Jyothi Engineering College
Reaccredited with NAAC (Grade A) and NBA Programmes*
Approved by AICTE and Affiliated to APJ Abdul Kalam Technological University
A CENTRE OF EXCELLENCE IN SCIENCE AND TECHNOLOGY BY THE CATHOLIC ARCHDIOCESE OF TRICHUR
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*NBA reaccredited BTech Programmes in Civil Engineering, Computer Science and Engineering, Electronics and Communication Engineering, Electrical and Electronics Engineering and Mechanical Engineering valid till 2025

CEL411 ENVIRONMENTAL ENGINEERING LABORATORY MANUAL

(Student Copy)

CREATING TECHNOLOGY
LEADERS OF TOMORROW

ESTD 2002

DEPARTMENT OF CIVIL ENGINEERING

JYOTHI ENGINEERING COLLEGE, CHERUTHURTHY

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

COLLEGE VISION

Creating eminent and ethical leaders through quality professional education with emphasis on holistic excellence.

COLLEGE MISSION

- To emerge as an institution par excellence of global standards by imparting quality engineering and other professional programmes with state-of- the-art facilities.
- To equip the students with appropriate skills for a meaningful career in the global scenario.
- To inculcate ethical values among students and ignite their passion for holistic excellence through social initiatives.
- To participate in the development of society through technology incubation, entrepreneurship and industry interaction.

DEPARTMENT VISION

To emerge as a Centre of Excellence in Civil Engineering through quality professional education and to create eminent leaders with values committed to the profession and society.

DEPARTMENT MISSION

1)To impart state of the art education and to provide industry exposure to students
2)To create civil engineers who successfully adapt and innovate solutions for the built environment
3)To inspire and transform the students to hard core professionals and academicians with ethical values.

PROGRAMME EDUCATIONAL OBJECTIVES

The program educational objectives of B Tech in Civil Engineering are

1. Graduates will have concrete knowledge in the application of necessary mathematical tools, scientific theories and modern developments in civil engineering.
2. Graduates will understand the societal needs and will be committed in developing optimal solutions.
3. Graduates will pursue higher education, research or entrepreneurship apart from being employable.
4. Graduates will be competent to face challenges in civil engineering through lifelong learning process and will have high ethical values, honesty and a sense of responsibility.

PROGRAMME OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

1. Acquire the ability to plan, furnish and or analyze designs and implement infrastructure related systems, produce related documents, drawings and reports and quantity estimates related to civil engineering domains
2. Apply theoretical concepts and technical skills in developing appropriate sustainable solutions through self-learning, research and team work for technical problems requiring civil engineering interventions towards better quality of life.
3. Utilize the acquired knowledge in environmental engineering and transportation engineering to conceptualize, analyze and evaluate specific problems in for water quality management, sanitation, pavement design, traffic engineering and transportation planning to develop appropriate solutions

Course Objectives

Sl .No	**Course Objectives**
CEL.411.1	To familiarize students with typical physical, chemical and bacteriological water quality parameters and their relevant standards to interpret the results
CEL.411.2	To analyze the prominent physical and chemical and bacteriological water quality parameters and to interpret the test result
CEL.411.3	To study the mechanism of water treatment in conventional water treatment plant and to find the optimum dose of coagulants
CEL.411.4	To acquire knowledge in domestic water quality issues of Kerala state so as to guide the people for remediation of such issues

Course outcomes

Sl .No	Course Outcomes
CEL411.1	Become able to analyze physical, chemical and bacteriological water quality parameters and interpret the results with respect to standards
CEL411.2	Become able to fix the dosage of coagulants, lime and bleaching powder in a water treatment plant and arrive at the quantity of coagulant and lime and bleaching powder required in a water treatment plant
CEL411.3	Able to deal with domestic water pollution problems and guide people for remedies for the same

Mapping Experiments and Course Outcomes

Sl no	Name of Experiment	Course Outcomes
1	Determination of Turbidity	1,3
2	Determination of PH Value	1,3
3	Total dissolved solids by Conductivity measurement	1,3
4	Determination of Total solids ,Total suspended solids , Total dissolved solids ,Total Volatile solids	1,3
5	Determination of Sulphate	1,3
6	Jar test for the determination of Optimum coagulant dosage	2
7	Determination of Alkalinity	1,3
8	Determination of Chlorides	1,3
9	Determination of Total hardness in water	1,3
10	Determination of available chlorine in Bleaching power	2
11	Determination of acidity	1,3
12	Determination of dissolved Oxygen	1,3

13	Determination of Bio chemical Oxygen Demand (BOD	1,3
14	Determination of chemical oxygen demand	1,3
15	Breakpoint chlorination	2,3
16	Determination of Iron in water	1,3
17	Determination of phosphate in water	1,3
18	Determination of nitrate in drinking water	1,3
19	Determination of Fluoride in water	1,3
20	Determination of two heavy metal concentrations	1,3
21	Test for coliform group in water (MPN)	1,3

CO-PO Mapping

PO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CEL411.1	3	2	1	1	-	2	3	1	-	1	-	1
CEL411.2	3	3	2	2	-	3	3	1	-	-	-	1
CEL411.3	3	3	3	3	-	3	3	2	-	2	-	1

CO-PSO Mapping

PSO CO	PSO1	PSO2	PSO3
CEL411.1	2	1	2
CEL411.2	2	1	1
CEL411.3	1	1	2

CEL411	ENVIRONMENTAL ENGG LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: This lab provides the knowledge on tests used to analyse the physio-chemical and bacteriological properties of water and explains the various method followed in the test along with its suitability as a drinking water.

Prerequisite: CET 304 Environmental Engineering

Course Outcomes: After the completion of the course, the student will be able to:

Course outcome	Description
CO1	Analyse various physico-chemical and biological parameters of water
CO2	Compare the quality of water with drinking water standards and recommend its suitability for drinking purposes

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	-	3	3	-	-	-	-	3
CO2	3	3	3	1	-	3	3	-	-	-	-	3

Assessment Pattern:

Mark distribution

Total marks	CIE	ESE	ESE Duration
150	75	75	3 Hrs

Continuous Internal Evaluation (CIE) Pattern:

Attendance	:15 marks
Continuous Assessment	:30 marks
Internal Test	:30 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of mark

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipment and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 Marks
(e) Record	: 5 Marks

Instructions:

- Any 12 of the 18 experiments included in the list of experiments need to be performed mandatorily.
- Virtual Lab facility cannot be used to substitute the conduct of these mandatory experiments.
- Periodic maintenance and calibration of various testing instruments needs to be made.
- Practical examination to be conducted covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Syllabus

1. Determination of pH, Electrical Conductivity and Turbidity*
2. Determination of TS, TDS and TSS, TVS *
3. Determination of Alkalinity and Acidity *
4. Determination of Hardness *
5. Determination of Chlorides
6. Determination of Total Iron
7. Determination of Biochemical Oxygen Demand*
8. Determination of Chemical Oxygen Demand*
9. Optimum Coagulant dosage*
10. Break point Chlorination *
11. Determination of Available Chlorine in a sample of bleaching powder
12. Determination of Sulphates
13. Determination of Fluoride
14. Determination of Dissolved Oxygen*
15. Determination of nitrates
16. Determination of phosphates
17. Determination of any two Heavy Metal concentration

18. Total coliforms *

Note: * mandatory

References

1. Standard Methods for the Examination of Water and Wastewater, 23rd edition, American Public Health Association, American Water Works Association, Water Environment Federation, 2017.
2. Water Supply Engineering, 33rd edition, Santhosh Kumar Garg, Khanna publishers.
3. Sewage Disposal and Air Pollution Engineering, 39th edition, Santhosh Kumar Garg, Khanna publishers.
4. IS: 10500:2012 Drinking Water - Specification, Second revision, Bureau of Indian Standards, 2012.

LIST OF CONTENTS

CHAPTER 1-Water

Water is essential for the existence of all living forms, certain systems of medical treatment suggests water as medicine. Studies have shown that the use of pure water can reduce the chances of cancer in the intestine, urinary bladder and also breast cancer in women.

While human life is directly related to water as stated above, indirectly also we have to depend on water for almost everything in life. Water is essential for the production of food materials we need, to maintain the equilibrium of nature, for existence of industry, for climate control, and for the maintenance of hygiene etc. Water is also one of the major means of transport, travel and tourism. Therefore, it is not an exaggeration that there is nothing is possible in life without sufficient water.

With increase in population and development in all spheres of life scarcity and pollution of water sources increase. The rain we get each year is earth's basic source of pure water. Earth gets approximately 5 to 6 lakhs cubic kilometers rain water each year. But as the world population is increasing by about 85 million yearly, it is a fact that per head supply of pure water is decreasing fast.

Therefore, now providing pure water to the people is a very tough job for almost all the countries in the world. In order to combat the situation every effort is devoted by various governments and as a result a branch of science known as water technology has emerged and its area of operation is rapidly expanding day by day. Research and development, continuous monitoring, social innovation are rampant in water sector and employment opportunities for water professionals are also increasing day by day .It is also prudent that at present enormous number of people earn their livelihood by doing research ,construction, maintenance , distribution etc in the water sector and this number is increasing day by day.

