlorine. For example, the testing of the suspended solids (SS) in the clarifier overflow is an independent sample and it needs to be correlated to the time of sampling because the SS can vary between low flows, average flows and peak flows. Invariably the SS at peak flows of a few hours in the early forenoon may be higher. If the timing is not given, this will give the wrong impression that the entire performance over the 24 hours has got higher SS. Representative samples should be taken with good judgement and should be analysed within 2 – 3 hours of sampling. A well-washed clean PVC or plastic bucket connected to a sturdy long handle may be suitable for grab sampling.

7.3.3 Composite Sample

Since the sewage quality changes with time in a day, the best results would be obtained by using some sort of continuous sampler-analyser.

The continuous analysis if practiced, will leave little time to the operators to pay attention for actual operation of the STP. Hence, for tests, which cannot wait due to rapid chemical and biological change of the sample, such as tests for dissolved oxygen and sulphide, a fair compromise may be reached by taking samples throughout the day at hourly or two-hourly intervals.

When the samples are taken, the containers shall be preserved immediately in a suitable ice box till they are taken to a laboratory and preserved in the refrigerator there till they are taken up for analysis. This is required to avoid anaerobic decomposition which will alter the composition and characteristics of especially the organic portions like BOD, etc. When all the samples have been collected for a 24-hour period, the sample from a specific location should be combined or composite together according to flow to form a single 24-hour composite sample. as under

- The rate of sewage flow must be known, and
- Each grab sample to be taken and in direct proportion to the volume of flow at that time.

Table 7.1 illustrates the hourly flow and sample volumes to be measured for a 12-hour sampling.

Table 7.1 Hourly flow pattern during composite sampling

Time	Flow (Mld)	Factor(*)	Sample Volume (ml)	Time	Flow (Mld)	Factor(*)	Sample Volume (ml)
6 AM	0.2	100	20	12 N	1.5	100	150
7 AM	0.4	100	40	1 PM	1.2	100	120
8 AM	0.6	100	60	2 PM	1.0	100	100
9 AM	1.0	100	100	3 PM	1.0	100	100
10 AM	1.2	100	120	4 PM	1.0	100	100
11 AM	1.4	100	140	5 PM	0.9	100	90

Source: JICA, 2011

Large sewage solids should be excluded from a sample, particularly those greater than 6 mm diameter. A composite sample according to the Table 7.1 would total 1,140 ml.

The factor (*) mentioned in Table 7.1 is a multiplying factor for flow. The factor is so adjusted or decided so as to arrive at a convenient sample volume. This factor generally remains constant for a particular STP. It also remains constant during composite sampling period so as to maintain proportionality between flow and sample volumes.

During composite sampling and at the exact moment of testing, the collected samples must be remixed so that they are of the same composition. Lack of mixing can cause changes in results samples of solids that settle out rapidly, such as those in activated sludge or raw sewage. Samples must therefore be mixed thoroughly and poured quickly before settling occurs. If this is not done, errors of 25 to 50 % may easily occur.

For example, on the same mixed liquor sample, one person may find 3,000 mg/L SS while another may determine that there are only 2,000 mg/L due to poor mixing. When such a composite sample is tested, a reasonably accurate measurement of the quality of flow can be made.

7.3.4 Sampling Method and Precautions in Sampling

In all cases of sampling, procedures described in 'Standard Methods for the Examination of Water and Wastewater (APHA)' or 'Manual of Methods for the Examination of Water, Sewage and Industrial Wastes (ICMR)' or other standard manuals should be followed.

The sampling procedure is very important and is based on the purpose of sampling and tests to be performed. In general, sewage samples shall not be aerated during collection. Some of the manually operated sampling apparatuses are shown in Figure 7.1. Each has its preference, but the syphonic bellow at A is the easiest to use anywhere.

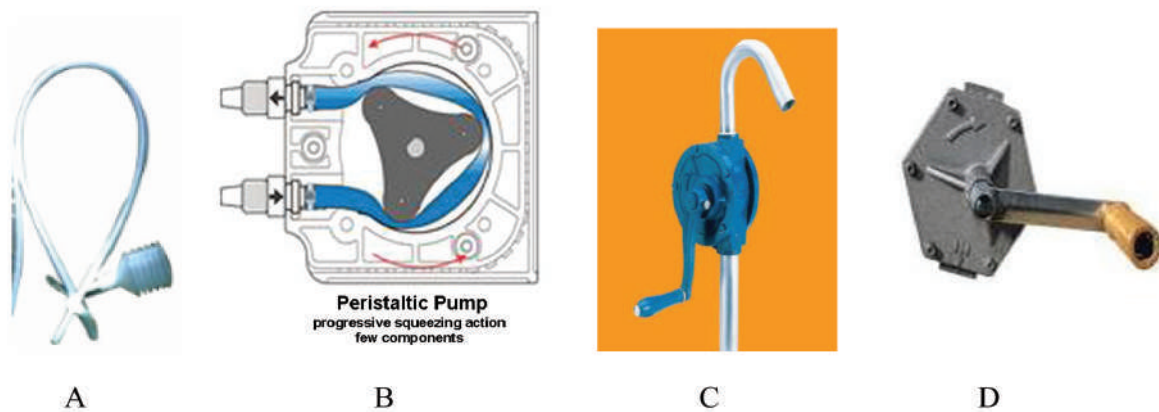


Figure 7.1 Typical sampling apparatuses used in sampling of sewage in STPs

A-Syphonic tube with bellows; B- Electrically operated peristaltic pump, C- Hand operated rotary with positive displacement, D- Hand operated rotary with circular movement

The use of the syphonic bellows tube involves the dipping of the free end of the tube into the liquid surface and keeping the pump end below the liquid level outside the structure and pumping the bellow, which starts a siphon action. Initially some portion of the sewage is to be discharged freely. If the sample is meant for determining the dissolved oxygen, the free end after bellows shall be extended by rubber tubing with a standard laboratory pinchcock and the free end of the tubing dipped into the BOD bottle to effect a submerged discharge very slowly. A timing of 10 seconds to fill the BOD bottle is considered as optimum. The sample shall be allowed to overflow for 5 seconds before the tube is withdrawn and the bottle is corked with the ground glass cork. This is possible only in the case of tanks with the liquid surface above ground level. If the liquid level is below ground level, a long handle connected scoop can be easily used. In this case, the scoop shall have a minimum of 1,000 ml volume and the above procedure can be done. The electrically operated peristaltic pumps (B) and other hand operated devices (C), (D) are fitted only for the final treated sewage samples. In all cases, the discharge end shall be submerged in the sampling bottle and overflow of samples shall be allowed for about 5 seconds.

7.3.5 Sample Volumes, Quantity and Storage of Samples

One to two litres of grab sample would be enough to perform all the tests and repeat some tests if required. For composite samples, a total quantity of 1 to 2 litres collected over a 24 hour period is adequate. Fractional sample at intervals of 1 to 2 to 3 hours should be collected in suitable containers, each sample being well mixed and a measured portion proportional to the flow transferred by means of a pipette, measuring cylinder or flask and integrated to form a 1 to 2 litre sample. Hourly records of flow normally available with the Plant Superintendent would facilitate taking representative samples. All samples should be immediately transported to the laboratory for analysis. In case there is any delay in transportation, the preservation time is to be as short as possible and in any case not exceeding 24 hours and the ice shall not be found melted on receipt of the sample.

7.3.6 Selection of Sampling Location

Theoretically, there is no end to the number of sampling stations that can be used in a STP. But then, it should be remembered that the best monitoring can be possible only when the barest minimum and objectively oriented sampling locations and tests are carried out instead of accumulating all and sundry data that will only confuse the situation. This is because the sewage passes through the STP on a time-deferred scale and if samples are taken all at the same time from inlet to outfall, the chances are that it is not representative of the true performance. A suggested set of sampling points is shown below.

- A. Raw sewage samples should be collected after screens or grit chambers.
- B. Samples of sewage from primary clarifier or secondary clarifier should be taken from the trough or pipe or before discharge weirs.
- C. Inlet to top feed media units should be collected below the distribution arm and the sewage from the outlet chamber or at the inlet to secondary sedimentation tank.
- D. A point where there is good mixing should be selected for sampling of mixed liquor in aeration tanks in the activated sludge process.
- E. Inlet samples of septic tanks, Imhoff tanks, and other sole treatment units such as waste stabilization ponds, oxidation ditches and aerated lagoons should be collected ahead of these tanks in their inlet chambers or channels leading to these units. Outlet samples should be collected outside the units in receiving weirs or channels or chambers.
- F. Sampling within these tanks should be specified in terms of depth or distance or both.
- G. Samples of raw sludge should be taken from sludge sumps or from the delivery side of the sludge pumps through sampling cocks.
- H. Return sludge sample in activated sludge plant is collected at the point of discharge into aeration tank.
- I. Samples from mixed primary and secondary sludge should be collected at the point of delivery to the digester.

- J. Digested sludge samples may be drawn from the sampling points in the digester or from the discharge end of the delivery pipe leading to drying beds or mechanical dewatering units.
- K. Digester supernatant may be drawn from sampling cocks provided for this purpose or through sampling ports on digester dome.
- L. In case of SVI determination, samples may be collected from a suitable sampling location in between the aeration tank and secondary clarifier.

The flow chart indicating the various treatment units and the sampling points may be exhibited prominently in the laboratory. A list of tests to be carried out daily on the samples may also be displayed as a wall chart.

7.4 RELEVANCE OF PARAMETERS

In general, the parameters can be classified as broadly into statutory need and plant control need. The plant control needs are mainly to understand whether the STP is functioning as per the design and to inform whether corrective measures are needed. Two separate records shall be kept; one for public consumption in respect of statutory discharge standards and the other for in-house plant control. These parameters are not for public consumption as they will be continually changing and the public may not be able to understand its nuances. For a typical STP irrespective of the treatment processes, such as ASP, SBR and MBBR the recommended tests are mentioned in Table 7.2, Table 7.3 and Table 7.4 and any additional tests/parameters can be included as indicated by the technology provider.

7.5 ANALYSIS PARAMETERS AND FREQUENCY (LIQUID AND SLUDGE)

7.5.1 Items and Frequency for ASP

For day to day plant control, various sundry data need not be accumulated. Recommended tests to be carried out in typical STPs on a daily, weekly, and monthly to biannual basis are shown in Table 7.2 overleaf, Table 7.3 overleaf, and Table 7.4 overleaf, shall be followed.

In respect of BOD test, a graph of BOD versus COD for the raw, primary treated, secondary treated and outfall sewage should be prepared every week and the daily COD readings used to interpret the BOD values. If treated sewage is to be used for agriculture then the safe limits for (a) Sodium Adsorption Ratio (SAR) should not exceed 18 and (b) RSC should not exceed 1.25 meq/L. The procedure for calculating SAR and RSC are shown in equation 7.1 and 7.2 respectively.