As an outcome of the above mentioned factors water testing laboratories are also increasing day by day. The initiatives taken by the government of India for establishing water testing laboratories all over the country and the training provided to the ordinary people through Rajiv Gandhi National drinking Mission are remarkable and its outcome is invariably conducive

1.1 Meaning of pure water

From the above reading the necessity of providing pure water to the people is confirmed beyond any manner of doubt .With that mindset, water quality standards have been fixed by various organizations and is being modified periodically. Necessary legislations and guidelines have been enacted in all the countries and the sole purpose is to provide pure water to the people

A simple and easy definition of pure water is given bellow:

1. Water should be clear
2. Should be without color and odor.
3. Should be Free from pathogenic micro-organisms
4. Should be Free from dangerous chemicals.
5. Should contain the required quantity of minerals and salts.
6. Should be non-corrosive.
7. Should not produce color on contact or should not be staining.

1.2 Significance of water quality parameters and water quality standards

Up to now, we have discussed the benefits of water to humans and other life forms. But unscientific and careless handling of drinking can lead to fatal results. Several diseases which can result in death are spread through water. The reason for contagious diseases like cholera, hepatitis, diarrhea and amoebiasis is due to microbial contamination of water. Certain minerals and chemical compounds reaching the body through water can often be the reason for diseases like fluorosis, blue baby syndrome and keratosis (which is the result of excess arsenic in the body). Also bathing in polluted water can be the reason for several diseases of the eye and skin. As we attain more development pollution of water sources also increase. water quality standards are annexed as annexure 1

CHAPTER 2

General Principles of Physical, Chemical and Microbiological Water Quality Analysis

The water quality parameters like color, taste and odor , turbidity, electrical conductivity, pH value etc. measurable by the 5 senses and certain special instruments, are the physical quality measuring scales. Collectively they are called organoleptic and physical water quality parameters. The importance of these parameters and method followed for analysis are given below

2.1 Turbidity

The material that do not dissolve completely in water like silt , clay floating vegetation ,algae and other carbon compounds are the reason for turbidity . Turbidity while imparting foul taste and odour to water, act as an adhering media for bacteria and virus

Turbidity is detected using the Nephelo turbidity meter. Light passing through water fall on the materials producing turbidity and reflect back. The intensity of the reflected light is measured using a Photo electric detector

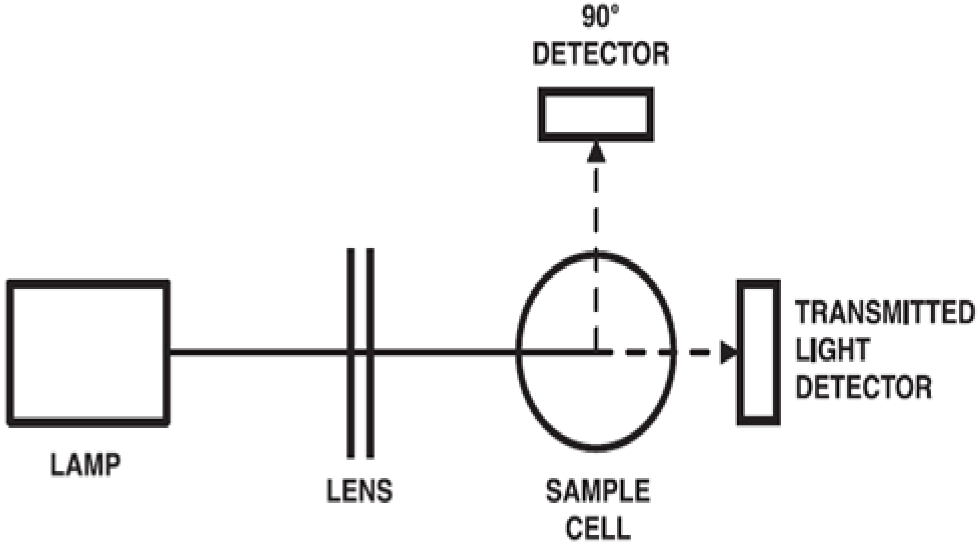


Fig 1 Turbidity Meter

Reflecting light will be more when turbidity is more. The quantity of light reflecting back is calibrated according to Nephelo turbidity unit (NTU), the unit used to measure turbidity.

One unit of turbidity is the turbidity produced when 1 mg. Silica (SiO2) is dissolved in 1 liter of distilled water.

2.2 pH Value (Potence Hydrogen)

Of the various water quality standards, pH value is a very important one. Other than water, the pH value of blood, stool, urine and other such fluids are also very important. pH value shows the presence or activity level of Hydrogen ions in water. The molecular formula of water is H2O. Water does not exist fully in the form of H2O. A small proportion dissociates and exists in the form of H+ (Hydrogen ion) and OH-(Hydroxyl ion) and the H^+ is having a significant effect on quality of water .The direct measurement of H^+ ions is often very difficult and hence Sri; S.P.L.Sorenson, a chemist in the Carlsberg laboratory in Denmark, put forward the concept of pH in 1909

$$\mathbf{pH= -log10\ [H]^{+}}$$

Even though Sorenson has given the name PH, later ISO modified it to pH.In neutral water the measure of H+ ions will be 10^{-7}moles / liter. When we say 1 mole solution of an element, it is the number of grams of that element equivalent to its molecular weight, dissolved in 1 liter of water. Since the molecular weight of hydrogen is 1.008gm, presences of H+ ion in neutral water will be10^{-7} x 1.008 gm/liter. Likewise, since the molecular weight of OH^- ion is 17. 008, (16 of oxygen and 1.008 of hydrogen), its presence in neutral water will be 10^{-7}x 17.008gm/liter. According to the theory of Ionization at a temperature of approximately 25^0C product of H^+ ions (moles) in 1 liter of water by OH^- ions (moles) in 1 liter of water, we always get the result 10^{-14}. This is called the ion product of water. So when the measure of H^+ ions is 10^{-7}, the pH value is – $\log10^{-7}$, is 7. If the measure of H^+ions is 10^{-5}, measure of OH^- ions will be 10^{-9} the pH value of that water sample will be 5.

When pH value is 7, it is the point where acidity and alkalinity are equal. If pH value is less than 7, acidic condition prevails and if it is more than 7, alkaline condition prevails .See figure 3 below. The pH is influenced by interaction with the atmosphere, presence of microorganisms, change in temperature and climate etc. Below pH 4, we get sour taste and above 8.5, it is alkaline taste.

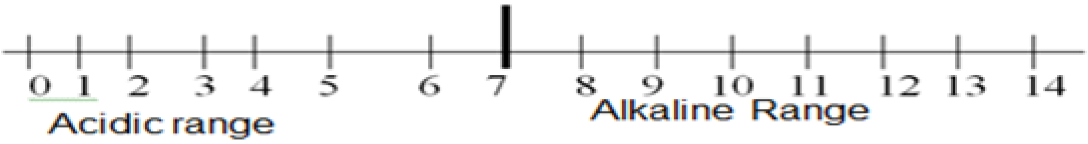


Fig 2 pH scale

The instrument used to measure pH is the pH meter. The glass electrode of the pH meter has the ability to attract H+ ions. Its bottom is very thin and finely finished. H+ ions create potential in pH electrode. Another potential originate from the reference electrode and electrolyte. The pH meter amplify the difference between the two potentials and convert it in to digital display to read. If we add quick lime, the pH value of water will increase, while addition of acids will decrease the pH.

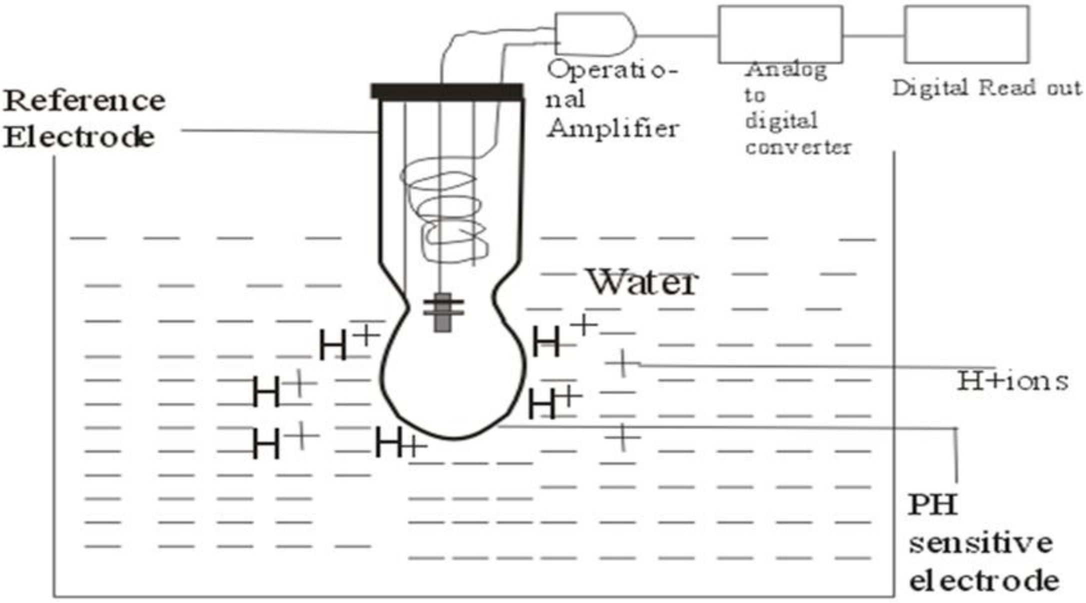


Fig 3 pH meter

2.3 Total dissolved solids by electrical conductivity measurement

Conductivity is the ability of a solution, a metal or a gas - in brief all materials - to pass an electric current. In solutions the current is carried by cations and anions whereas in metals it is carried by electrons.