$$SAR = \frac{Na^+}{\left(\frac{Ca^{++} + Mg^{++}}{2}\right)^{\frac{1}{2}}} \quad (7.1)$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+}) \quad (7.2)$$

where all ionic concentrations are expressed as meq/litre

Table 7.2 Recommended Plant Control Tests on a Daily basis in a typical STP

No.	Tests	Raw sewage	Primary clarifier outlet	Aeration tank	Secondary clarifier outlet	Outfall	Primary sludge	Return sludge	Thickener underflow	Digested sludge	Sludge cake
1.	Temperature	•	•	•	•	•		•		•	
2.	pH	•	•	•	•	•	•	•	•	•	
3.	Alkalinity	•	•		•			•		•	
4.	BOD (Total)	•	•		•	•					
5.	COD (Total)	•	•		•	•					
6.	TSS	•	•		•	•					
7.	VSS	•	•		•	•					
8.	Residual Chlorine					•					
9.	Moisture Content						•	•	•	•	•
10.	MLSS			•							
11.	MLVSS			•							
12.	DO			•	•						
13.	SV ₃₀			•							
14.	SVI			•							
15.	Ammonia, Nessler	•		•		•					
16.	Ortho P, Nessler	•		•		•					
17.	Sulphide	•				•					

Table 7.3 Recommended Plant Control Tests on a Weekly basis in a typical STP

No.	Tests	Raw sewage	Primary clarifier outlet	Aeration tank	Secondary clarifier outlet	Outfall	Primary sludge	Return sludge	Thickener underflow	Digested sludge	Sludge cake
1.	BOD (Filtered)	●				●					
2.	COD (Filtered)	●				●					
3.	Microscopy (*)			●							
4.	Faecal Coliform					●					
5.	Total Coliform					●					
6.	Oil and grease	●				●					●
7.	Total residual chlorine					●					
8.	Ammonical Nitrogen	●				●					
9.	Total Kjeldahl Nitrogen	●				●					
10.	Nitrate Nitrogen	●				●					
11.	Free ammonia	●				●					
12.	Dissolved Phosphates (P)	●				●					
13.	Sulphate	●				●					
14.	Chloride	●				●					
15.	Silica	●				●					
16.	Ca	●				●					
17.	Mg	●				●					
18.	TDS	●				●					
19.	Conductivity	●				●					

*Identify the following by microscopy.

Rotifers, Crustaceans, Protozoa, Ciliates, Nocardia, Ceronithrix, Nematodes

Table 7.4 Recommended Plant Control Tests on a Monthly to Biannual basis in a typical STP

No.	Tests	Raw sewage	Primary clarifier outlet	Aeration tank	Secondary clarifier outlet	Outfall	Primary sludge	Return sludge	Thickener underflow	Digested sludge	Sludge cake
1.	Mercury (Hg)	•				•					•
2.	Lead (Pb)	•				•					•
3.	Cadmium (Cd)	•				•					•
4.	Hexavalent Chromium (Cr+6)	•				•					•
5.	Total chromium (Cr)	•				•					•
6.	Copper (Cu)	•				•					•
7.	Zinc (Zn)	•				•					•
8.	Nickel (Ni)	•				•					•
9.	Manganese (Mn)	•				•					•
10.	Iron (Fe)	•				•					•
11.	Vanadium (V)	•				•					•
12.	Cyanide (CN)	•				•					•
13.	Fluoride (F)	•				•					•
14.	Phenolic compounds					•					•
15.	Arsenic (As)	•				•					•
16.	Selenium (Se)	•				•					•
17.	Ca					•					
18.	Mg					•					
19.	Na					•					
20.	K					•					
21.	Chloride					•					
22.	SO ₄					•					
23.	Alkalinity					•					
24.	CO ₂					•					
25.	HCO ₃					•					
26.	Bio-assay test	•				•					•
27.	Radioactive materials:	•				•					•
	(a)Alpha emitter	•				•					•
	(b)Beta emitter	•				•					•

Note: Radioactive materials testing is to be done only by laboratories authorized for this purpose.

7.5.2 Items and Frequency for WSP

In general parameters of testing for diurnal examinations arise only when the treatment process is dependent on solar energy like in the case of ponds. In such cases, the tests will be as follows.

Care, safety and wisdom are paramount in taking samples from ponds especially diurnal samples as chances of vermin and reptiles straying around in wet climates and high summer cannot be ruled out. Proper clothing, safety wear, etc., and the presence of a qualified ambulance person with tool kit is mandatory in the diurnal sampling.

A better way of managing this will be to leave a floating or other pump set erected in the daytime and operate it by remote switch in the night and collect the sample from the outlet hose of the pump set sufficiently far away at a well-lighted and safe and secure location. Table 7.5 mentioned the recommended plant control tests on a monthly basis in a typical WSP.

Table 7.5 Recommended plant control tests on a monthly basis in a typical WSP

No.	Parameter	Sample Type	Remarks
1.	Flow	-	Both raw sewage and final effluent flows
2.	BOD	C	Unfiltered samples (A)
3.	COD	C	Unfiltered samples (A)
4.	Suspended solids	C	
5.	Ammonia	C	
6.	pH	G	Two samples one set each at 8:00-10:00 h & at 14:00-16:00 h
7.	Temperature	G	
8.	Fecal coliforms	G	Take sample between 08:00 & 10:00 h
9.	Total nitrogen	C	Only when effluent being used (or being assessed for use) for crop irrigation. Ca, Mg and Na are required to calculate the sodium absorption ratio (SAR) (D)
10.	Total phosphorus	C	
11.	Chloride	C	
12.	Electrical conductivity	C	
13.	Ca, Mg, Na	C	
14.	Boron	C	
15.	Helminth eggs (B)	C	
16.	Dissolved Oxygen	-	At dawn and dusk

C=24-hour flow-weighted composite sample; G=grab sample.

(A) Also on filtered samples if the discharge requirements are so expressed.

(B) *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale* and *Necator americanus*.

(D) $SAR = (0.044Na) / [0.5(0.050Ca + 0.082Mg)]^{0.5}$ where Na, Ca and Mg are in mg/L.

Source: Duncan Mara, 1997

7.6 SAMPLING AND MICROBIOLOGICAL TESTING OF RAW AND TREATED SEWAGE

7.6.1 Need for Microbiological Testing

Many water borne pathogenic organisms which can cause diseases as in Table 7.6 and even cause epidemic, are transmitted through the water route when infected with sewage which is not fully treated. This is because these organisms enter the water from the faeces of individuals suffering from these diseases and remain as carriers of these organisms even after they are supposed to be fully cured like the famous “Typhoid Mary” a nurse who was cured but her night soil continued to exhibit the typhoid organisms.

Table 7.6 Diseases Attributable to Sewage Pollution of Drinking Water

No	Diseases	Causative Organism	Source of Organisms	Symptoms
1	Gastro-enteritis	Salmonella	Animal or Human faeces	Diarrhoea, Vomiting
2	Typhoid	Salmonella typhosa	Human faeces	Inflamed Intestine, Enlarged Spleen, Step ladder temperature
3	Dysentery	Shigella species	Human faeces	Diarrhoea
4	Cholera	Vibrio cholera	Human faeces	Sever, Diarrhoea, Dehydration
5	Infectious hepatitis	Virus	Human faeces, Shell fish	Yellowed Skin, Abdominal Pain
6	Amoebic dysentery	Entamoeba histolitca	Human faeces	Diarrhoea, Dysentery
7	Giardiasis	Giardia lambia	Animal or Human faeces	Diarrhoea, Cramps, Nausea, Weakness

It is both difficult and time consuming to check the treated sewage for each of these organisms. A sterile laboratory is required, which is admittedly not easy in many parts of India especially outside the metro cities. Extensive research has shown that if the coliform group of bacteria is present, there is a probability that one or more pathogens may also be present. Therefore, coliforms have been chosen to be the bacterial group routinely tested when there is a need for assessing the bacteriological safety. Presence of any of the coliform group of bacteria (total coliforms) indicates general contamination, while the presence of faecal coliforms indicates contamination of human or animal origin. These can be differentiated from other coliforms by incubating on selective media at 44.5°C.

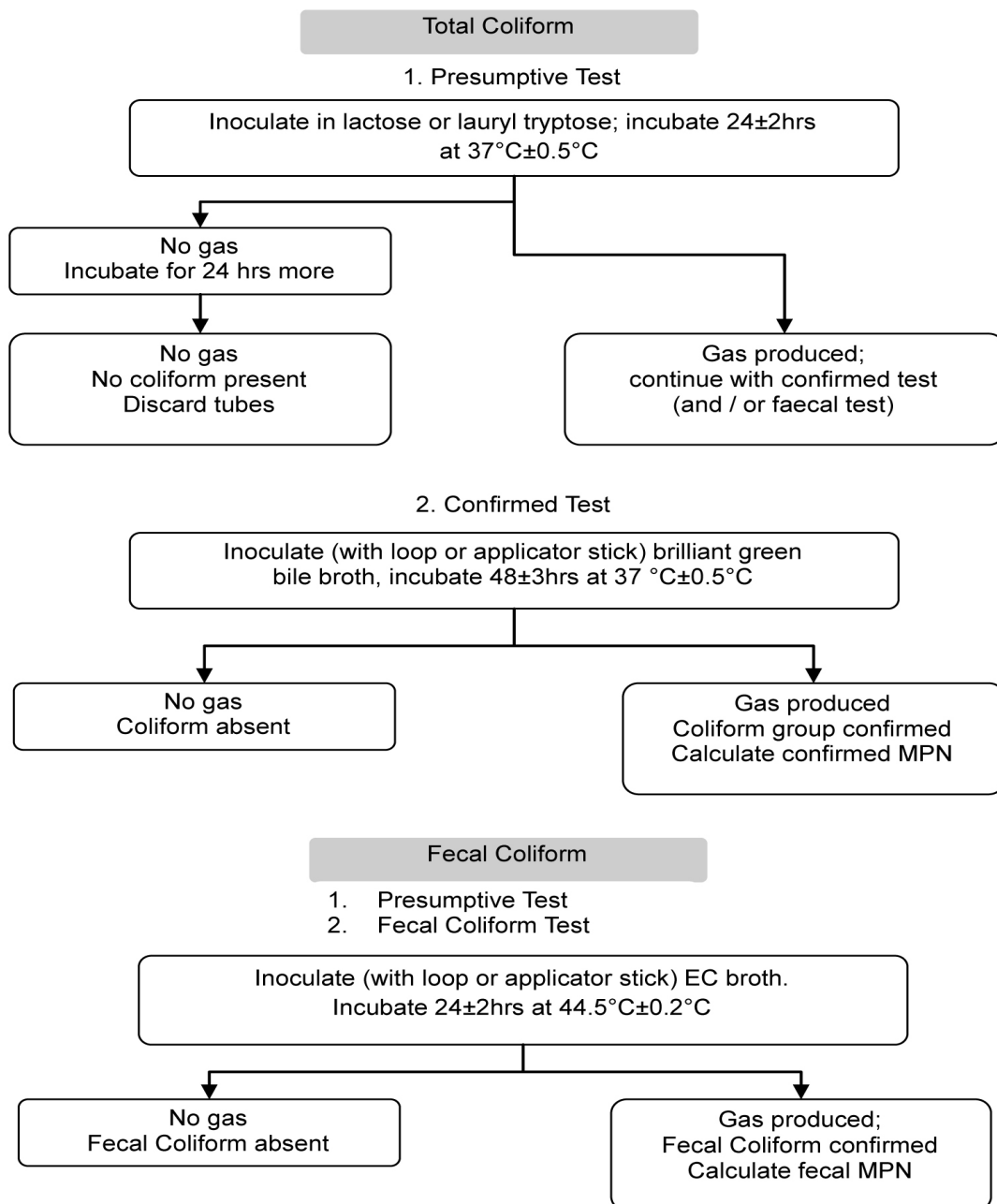
7.6.2 Testing Method

7.6.2.1 Multiple Tube Fermentation Method

7.6.2.1.1 Total Coliform Test

The oldest test is the multiple tube fermentation test. In this test, three sequential steps are performed as presumptive, confirmed and completed tests. A moderately selective Lactose broth medium (Lactose Lauryl Tryptose Broth), containing a Durham tube is first used in the presumptive test to encourage the recovery and growth of potentially stressed coliforms in the sample.