How well a solution conducts electricity depends on a number of factors:

- Concentration
- Mobility of ions
- Valence of ions
- Temperature

All substances possess some degree of conductivity. In aqueous solutions the level of ionic strength varies from the low conductivity of ultrapure water to the high conductivity of concentrated chemical samples.

Conductivity may be measured by applying an alternating electrical cur-rent (I) to two electrodes immersed in a solution and measuring the resulting voltage (V). During this process, the cations migrate to the negative electrode, the anions to the positive electrode and the solution acts as an electrical conductor

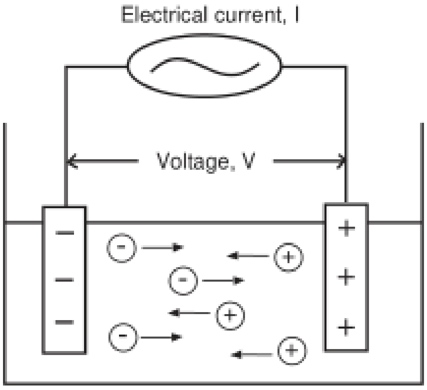


Fig 4 Conductivity Meter

The electrical conductivity of water is its capacity to carry electric charge. The electrical conductivity of water is directly proportional to the quantity of dissolved solids present in the water. Most of the salts exist as ions in water. It is these ions that conduct electricity. Therefore, conductivity can be used as a quick means to detect the quantity of ions dissolved in water. A conductivity meter is used for this purpose. Conductivity can also be used as method for estimating total dissolved solids in water.

This is the measure of the total concentration of ionic species of a sample. Its magnitude is relative to the standard solution used to calibrate the meter. Conductivity readings are converted to TDS readings by multiplication with a known mathematical factor. The factor depends on the reference material used to prepare the standard.

Conductivity is usually measured in micro or milli siemens per centimeter. It can also be measured micromhos /cm or millimhos /cm. Specific conductance is a conductivity measurement made at or corrected to 25° C [3]. This is the standardized method of reporting conductivity. As the temperature of water will affect conductivity readings, reporting conductivity at 25° C allows data to be easily compared[3]. Specific conductance is usually reported in uS/cm at 25° C [6].

2.4 Measurement of chemical water quality parameters

The presence of chemical compounds in water is identified using chemical quality measuring scales. The important among them as per the syllabus are given below

1. Alkalinity

2. Hardness

3. Chloride

4. Iron

5. Manganese

6. Sulphate

7. Sulphide

8. Dissolved oxygen

10) Available chlorine in bleaching powder

11) Residual chlorine in water

Several methods from chemistry are used for analysis of water. Some of the important ones are discussed below.

1. Volumetric analysis

2. Colourimetry

3) Turbidimetry

4) High tech methods

2.4.1 Volumetric analysis

In water quality examinations, volumetric analysis is used extensively. In this method which is also known as titration, a particular chemical present in water is permitted to react with another chemical of known concentration in a predetermined form. When reaction is complete the end point is visualized with the help of an indicator. For example, let us take the reaction between an acid and an alkali. An accurate volume of water, of which acidity is to be determined, is taken and an indicator known as phenolphthalein, which can change color in an alkaline media, is added as indicator. To this mixture alkali (NaOH) is added little by little. The alkali, NaOH, react with the acid in water and when all the acid is consumed by the alkali, the indicator phenolphthalein react with the free alkali and produce a pink colour.After recording the volume of NaOH consumed (V_2), using the basic chemical formula, the quantity of the chemical compound of unknown concentration (acidity in water) is calculated.

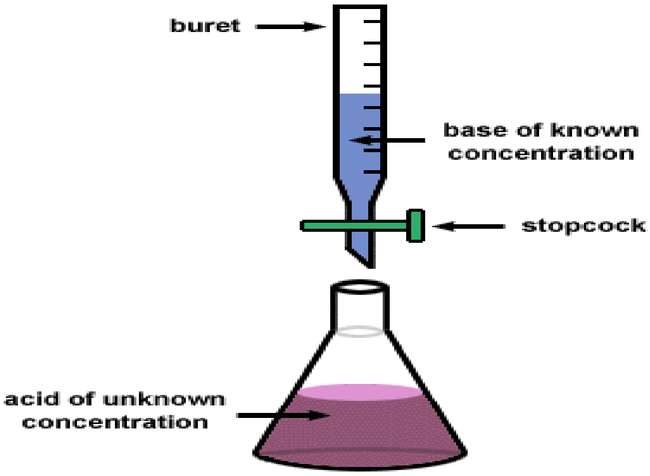


Fig 5 Volumetric analysis between an acid and base

$$V_1N_1=V_2N_2$$

where, V_1= volume of water used for the experiment

N_1= The normality of the chemical compound in water, of which concentration is to be determined.

V_2= The volume of the reagent of known normality , required to react with the chemical compound present in water

N_2= Normality of the reagent.

Using the results of the experiment, the value of N_1 is determined and from that value the quantity of chemical compound in water is calculated. The reagents and indicators used in this method for certain parameters are given below

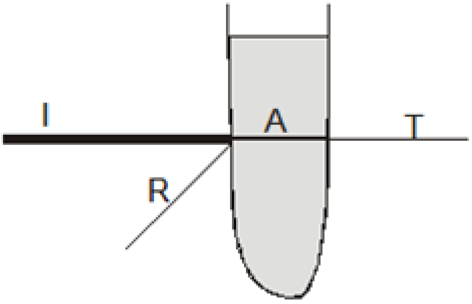
Sl No	**Parameter to be determined**	**Reagent**	**Indicator**	**End point**
1	Acidity	Sodium hydroxide	phenolphthalein	Pink color
2	Alkalinity	Sulphuric acid	Methyl orange	Orange –red
3	Hardness	EDTA buffer	Eriochrome black-T	Blue color
4	Chloride	Silver Nitrate	Potassium chromate	Red deposit

2.4.2 Colourimetry

Colorimetry is a method which is also used extensively to estimate the quantity of certain chemicals present in water. The procedure is based on the principle that when a chemical to be measured, react with certain predetermined chemicals, color is produced and the intensity of that color produced will be proportional the concentration of the chemical to be measured. When the concentration of the said chemical increases, the intensity of color may increase or decrease. For example When 1, 10-Phenanthralene and ammonium acetate are added to water, it reacts with iron present in water and more or less a red color is produced. The intensity of color produced is proportional to the quantity of iron present in water. Similarly when spands is added to water, it reacts with fluoride and color is produced but the intensity of color decreases as the concentration of fluoride increases. In both the above cases the color produced is the basis of measurement and it is carried out by measuring the intensity of the color produced. Once the color is produced by the method stated above the next step is to measure the intensity of color. For which various instruments like colorimeter, visible spectrophotometer. Ultraviolet spectrophotometer, infrared spectrophotometer etc are used depending upon the various wavelength of light used for measurement in the particular type of equipment

2.4.2.1 The basic principle of colorimetry.

When light falls on colored liquid a fraction of the light reflect back, another fraction is absorbed, and the rest is transmitted through. Since the reflecting fraction is only about 3 to 4%, it is usually neglected. See the figure 6 below



I = Incident light
R =Reflected Light
A=Absorbed Light
T=Transmitted Light

Fig 6 The changes occurring when light fall on coloured liquid

If the intensity of colour is more, the fraction of light coming out of the liquid is less and the fraction absorbed is more. Also if the thickness of the liquid is more, the fraction of light coming out of it will be less. When the intensity of colour is measured, using light, the wave length of the light used is important. When light pass through a liquid, its absorbing, transmitting, and reflecting behavior is considerably influenced by wavelength. Wavelength is the distance between two crests in the pathway of light as shown in fig 7 below

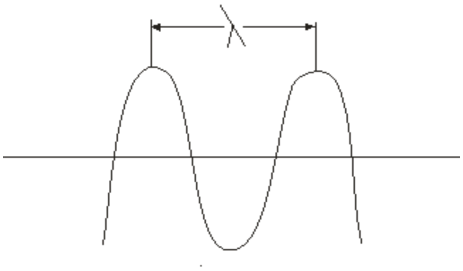


Fig 7 Wavelength

Based on wave length light is classified into X ray, Ultraviolet ray, Infrared ray, microwaves, Radio waves etc. . The great progress achieved by science has made the

artificial preparation of all these light forms possible. It is now become possible to use them for several purposes especially for scientific measurement of many chemicals. Today, instruments using visible rays, UV rays and infra red rays are available to measure water quality standards as well as for other measurements

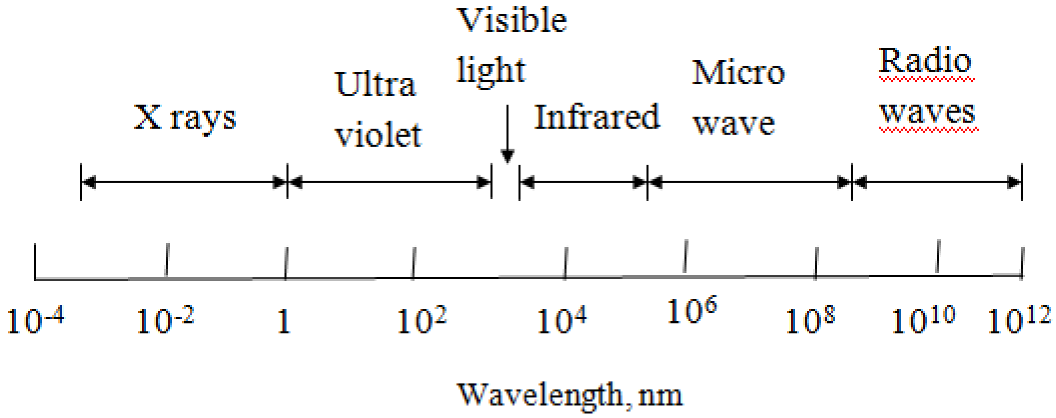


Fig 8 Different rays and its wavelength

The unit of wavelength is Nano meter (1 nm=10 $^{-7}$ cm)

When light ray passes through colored liquid, the ability to absorb light differ according to the wavelength. The wave length at which the maximum light is absorbed is used for examination of samples. In colorimetry, the intensity of light passing through water is usually measured using instruments known as colorimeter and spectrophotometer. But there are two basic principles ie lamberts are beers law which facilitate the colorimetric measurement possible

2.4.2.2 Lamberts and Beers law

We have seen that in colorimetry, for quantitative determination of chemical compounds, intensity of color is to be measured. But in this method there are two rules relating the thickness of the vessel containing the liquid which measure the intensity of light and the intensity of color. Only when the two rules invented by Lambert and Beer are obeyed, the quantitative determination of chemical compounds using colorimetry is accurate. Therefore in the study of colorimetry, the knowledge of this rule is very essential. According to Lamberts law, when monochromatic light pass through a medium, the intensity of transmitted light is inversely proportional to the thickness of the medium.

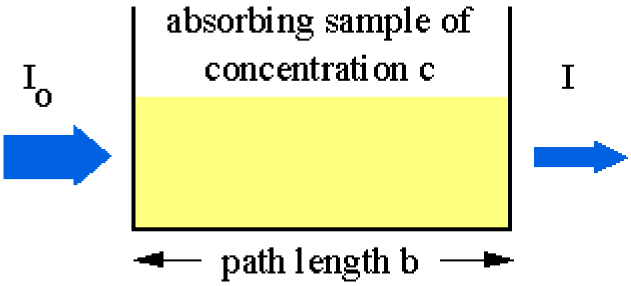


Fig 9 lamberts and beers law

That is, $T=I/I_0=10^{-a_1 e}$

Where, T=Transmittance

I_0= The intensity of light entering the medium

I = The intensity of transmitted light

a_1 = Constant of the medium

e = The thickness of the medium absorbing the light

Beer's law

According to this rule, the intensity of a beam of light passing through a medium which absorb light, is inversely proportional to the color intensity of that medium.

That is, $T= I/IO = 10^{-a2C}$

Where, a_2 = the constant of a particular medium.

C= The color concentration of the medium

2.4.2.3 Colorimeter and spectrophotometer

Colorimeter and spectrophotometers are instruments used to measure the intensity of light by using lamberts are beers law . colorimeter is comparatively less sophisticated compared to a spectrophotometer and hence less costly and less accurate .Colorimeter works only in the visible range of light ,there are spectrophotometers which can work in the visible , ultraviolet and infra red range. The working principle of colorimeter and spectrophotometer commonly used in water analysis are explained here . The main parts of these instruments are illustrated in Fig-10 and Fig-

11.The main difference between colorimeter and spectrophotometer is in the quality of the arrangement for producing monochromatic light. When colorimeter uses a colour filter for this, an expensive diffraction grating is used in spectrophotometer. Therefore when more examination and accuracy is needed spectrophotometer is acceptable. If the wave length to be used falls in the visible range, a visible spectrophotometer, and if it is in the UV range an ultraviolet spectrophotometer is used. To find out the presence of iron, manganese, fluoride, phosphate etc. a visible spectrophotometer, and for lignin, tannin, nitrate etc.an ultraviolet spectrophotometer is used. The following are the common parts of these instruments

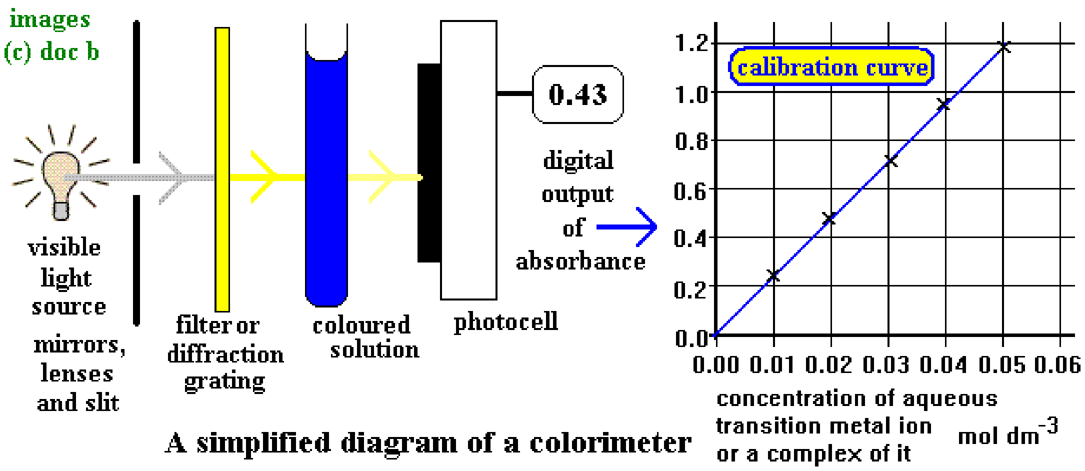


Fig 10 colorimeter and calibration graph

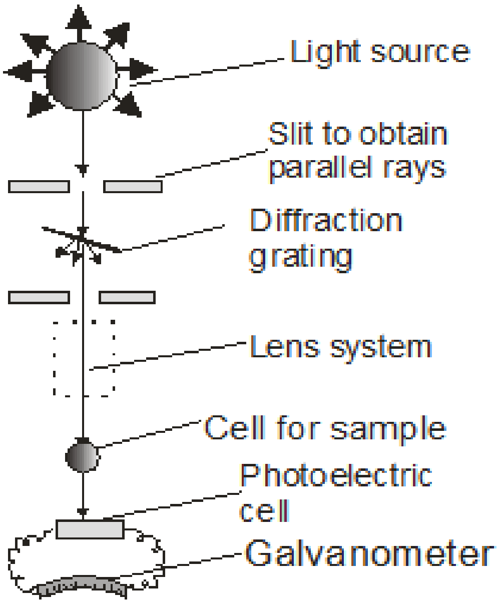


Fig11 Schematic diagram of a spectrophotometer

Light originate from the energy source. The light is converted to single wavelength (polarized light) in the energy spreader. This light is passed through the sample. After absorption, the intensity of remaining light is measured in the energy detector. From comparatively less expensive colorimeters to very expensive and very complex spectrophotometers work on this principle.

2.4.2.4 Method of working

The chemicals to be added to detect the presence of each of the chemical compounds in water is already found out through experiments and observations. Before using for this purpose, the instruments have to be standardized. Different concentrations of solutions of the sample to be identified are made in distilled water and the predetermined chemical is added in the prescribed measurement and the transmittance or absorbance of colour produced is measured and a graph is plotted. Suppose the instrument is to be standardized to determine the concentration of iron. To water containing different concentrations of iron (0.2, 0.4, 0.6, 0.8 mg /liter) 1, 10 phenanthroline and ammonium acetate are added in the quantity determined. The transmittance or absorbance of each sample is measured in the instrument. A graph is plotted as given in to complete the standardization. To find out the concentration of a particular chemical, colour is produced as per given procedure

of particular chemical in the sample of water can easily be found out from the standard graph and its transmittance or absorbance is measured in the instrument. The concentration