If harsher selective conditions are used, a deceptively low count may result. A tube containing both growth and gas is recorded as a positive result. It is possible for non-coliforms (*Clostridium* or *Bacillus*) to cause false positives in this medium, and therefore, all positive tubes are then inoculated into a more selective medium (Brilliant Green Lactose Broth or EC Broth) to begin the confirmed test. The confirmed test medium effectively eliminates all organisms except true coliforms or faecal coliforms, depending on the medium and incubation conditions. If a positive result is recorded in these tubes, the completed test is begun by first streaking a loopful of the highest dilution tube, which gave a positive result onto highly selective Eosin Methylene Blue (EMB) agar. After incubation, subsequent colonies are evaluated for typical coliform reactions. A schematic illustration is presented in Figure 7.2.



Source: EPA, 2008

Figure 7.2 The Progress of the Multiple tube testing for Coliforms

The sample of the tubes tested either yielding gas or otherwise are shown in Figure 7.3.

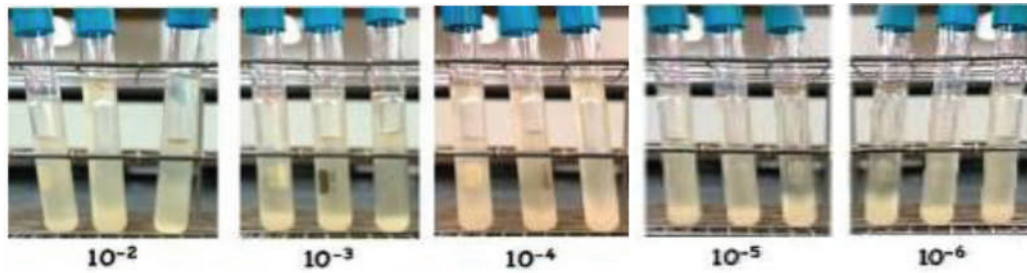


Figure 7.3 The Fermentation as seen from the gas in the Inverted vials inside the tubes

7.6.2.1.2 Faecal Coliform Test

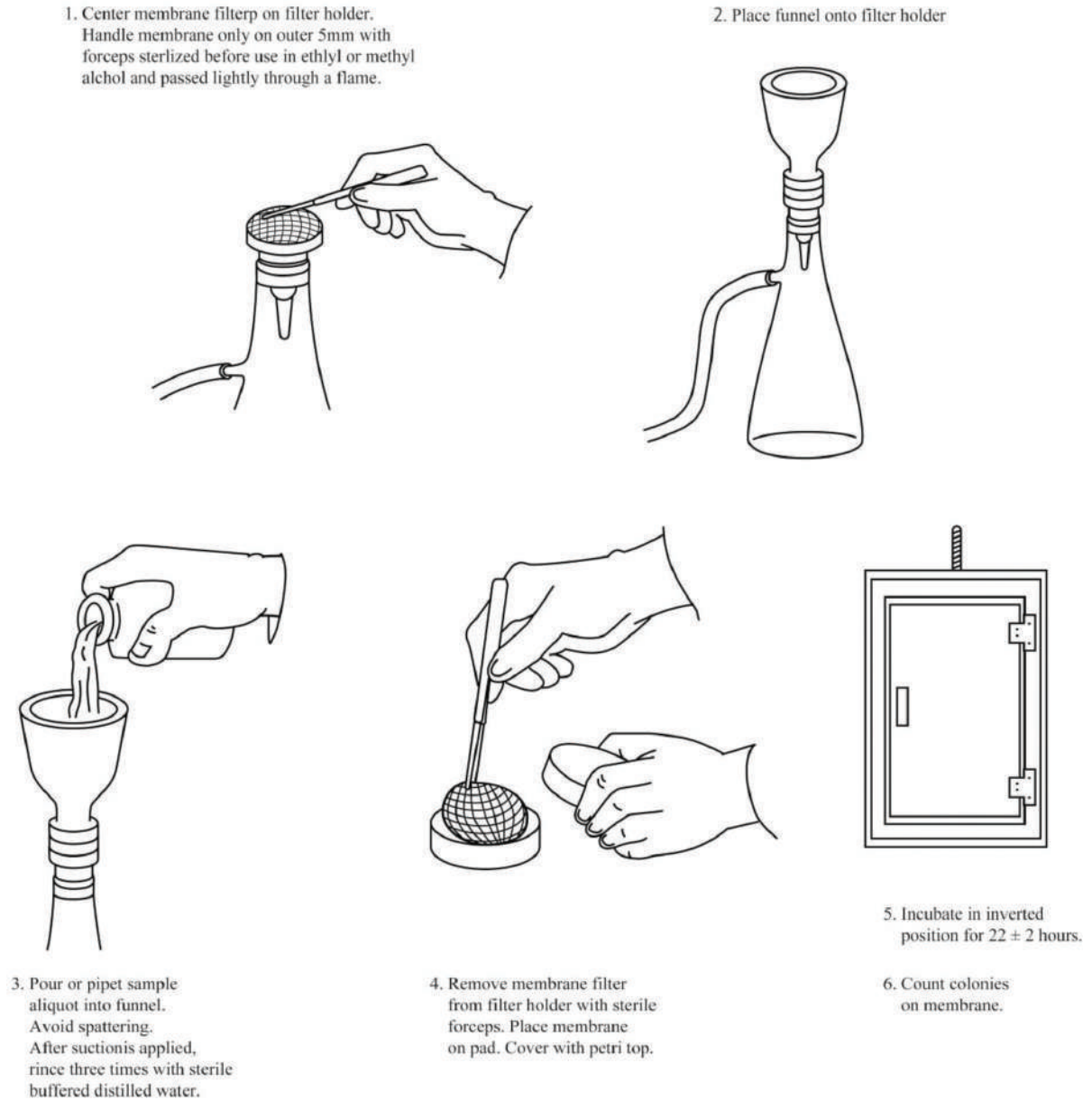
This test indicates the potential presence of pathogenic organisms. After presumptive test, which is the same as for the total coliform test, test the sample with water bath set at $44.5^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$ in EC broth media. A schematic illustration is presented in Figure 7.2. Based on the dilutions used, the number of tubes adopted and the identified number of tubes with gasification, a statistical formulation is made out called the Most Probable Number (MPN) in 100 mL of sample. It should be noted that a confirmed test may require anywhere up to 72 hours.

7.6.2.2 Membrane Filter Test

In this procedure, a given size sample, generally 100 ml, is filtered through a membrane, small-pore filter, which is then incubated in contact with a selective culture agar at 37°C . A coliform bacteria colony will develop at each point on the membrane where a viable coliform will be left on the membrane during filtration. After an incubation period of 24 hours, the number of colonies per plate is counted. They represent the actual number of coliforms that were present in the volume of samples filtered. The procedure is illustrated in Figure 7.4 overleaf. The incubated plates may appear as in Figure 7.5 overleaf. The number of colonies in a dish can be counted using a colony counter, which can be manual or automatic counter or hand held digital type as shown in Figure 7.6.

7.6.2.3 Colilert Test

The Colilert test is a relatively new method and has been accepted by the U.S. EPA for coliform testing. This is a presence/absence test and it does not indicate the extent of contamination. It is reported as having been proven to be just as accurate as the membrane filtration method. In this method, the Colilert reagent contains a formulation of salts, nitrogen, and carbon sources that are specific to total coliform. It contains specific indicator nutrients that create a yellow colour when total coliforms are present and fluorescence when *Escheria Coli* (*E. coli*) is present. The reagent is added to a 100-millilitre water sample in a sterile, non-fluorescent borosilicate glass container. The vessel is capped and shaken vigorously by repeated inversion, to aid in mixing of the reagent. It is incubated at 35°C for 24 hours. After 24 hours, the technician compares the reaction vessels to the colour in a comparator supplied with the test kit. If the inoculated reagent has a yellow colour equal to or greater than the comparator, the presence of total coliform bacteria is confirmed.



Source: EPA, 2008

Figure 7.4 The Progress of the Filter Technique for Coliforms

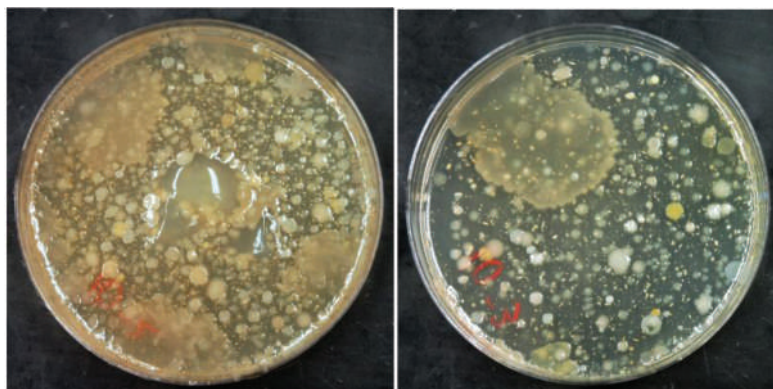


Figure 7.5 Illustrative Appearance of Cultured Plates showing the growth of Colonies



Figure 7-6 Colony Counters: Automatic integrating pen type and Grid plate for manual use

The sequence of Colilert testing is shown in Figure 7.7.