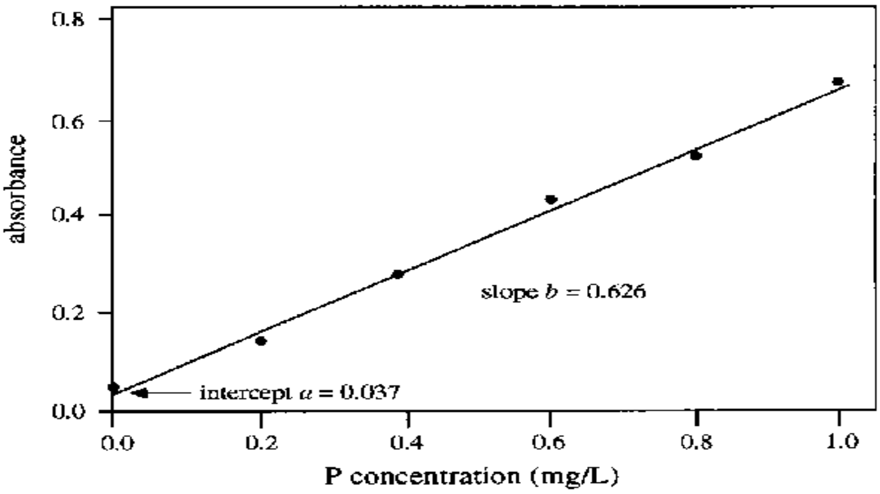


Fig 12 Sample of a standard curve for a spectrophotometer

Table below shows the various chemicals and wavelength to be used for estimating the presence of Iron, fluoride and Nitrate

Sl No	**Chemical to be determined**	**Chemical added**	**Color**	**Wave length nm**
1	Iron	1.10 Phenanthroline	Light brown	510
2	Fluoride	Spadns reagent	Color reduces	570
3	Nitrate	1N hydrochloric acid	Color not detectable	220@275

2.5 Biochemical oxygen demand (BOD)

BOD is the quantity of oxygen required to convert the organic matter in the water , to carbon dioxide and water by oxidation. When BOD increases, it means increase in water pollution level. To calculate BOD, the dissolved oxygen is water is first assessed. Next the sample is kept at 20^{0c} in a BOD incubator for 5 days and the DO is again determined. The difference between these two values gives BOD .In case the BOD values are high it may be required to dilute the sample. Care should also be taken to see that the required

microorganisms are present in the sample and also the nutrients required for the growth of microorganism. The main limitation of this experiment is the lengthy time requirement but it gives an idea about the efficiency of microorganisms in purifying the waste water under consideration

2.6 Chemical oxygen demand

COD is the quantity of oxygen required to oxidize the organic matter in water using chemical compounds. First the organic matter is oxidized using sulphuric acid and potassium dichromate. The quantity of dichromate remaining is calculated using solution of ferrous ammonium sulphate by volumetric method. The quantity of oxygen required can be calculated from this. When oxidation is done using chemicals, majority of organic matter gets oxidized. But bacteria cannot utilize that much organic matter. Therefore generally, the value of COD is more than the value of

BOD. Simple methods for the determination of COD are available. Using this we can have the results within about three hours. But COD is not suitable to find out the activity level of bacteria.

2.7 Turbidimetry

Turbidimetry is another method for analysis of water quality parameter. In which turbidity is formed by reaction of a pre-determined chemical with the mineral to be measured .The method is based on the concept that the turbidity formed is proportional to the quantity of chemical present .The instrument is to be standardized with different quantity of known mineral reacting with standard chemical and by measurement of turbidity and plotting a graph between turbidity and the chemical present.

For estimation of sulphate turbidimetry is used in which barium chloride is added to the water containing sulfate. Barium sulphate is formed and that causes turbidity in water . Turbidity formed is proportional to the quantity of sulfate present and that can be measured from the standard graph prepared earlier

2.8 High tech equipment for water analysis

Along with increase in water pollution analysis of other water quality parameters like heavy metal, pesticides, atomic emissions etc are required and for which high tech equipments as listed below are being used by some laboratories. All those equipments are very costly and sophiscated

1) Atomic Absorption Spectrophotometer (AAS)

2) Gas chromatograph (GC)

3) Inductively coupled plasma spectrophotometer (ICPS),

4) Higher performance liquid chromatograph (HPLC),

5) Ion chromatograph (IC),

6) Infrared spectrophotometer

Detailed study of all the equipments are not in our scope but precise description about AAS and GC are given. This instrument is mainly used for the examination of heavy metals which has the possibility of dissolving in water. An atomizer-burner, one prism, a slit through which only radiations of a particular wave length pass through, a phototube to measure the intensity of radiation using a photocell and amplifier. these are the main parts of an AAS

The water containing the metal to be determined is ejected under control in to the flame. Water is converted to steam and the inorganic salts are either atomized or converted to chemical complexes. When heat further increases, the metals evaporate and their atoms acquire high energy. The radiations produced under this condition are passed through a prism to separate different wavelengths and the particular wavelength needed for examination is isolated using the slit. This radiation is then measured in the phototube. From the intensity of this radiation, the presence of the metal is quantitatively determined.

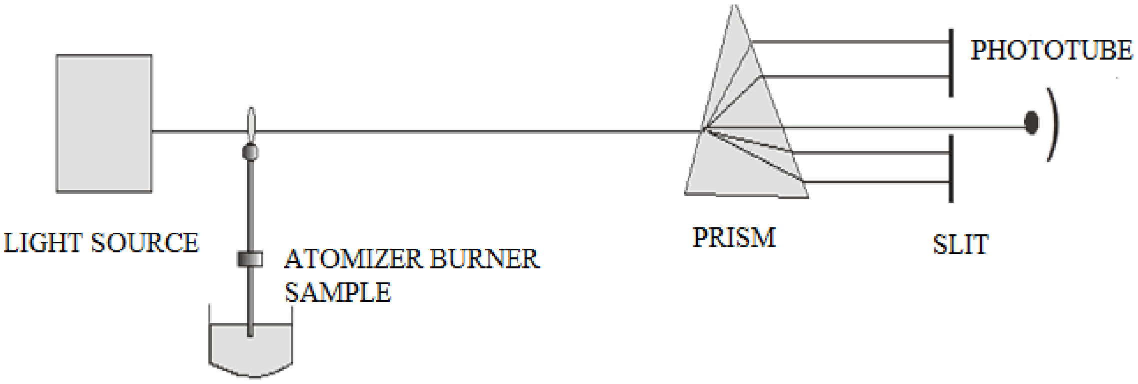


Fig 13 Atomic Absorption Spectrophotometer

The light source emits radiation of the required wavelength. When this radiation passes through metals atomized by heat, it is absorbed. That is why this instrument is known as atomic absorption spectrophotometer. Atoms of each of the metals has the ability to absorb light beams of a particular wavelength. Therefore, depending on the metal to be determined, the wavelength of the light beam has to be adjusted. To make this possible, particular light source known as hollow cathode lamp is used for each metal. First light beam is passed through without the sample and its intensity is measured. Then the sample is atomized by heat and light is again passed through. A part of the light is absorbed by the atomized sample. The reduction in the intensity of light is proportional to the quantity of the metal present in water. Atomic absorption spectrophotometer works on the above principle.

2.9 Chromatography

Chromatography is a method of examination developed after 1951. This is a method of separating various components of a mixture based on its relative affinity. For example, carbon dioxide dissolves in water better than methane. If a sample containing both of these gases is kept in contact with water, carbon dioxide dissolves well in water while methane dissolves only less. Since this characteristic behavior is different for different molecules, they can be separated. This is theory behind chromatographic analysis. In modern chromatography, separation was achieved in 1906 when a biologist known as Michael Tswett was able to separate chlorophyll and pigments by passing plant extracts through a glass column of petroleum ether solution. In modern chromatography a mixture is separated in to its components in two stages. First is the stationary phase and the second, the moving phase. The stationary phase can be either a solid or a liquid. The moving phase can be a liquid or a gas. When a gas is used as the moving phase, it is known as gas chromatography and if it is a liquid, liquid chromatography.

In water quality examinations, gas chromatograph is mainly used to detect and measure the presence of insecticides. The main parts are given in fig-19. Any gas like hydrogen, helium, nitrogen etc. is used in the gas cylinder. The gas passes through the column in pre determined temperature and velocity. A small fraction of the sample to be examined is injected in to the sample injection port. The sample is evaporated and separated to its various components.

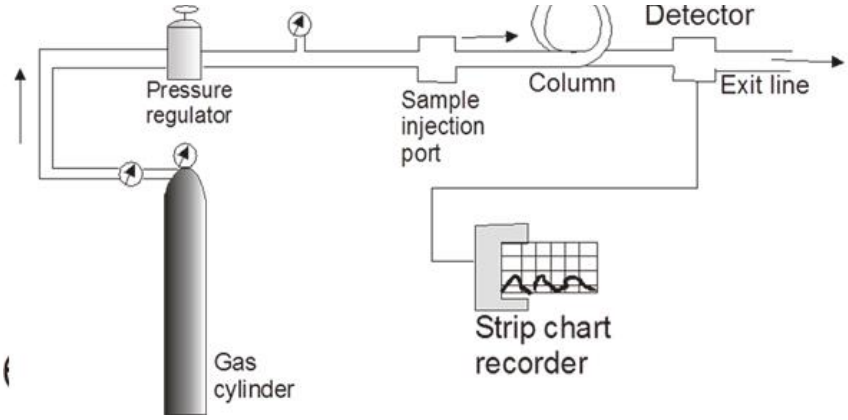
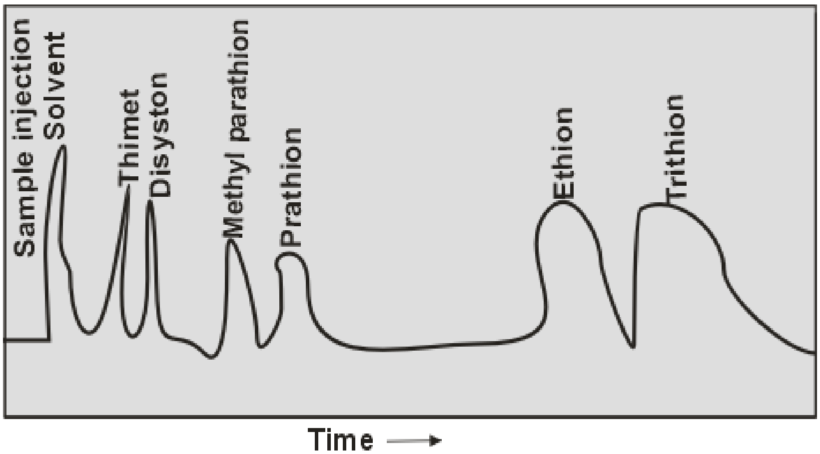


Fig-14 Gas chromatograph.

The continuously flowing gas, carries the gaseous components of the sample through the chromatography column. The sample in full gaseous form is separated in to several parts according to their affinity and comes out through the gaseous medium at different velocities. The detector in the chromatograph identifies each of the gaseous part coming out like this, and send it to the recording devise. The final result can be taken from the recorder. In fig- 20, a recorded graph of the quantitative estimation of insecticides in a water sample is given.



Gas chromatogram produced from pesticide analysis, using an electron capture detectir and a packed column

Fig-15 A sample graph obtained when the presence of insecticide is estimated using gas chromatograph

From the graph it is possible to estimate quantitatively the presence of each of the insecticides in the water sample. For example suppose the presence of ethion is to be estimated. It will be proportional to the area of the shaded portion in the graph. All of the other components in the insecticide can be estimated similarly.

2.10 Microbiology

2.10.1 Introduction

Microbiology is the study of micro organisms. This includes bacteria, virus, protozoa, fungus, algae etc. These micro organisms are strongly related to human life and human health. There are organisms useful as well as harmful to man. It is very meaningful to say that microorganisms clean the earth. The role of microorganisms in consuming all the impurities produced since the beginning of the earth is amazing. Not only that, in their absence even the existence of earth is impossible. They have a decisive role in the manufacture of cheese, wine, penicillin, alcohol and many other very essential consumables. Conversely, they are causes for spreading of many fatal diseases in humans.

2.10.2 Growth of microbiology

The history of microbiology starts from the discovery of microorganisms by Antony van leaven hock (1632 – 1723) of Holland, using a lens. By the time of Louis Pasteur (1822 – 1895) the study of micro biology acquired a scientific status. It is Pasteur who discovered that the reason for most of the diseases is microorganisms entering human body. He also invented antirabies vaccine and discovered the role of microorganisms in fermentation, a practice extensively used in industry. Robert Koch (1843 – 1910) from Germany is another scientist who gave great contribution to the growth of microbiology. He identified the microorganisms responsible for cholera, tuberculosis and anthrax. Many of the procedures popular today in microbiology (staining, pure culture) are the contributions of Koch

Even though by the beginning of the 20th century, it was discovered that the reason for many diseases are bacteria, scientists ascertained that the reason for diseases like influenza, small pox, chicken pox etc. is the presence of certain organisms even smaller than bacteria. This led to the discovery of viruses. In 1892, The Russian scientist Dimitri Ivanovsky isolated the virus responsible for mosaic disease in tobacco plant. This was the beginning of the branch of science known as virology. Afterwards science was able to isolate and identify large number of viruses responsible for many diseases in humans. The accidental discovery of penicillin in 1929 by Alexander Fleming, a bacteriologist led to great leap in modern healthcare

2.10.3 Microorganisms responsible for water born diseases

Consumption of water containing pathogenic microorganisms is the reason for spreading of diseases through water. The main reason for water pollution is excreta and other impurities reaching drinking water.

Mainly, 3 types of microorganisms are the carriers of diseases in water

1. Bacteria

2. Virus

3. Protozoa

2.10.4 Indicator organism- coliform bacteria

Routine water testing for pathogenic bacteria in the gastro intestinal tract is very difficult and expensive. But it is relatively easy to find out bacteria like coliform and streptococcus which are found in plenty in the intestine and which do not produce fatal diseases. The presence of such bacteria can be considered as proof of pollution due to human excreta. Therefore these types of bacteria are called indicator organisms. In India, the indicator organism generally used in water examination is the coliform.They are a group of bacteria found in the excreta of humans and other hot blooded animals. About 10% of the total bacteria in human excreta are coliforms. Coliforms are gram negative bacteria growing in the presence or absence of oxygen; rod shaped, and which does not produce spores. Considering everything, because they are the safest specimen, coliforms are selected as indicator organism. The reasons are given below.

1. This is abundant in human intestine.

2. Live longer outside the intestine than any of the pathogenic bacteria coming from intestine.

3. The examination of coliform is very simple.

As indicator organism coliforms have the following limitations.

1. Since they live in the intestine of other hot blooded animals, even if the presence of coliform is proved, it is not possible to confirm that pollution occurred exclusively from human excreta.

2. Even after coming out of the intestine of hot blooded animals, coliforms can live long periods in polluted water sources, and can achieve reproduction.

CHAPTER 3

Laboratory analysis for the conventional parameters

The procedures for analysis of the following parameters are given chronologically

1)Determination of Turbidity

2)Determination of pH value
3)Total dissolved solids by conductivity measurement Total dissolved solids
4)Solids
5)Sulphate and sulphide
6)Jar test for fixing dosage of alum and lime
7)Alkalinity
8)Total Hardness
9)Chloride
10)Available chlorine in bleaching powder
11) Residual chlorine
12)Dissolved oxygen
13)Bio – chemical oxygen demand

14)Chemical oxygen demand

15)Iron

16)Manganese

17)Acidity

18)Nitrate

19)phosphate

20)MPN (Most Probable Number) Bacterial Analysis

Experiment No:…… **Date:…………………**

DETERMINATION OF TURBIDTY

AIM

To determine turbidity of given sample using Nephelometer in NTU.

PRINCIPLE

Turbidity is caused in natural waters by finally divided suspended particles of clay, silt, sand or by some organic materials, and by microscopic organisms. It is usually expressed in mg/l (or ppm), and may be determined by optical observations. The standard unit of turbidity is that turbidity which is produced by mixing 1mg of finally divided silica SiO_2 (called Fuller's earth) in one litre of distilled water. The method presented below is based on a comparison of the intensity of light scattered by the sample in specific condition with the intensity of light scattered by standard reference suspension under the same conditions. Higher the intensity of scattered light, higher the turbidity. Formazin polymer is used as the primary standard reference suspension. It is easy to prepare and is reproducible in its light scattering properties than the clay or turbid natural water standards previously used. The turbidity of given concentration of formazin has an appropriate turbidity of 100 NTU when measured on a candle turbidity meter. Nephelometric turbidity units based on formazan preparation will have approximate units derived from Jackson candle turbidimeter but will not be identical to them.

APPARATUS

Nephelometer with accessories

REAGENTS

1. Turbidity free distilled water (for setting zero)
2. Formazin turbidity concentrates (hydrazine sulphate + hexamine)
3. Formazin standard (for setting 100 of the instrument)

PROCEDURE

1. Switch on the instrument and allow 10-15minutes warm up
2. Select appropriate range
3. Keep calibration control to maximum clockwise position
4. Insert the test tube with distilled water in ot the cell holder and cover with light shield
5. Adjust set zero controls to get zero on the display
6. Remove the test tube and replace with test tube containing standard solution (50NTU)
7. Adjust calibration control such that the display indicates as follows

Sl no	Source of sample	Turbidity

Discussion

Questions

1)What are the adverse effects of turbidity

a) Disinfection is practically difficult since the turbid particles provide shield for the microorganisms

b) Turbidly makes the water aesthetically unfit-People do not accept

c) treatment is required for removal of turbidity

2)Discuss the significance of determination of turbidity in sanitary engineering

Turbidity is the important water quality parameter that decides the quality of water . the type of treatment is generally decided based on the presence of turbidity . turbidity imparts aesthetically negative appearance for the water. It gives an indication about the suitability of the sources of water

2) **What is the source of turbidity in drinking water**
3) Source for turbidity is enormous

Occurrence/Origin: Clay particles, sewage solids, silt and sand washings, organic and biological sludges etc

During floods it may be top soil containing clay, silt etc

In glacier feed rives it may be colloidal particle due to grinding of glacier

In rivers it may be residue of farming operation

Organic matter from industries contributes for turbidity

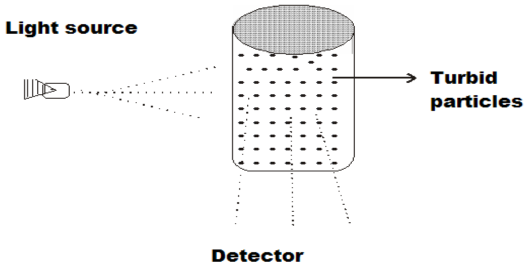
Growth of bacteria on organic matter produces turbidity

Agricultural runoff stimulates growth of algae contribute to turbidity

Iron in water may contribute turbidity

4) What is the principle of working of a nephelo turbidity meter

Picture below shows the turbidity meter in which light is incident on the water containing turbidity. the light gets reflected when it is incident on the turbid particles. The reflected light is proportional the quantity of turbid Particles present. The is reflected light is measured in a detector on digital or other type of indicator



5) What is the standard unit of turbidity and how is it defined

NTU (Nephelo turbidity unit) is the unit for measurement of turbidity . It is the turbidity produced by one gram of silica in 1litre of distilled water

6) What are adverse effects of turbidity in water treatment process

Removal of turbidly is complicated and needs coagulation flocculation / filtration etc in water treatment .High turbidity in drinking water can shield bacteria or other organisms so that chlorine cannot disinfect the water as effectively.