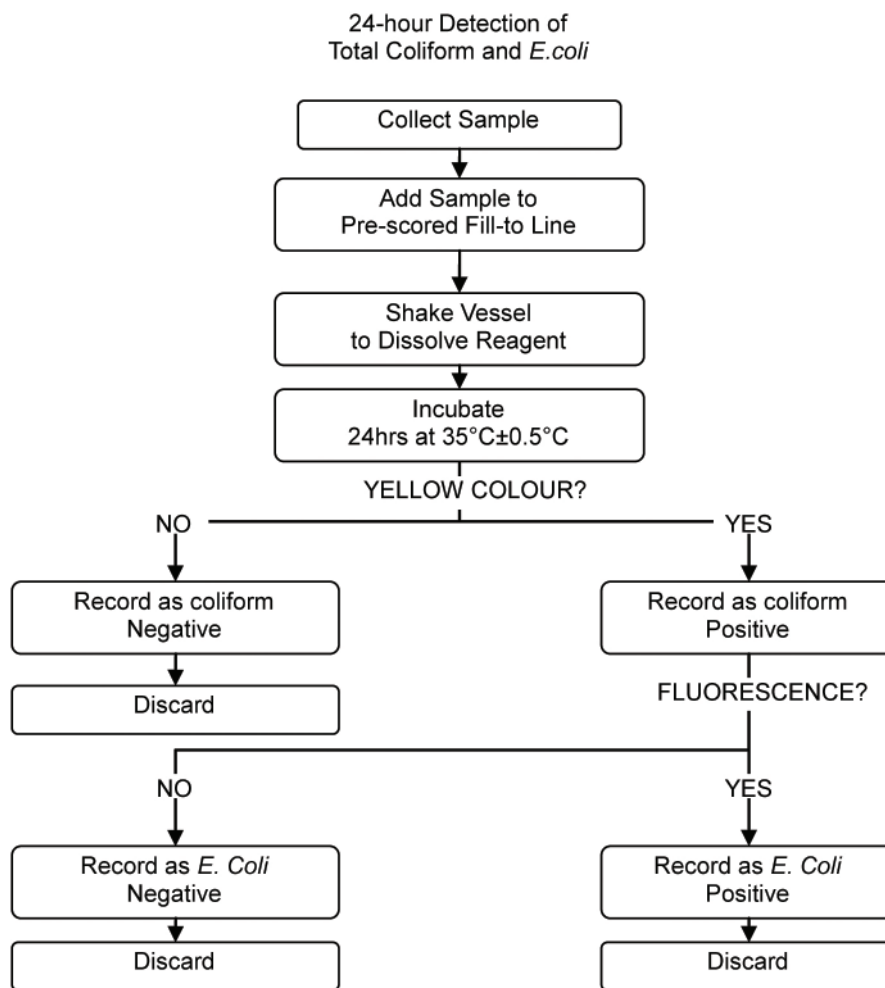


Figure 7.7 The Progress of the Colilert technique for Coliforms

A rapid 7-hour faecal coliform (FC) test for the detection of FC in water has been developed. This membrane filter test utilizes a lightly buffered lactose-based medium (m-7-hour FC medium) combined with a sensitive pH indicator system. The 7-hour FC test was found to be suitable for the examination of surface waters and non-chlorinated sewage and could serve as an emergency test for detection of sewage or faecal contamination of potable water.

It is particularly useful for rapid detection of recreational water quality changes related to storm water runoff, sanitary waste spills or bypasses, and for sewage monitoring for treatment malfunction.

7.6.2.4 Recommended Testing for Treated Sewage

Whatever are the advancements occurring elsewhere in the world, while recommending a specific testing procedure for Indian situation, the following must be considered:

- A. The fact that maintaining a sterile microbiological laboratory in a STP is still a far cry for many ULB once it migrates outside the metropolitan cities.
- B. The testing skills are speciality oriented and employing microbiologists full time by these ULB will be impractical especially as these microbiologists will not have promotional opportunities as compared to their employment in other R&D institutions.
- C. These tests are not mandatory testing on a daily basis and can be carried out once a fortnight by the staff of the metropolitan laboratories by collecting and preserving the samples in suitable iceboxes for transporting overnight to their laboratories.

Considering all the above points, the multiple tube method of MPN/100 ml should be continued for some more time for total coliforms and faecal coliforms. The tests can be cross verified by plate count if felt necessary. The sampling procedures and analytical procedures shall be according to the Standard Methods (or) as in force by the concerned Pollution Control Board (PCB), as the case may be.

7.7 QUICK AND APPROXIMATE MEASUREMENT METHODS

7.7.1 Test Paper Method

Tests which can be done with this method are pH and sulphide. These are mainly qualitative and are of only incidental value.

7.7.2 Detector Tube Method (Transparency Tube, BOD Tube (UK))

Refer to Section 4.7.4.1 "Process Control", Figure 4.13.

7.7.3 Cylinder Test

(Including simplified colorimetric determination and simplified absorption spectrophotometry)

The colorimetric tests depend on the two hypotheses namely, the Beer's law and Lambert's law, which in simple terms correlate the concentration of a solute in a solvent to the absorbance of monochromatic light when passed through the solution and the path length through which such a passage has taken place. This is the principle behind estimations using a calorimeter or spectrophotometer. There is also a possibility that these can be estimated by using Nessler tubes in the laboratory without depending on these electrically operated meters. Standard solutions are prepared with known concentrations of solutes and stored in tightly corked Nessler tubes of 50 ml.

When a new sample is to be tested, it is put through the sample preparation and thereafter is compared by looking down through a Nessler tube filled with the prepared sample and comparing with already prepared reference tubes. Thus, an idea of the concentration is obtained. This test is very useful on a day to day basis.

The presence of DO in aeration tank requires the elaborate procedure of using a meter operated electronically and keeping the probes well cleaned at all times. This is not always possible. Moreover, typical plant control requires an answer to the question of whether residual DO is present or absent in the secondary clarifier overflow. This can be easily carried out in the field as follows:

1. Take a 10 ml well washed test tube.
2. Hold it gently against the weir overflow sideways.
3. Allow the sewage to fill the tube and overflow for a few minutes.
4. Gently take the tube and pour out about 2 ml.
5. Add few drops of manganous sulphate solution.
6. Add a few drops of potassium iodide solution.
7. Close the top with the thumb and invert a few times.
8. Allow to stand for a few minutes.
9. If there is a yellow precipitate, DO is present.
10. If there is a white precipitate, there is no DO.

7.8 DATA ANALYSIS (ACCURACY AND PRECISION)

All analyses carried out should be properly recorded. Routine daily analysis, periodic analysis and special analysis should be recorded separately. Copies of these reports should be sent to the Plant Superintendent immediately after the analysis is done with explanatory notes to indicate any unsatisfactory conditions or abnormalities.

The Plant Superintendent should study the reports and direct the operating staff for proper corrective measures in the operation schedule. Such measures taken should be reported to the laboratory scientists who should check the efficiency of corrective measures by re-sampling and analysis. Corrective measures followed by sampling and analysis should be repeated till such time as satisfactory results are obtained.

Data collected over a period of time on various parameters of plant control should be analysed and represented on charts and graphs and displayed in the laboratory for ready reference by the supervisory staff and visitors. These should be included in the weekly, monthly and annual reports of the laboratory.