Experiment No:…… **Date:…………………**

DETERMINATION OF pH VALUE

AIM

To determine the pH of the given samples using Universal using digital pH meter, Universal indicator , and using litmus paper

PRINCIPLE

Note-refer chapter 2 pH value

APPARATUS

1. pH meter with electrode
2. Beaker
3. Thermometer

VARIOUS METHODS ARE USED FOR THE MEASUREMENT OF PH VALUE

1) by using pH meter
2) by using universal indicator
3) by using litmus paper

PROCEDURE-

1 Using pH meter

Normally reading can be taken directly by dipping the electrode and taking the reading from the instrument periodically calibration is to be done for and procedure for the same is given below

1)The electrode is washed with distilled water and rinsed with the solution and then it is dipped in the solution.

2)The reading on the dial indicates the pH of the solution.

3)The procedure is repeated for any other solution and pH values are tabulated.

Calibration of pH meter

1. Buffer solution of pH 4.0 is taken in a beaker and the electrode is dipped in this solution. Then calibration knob is rotated such that reading is 4 in the dial.

2. The electrode is withdrawn and washed with distilled water.

3. Another buffer solution of pH 9.2 is taken and the electrode is rinsed with this solution. Then the electrode is dipped in this solution.

4. If it reads 9.2 then the instrument is calibrated. If not, the calibration knob is adjusted so that the reading in the dial comes to 9.2.

5. Now the instrument is ready for use. A solution whose pH is found to be is taken in a beaker and the temperature knob is adjusted such that the temperature of the solution is adjusted on the temperature di

2 Using universal indicator

1. 10 ml sample is taken in a test tube and 0.2ml of universal indicator is added
2. Mix the solution in the test tube thoroughly.
3. Observe the tinge of colour developed in test tube and match with the colour scale given on the indicator bottle itself.
4. The colour scale given on the bottle will give the pH value directly.

3 Using pH papers

1. Dip the pH paper in the sample.
2. Compare the colour with that of the colour given on the wrapper of the pH paper

Serial number	**Source of sample**	**pH using pH meter**	**pH using universal indicator**	**pH using pH paper**

DISCUSSION

QUESTIONS

1) What is pH

A functional definition of pH is the measurement of acidity or alkalinity of a solution which is measured on a scale of 0 to 14. A pH value below 7 implies an acidic substance, while a pH above 7 indicates the material is alkaline. Water is often thought of as “neutral,” meaning it has a pH of 7 and is neither acid nor alkaline. However, this is only true for pure water and only at a specific temperature*

2)Discuss the relationship between (a)pH and hydrogen ion concentration (b) pH and hydroxyl ion concentration?

A solution with a concentration of hydrogen ions higher than 10^{-7}mol/L is acidic, and a solution with a lower concentration is alkaline (another way to say basic). Using the formula, $pH=-\log[H^+]$, a pH of **7** is neutral, a pH less than **7** is acidic, and a pH greater than **7** is basic.

In this type of problem hydrogen iron concentration is expressed as moles /litre (M)and in neutral water it is 10^{-7} moles /litre(molecular weight expressed in grams / litre)

There is also another relation $[H^+]x[OH^-]=10^{-14}$ at 25 ^{0} C

2)What is the hydrogen ion concentration of a solution with pH is 5.60?

In this problem we are given pH and asked to solve for the hydrogen ion concentration. Using the equation, pH = − log $[H^+]$, we can solve for $[H^+]$ as,

$$- pH = \log [H^+]$$

Where pH is 5.6

$$[H^+] = 10^{-5.6}$$

. The hydrogen ion concentration,

$$[H^+] = 10^{-5.6} \approx 0.0000025 = 2.51 \times 10^{-6}\ M.\text{(moles per litre)}$$

We can always check our solution by computing pH −log $(2.5 \times 10^{-6}) \approx 5.6$.

10)The hydroxyl ion concentration of water is 10^{-6} moles /litre. Find the pH value

$[H^+]x[OH^-]=10^{-14}$

$10^{-6}[H^+] =10^{-14}$

$[H^+] =10^{-14}x10^{6}=10^{-8}$

pH=-log10^{-8}=8

3) How much is the increase in hydrogen ion concentration when pH is reduced from 5 to4

When pH is reduced from 5 to 4

Consider the decrease in pH from 5 to 4

H^+ concentration when pH is 5

5= -log $[H^+]$

$H^+=10^{-5}$

H^+ concentration when pH is 4

4= -log $[H^+]$

$H^+=10^{-4}$

Increase in hydrogen ion concentration=10^{-4}-10^{-5}=

4) What are the bad effects of low and high pH

If the pH is low water becomes acidic . acidic water is corrosive and it will be having sour taste . the solubility of such water will be high . In the case water with high pH there will be alkaline tase and there is possibility for deposition

5) What is buffer solution

Buffer solution is one which resist change in pH even when appreciable amount of acid or base is added to it

6)) Whether aeration is having any effect on the pH of water Explain

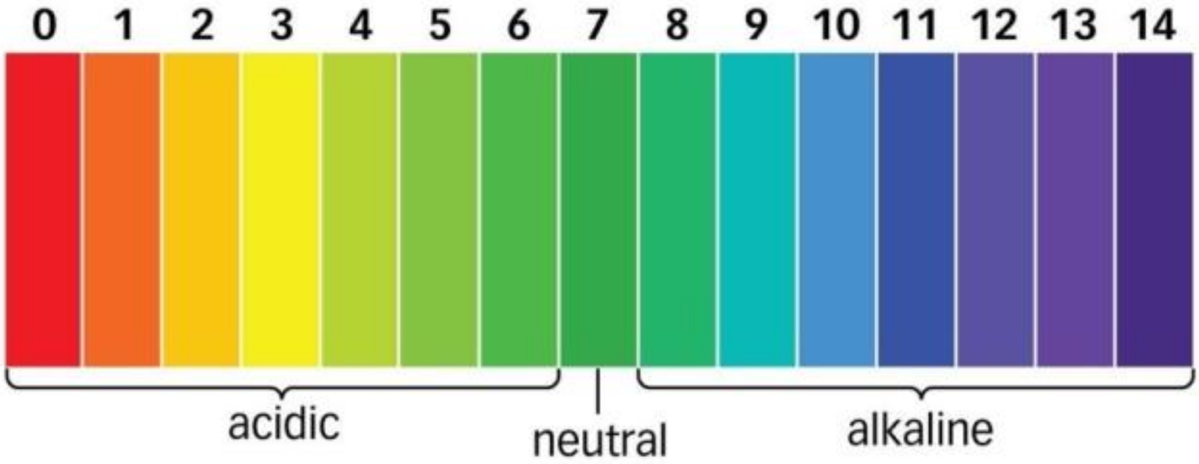
If the pH is low and that may be due to presence of CO^2 , up on aeration the CO^2 starts escaping and due to that the pH increases

7)What are the methods used to increase /decrease the pH of water

For increasing pH lime may be added and for decreasing weak acids

8) what is pH scale

pH scale is representation of acidic alkaline and neutral range of pH between apH value of 0to14 as shown in the figure below



9)How do pH value change in surface and ground water

As the water depth increases pH may also increase. refer the picture which shows the percolation of water through the ground

10)What are the methods used to increase /decrease the pH of water

For increasing pH lime may be added and for decreasing weak acids

Experiment No:…… **Date:…………………**

DETERMINATION OF SOLIDS IN WATER

AIM

To determine the following type of solids in a given sample of water

1) Total solids
2) Total dissolved solids
3) Total suspended solids
4) Total volatile solids

BY EVAPORATION

DETERMINATION OF TOTAL SOLIDS

APPARATUS

1. Evaporating dishes of 100 ml capacity made of porcelain or platinum.
2. Steam bath
3. Drying oven
4. Desiccators
5. Analytical balance.

PROCEDURE

1. A clean evaporating dish is ignited in muffle furnace for one hour at $550\underline{+}50^0$C.
2. It is then cooled and desiccated. Note the empty weight of the dish (W1).
3. A measured quantity of the sample is transferred to the dish and the contents are evaporated to dryness in a steam bath and then in a hot air oven for 1hr at $103\text{-}105^0$C.
4. It is cooled, desiccated and weighed (W2).