7.8.1 Processing Water Quality Test Data

The analysis of results must be done judiciously. One should not jump to conclusions. Logic of the results should be first verified instead of blindly taking it for granted. Some of the fundamentals to be followed are listed overleaf:

1. The outlet BOD of any unit cannot be higher than the outlet BOD of the upstream unit
2. The ammonia of final treated sewage cannot be the same or higher than that in raw sewage
3. The ortho P of final treated sewage cannot be the same or higher than that in raw sewage
4. The SS of final treated sewage cannot be higher than that of raw sewage
5. Rotifers, Crustaceans, Protozoans cannot be absent if BOD reduction is at least 75 %
6. Follow the final BOD and SS on a graph, which will show any sudden lapses.
7. At regular intervals refer the sample confidentially to a recognised laboratory to keep a check on the results of 2 to 5 % samples.
8. Whenever visiting a STP, verify DO qualitatively by the Winkler method
9. Whenever in the STP, take time to see through the oil immersion microscope for live micro-organisms
10. It is most important that analysts alone are not held responsible for plant failures

7.8.2 Accuracy of Measured Values

1. If ammonia is reported as nitrified, bicarbonate alkalinity must be reduced 7 times.
2. If this is not the case, carry out a repeat test before deriving conclusions.
3. Make an "audit" for BOD removed versus kWh spent on aeration system.
4. Hypothetical ionic equilibrium may not tally in all the lab results.
5. This may be a genuine case as precise chloride estimation is very difficult.
6. In such case, it is better to adjust the chloride value to bring the ionic equilibrium.
7. The COD reduction in treated sewage Vs. raw sewage cannot be less than BOD reduction.
8. If this is the case, the results are suspect.

With the availability of personal computers and software at reasonable cost, the advantages of electronic data processing for storage, retrieval and processing of laboratory test results are obvious. To start with, the analysis results may be entered from the daily records into the computer. A simple programme can be written for retrieval and presentation of data relating to any particular parameter. This can be in the form of display of data for a fixed period or weekly or monthly averages or the results of analysis carried out on samples collected at a particular time of the day for the period to be studied etc. A slightly more detailed programming can be prepared for the computer to go through the results of specified parameters entered daily and display or print out any figures, which exceed a present value. This can be immediately passed onto the treatment plant staff for investigation and rectification. The computer can also be programmed to display and print out graphs showing the variation in any specified parameters over a period of time.

Analytical instruments are also available for carrying out tests automatically on a large number of samples simultaneously and electronically feed the data directly into the computer using a data logger module.

7.9 FREQUENCY MANAGEMENT

Laboratory results must stop at the plant-in-charge level and should not go all the way to the official in charge of the total O&M of the sewerage infrastructure in the head office on a daily basis. This will only set in motion a parallel organization in detecting & reporting matters and replying to higher authority and the staff will lose interest. On the other hand, a fortnightly concise physical reporting, illustrating any specific changes in raw sewage or treated sewage and suggesting ways and means and asking for specific funds / assistance alone should be sent to the official in charge of the total O&M of the sewerage infrastructure in the head office.

7.10 PLANNING OF LABORATORY FACILITIES

This is explained in detail in Part A manual section 5.5.5 and in Appendix A.5.3, A.5.4 and A.5.5.

7.11 UPKEEP OF PLANT LABORATORY

A well designed and adequately equipped laboratory under a competent analyst is essential in all STP. Very small STP and WSP need not have their own laboratories if the facilities of a nearby laboratory are available. The results of the laboratory analysis will aid in the characterization of any sewage, pinpoint difficulties in the operation and indicate improvement measures, evaluate the composition of sewage and thus estimate the efficiency of operation and measure the probable pollution effects of the discharge of such sewage on the receiving water bodies.

The analytical data accumulated over a period to time is an important document for safeguarding the STP from allegations of faulty operation. The laboratory should also engage in research and special studies for evolving improvements and innovations in plant operation. The laboratory therefore must form an integral part of the STP.

7.12 DISPOSAL OF LABORATORY WASTES

Any office or other place where a number of people work requires a proper waste disposal system. In the case of a laboratory in a STP, special care has to be taken since the laboratory handles harmful chemicals and the samples themselves are capable for transmitting pathogens.

7.12.1 Solid Waste

Solid waste may include filter residues, used cotton plugs, etc. These should be collected and disposed scientifically in an eco-friendly method approved by the local PCB.

7.12.2 Liquid Wastes

Since the laboratory is attached to a STP, it will be possible in most cases to drain the laboratory wastes to the inlet chamber of the STP, if necessary, by pumping. However, since the laboratory wastes may also contain concentrated acids and alkalis, it may be necessary to provide a small holding tank where the concentrated chemicals will be diluted and neutralized to avoid the possibility of affecting the biological activity of the STP.

7.12.3 Radioactive Wastes

If radioactive materials are suspected to be present in the waste samples, special precautions will have to be taken to protect the laboratory staff. Advice on this aspect may be obtained from the Atomic Energy Department (AED).

7.13 PERSONNEL

Laboratories of large STP should be under the charge of a qualified and experienced analyst supported by junior technical staff having background in the field of chemistry, biology and bacteriology. The analyst should assimilate the details for functioning of the plants by experience and acquire the necessary preparedness for receiving further specialized training including performance interpretation and application of advanced techniques, which enable the analyst to participate in the efficient operation of the STP. However, this does not mean that the qualified and experienced analyst who has accumulated a lot of experience over the years will replace the Engineer-in-charge of the plant but will instead progress in his own hierarchy and become a Chief Chemist. Cross migration between these two disciplines should not be entertained in the hierarchy.

7.14 SUMMARY

Water quality analysis in STPs provides useful parameters for judging appropriateness of process control and quality of the treated sewage. Water quality analysts should have thorough understanding of analysis items and frequencies prescribed for the STPs and provide the results of analysis to the plant-in-charge.