Total Solids

Total residue in mg/l = $\frac{(W2 - W1) * 1000}{V}$, where

W2=weight of the sample + dish in gms

W1=weight of the dish in gms

V = ml of the sample

DETERMINATION OF TOTAL DISSOLVED SOLIDS (TOTAL FILTERABLE RESIDUE)

APPARATUS

1. Evaporating dishes of 100 ml capacity made of porcelain or platinum.
2. Glass fibre filter discs or filter paper
3. Filter holder
4. Suction apparatus
5. Drying oven
6. Muffle furnace
7. Desiccators
8. Analytical balance
9. Gooch crucibles.

PROCEDURE

1. Gooch crucibles are placed and filter discs or filter paper is placed in it.
2. Vacuum is applied and it is washed two or three times with 20ml of distilled water.
3. An evaporating dish is ignited as indicated earlier, weighed and stored in a desiccators (W3).
4. A known volume, say 100ml of well-mixed sample is poured over for 3min even after all water has been sucked. 100ml of the filtered sample is transferred to the dish already ignited and weighed (V).

5. The contents in the dish are placed over steam bath and evaporated to dryness.
6. The dry evaporated sample and the dish are placed in a hot air oven at 180 ± 2^0C for 1hr.

7. The evaporating dish and contents are desiccated and weighed till a constant weight is obtained (W4).

Calculations

Total dissolved solids in mg/l $= \frac{(W4 - W3) * 1000}{V}$ where,

W4=weight of the dried residue + dish in gms
W3=weight of the dish in gms
V = ml of the filter used

DETERMINATION OF TOTAL VOLATILE SOLIDS

Quantity of total volatile solids can be estimated by subtracting total fixed solids from the total dissolved solids

Total fixed solids can be determined by the method given below:

1.Keep the same dish used for determining total dissolved solids in a muffle furnace for 1 hour at 550Oc.
2.Allow the dish to partially cool in air until most of the heat has dissipated. Then transfer to a desiccator for final cooling in a dry atmosphere
3.Weigh the dish as soon as it has cooled(W3)
4.Weight of total fixed residue = W3-W1 where W1 is the empty weight of the dish
5.Volatile dissolved solids= Dissolved solids –Fixed Solids.

DETERMINATION OF TOTAL SUSPENDED SOLIDS (TOTAL NON FILTERABLE RESIDUE)

APPARATUS

1. Glass fibre filter discs or filter paper
2. Filter holder
3. Suction apparatus
4. Drying oven
5. Muffle furnace

6. Desiccators
7. Analytical balance.

PROCEDURE

1. The glass fibre filter is prepared as indicated in the earlier case or filter paper may be used.
2. The filter disc or filter paper is removed and dried in an air oven for 1hr at 103-105^{0}C. It is cooled, desiccated and weighed (W5).
3. A sample that will not yield more than 200gm total non-filterable residue is pipetted out and passed through the filter disc or filter paper.

4. The filter is removed dried, cooled, desiccated and weighed (W6).
5. Repeat heating, cooling and weighing till constant values are obtained.

Calculations

Total suspended solids in mg/l $= \frac{(W6 - W5) * 1000}{V}$

where

W6=weight of the residue + filter in gms

W5=weight of filter in gms

V= volume of sample in ml

Settleable solids

1) What is the significance of settleable solids

Settleable solids is to be removed in sedimentation tanks. these are generally organic in nature. these are solids in suspension which settle because of influence of gravity . the determination of settleable solid is is important

a)To find the need for sedimentation tank

b)To find the physical nature of the water that is entering the stream

2) what is the significance of settleable solids in sanitary engineering

a) to determine the nature of treatment to be proposed b)to determine the suitability of the water for domestic and other purposes

3) how does the volatile soil affect the strength of the sewage

Generally volatile solids represents the organic matter in the sewage . organic matter is the factor that decides the strength of the sewage . if volatile solids is more it means that organic matter is more and that means that the strength of the sewage is high and vice versa

4)what is the significant information furnished by the determination of volatile soilds ?

1) evaluate the strength of sewage

2)loading in waste water treatment

3)amount of solids remaining after treatment

5) What is sludge volume index ?

Is defined as the volume occupied in ml by one gram of solids in the mixed liquor after settling for 3o minutes

SVI represents the physical quality of the sludge

Settling character of the sludge helps to find the rate o recycle to maintain the required Recycle of sludge , to maintain the required MLSS and F/M ratio

A high value of sludge volume index poor settling character of the sludge . Desirable value is 100 or less than that

Experiment No:…… **Date:…………………**

MEASUREMENT OF TOTAL DISSOLVED SOLIDS BY USING CONDUCTIVITY MEASUREMENT

Electrolytic conductivity is a measure of the ability of a solution to carry electric current. This number depends on the total concentration of ionised substances in the water and the temperature at which measurement is made. Freshly distilled water has a conductivity of 0.5 – 2.0µ mhos per cm increasing to 2 – 4 µmhos per cm after a few weeks of storage. This is due to absorption of CO2 and ammonia by the water.

PRINCIPLE :

Conductivity can be measured in a conductivity meter. This cell has a platinum electrode. Normally 0.01 or 0.001 N KCl solution is used as a standard solution for calibration and this solution (0.01 N) have a specific conductance of 1413 µ mho per cm at 25^0C.

APPARATUS

1.) Conductivity meter
2.) Beaker

REAGENTS

1.Ion free or double distilled fresh water

2.0.01 N KCl solution

Dissolve 745.6 mg of anhydrous KCl in freshly boiled double – distilled water and make up to 1.0 litre.

Procedure

Calibration of the instrument

1) Switch on the instrument

2) Put the cell in the solution whose specific conductivity is known (0.1N KCL)

3) Select function switch in conductivity position and range switch in higher side. with the help of a calibration knob. adjust conductivity as per temperature ie for 30^0C 14.12 millimhos

4) Measurement of Conductivity at 25^0C-Select function switch for appropriate temperature from the manual (at 25^0C for 0.1NKCL12.88 millimhos) using the rear panel temperature mob). Then measure the conductivity

5) Measurement of TDS-select function switch to TDS and adjust7.459or 0.745 with the help of rear panel factor knob for 0.1Nor o0.01NKCL. then measure the TDS directly

.

Sl no	**Name of sample**	**Conductivity in micromhos/cm**	**TDS**

DISCUSSION

Questions &Answers

1) what are the sources of total dissolved solids in water

Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphate and, particularly in groundwater, nitrate

2)How do conductivity and TDS related in drinking water

Conductivity and TDS are proportional approximately TDS=conductivity in micromhos /cm multiplied by 0.66

3)What are the environmental significance of conductivity and TDS

TDS or Total Dissolved Solids is a measure of the total ions in solution. EC is actually a measure of the ionic activity of a solution in term of its capacity to transmit current. In dilute solution, TDS and EC are reasonably comparable

4)What is the effect of temperature on the conductivity of water

Electrical conductivity increases with increase in temperature An arbitrary constant is commonly used for temperature compensation assuming that EC-temperature relation is linear (for example 2% increase of EC per 1 °C increase in temperature

Experiment No:…… **Date:…………………**

DETERMINATION OF SULPHATE IN WATER

AIM

To determine the amount of sulphate in a given sample

GENERAL

Sulphate is widely distributed in nature and may be present in natural water in concentrations from a few mg/l to several mg/l. When present in excess, its cathartic effect upon humans makes the sulphate important in public water supplies. They get converted into H2S under reducing environment and cause foul odours and corrosion to pipes and sewers. Mine drainage waste may contribute large amount of sulphates. The water with appreciable amount of sulphates have a tendency to form scales in boilers and heat exchangers.

PRINCIPLE

Sulphate can be measured by gravimetric or turbidimetric method; of which latter is widely used, as it is rapid. Sulphate ion are precipitated in the form of BaSO4 by adding BaCl2 in slight excess of water acidified with HCl. Samples are acidified to eliminate the possibility of precipitation of BaCO3 which might occur in highly alkaline water, maintained near boiling temperature. Excess BaCl2 is used to produce sufficient common ion to precipitate sulphate as completely as possible. BaSO4 is insoluble in water. Hence the light absorbance of BaSO4 suspension is measured by turbidity meter at 420nm and sulphate concentration is determined by comparing the reading (absorbance) with a standard curve.

APPARATUS

1. Magnetic stirrer
2. Photometer, either Nephelometer
3. Stop watch
4. Measuring spoon 0.2 to 0.3 ml capacity

REAGENTS

1. Buffer solution A and B

2. $BaCl_2$ solution

3. Standard sulphate solution.

PROCEDURE

Make a preliminary assessment of the sulphate content and if it is less than 10mg /litre use Buffer solution B otherwise start with Buffer solution A

1. Measure 100 ml sample or a suitable aliquot made up to 100ml into 250ml Erlenmeyer flask

2. Add 20ml buffer solution A and mix in the magnetic stirrer

3. While stirring add a spoonful of BaCl2 crystal and begin to measure time immediately

4. Stir at constant speed for 60+/- 2 seconds

5. After stirring is completed measure the turbidity of the solution

7. Prepare a calibration curve for two cases ie for less than 10 mg /litre and above 10 mg /litre as per the above procedure and use it for estimation of sulphate

8. Absorbance (turbidity) Vs sulphate concentration is plotted and a curve is obtained.

9. Measure the sulphate content from calibration curve

Note ; Please see that both the cases is to be separately considered.

Tabulation and calculation

Sample no and description	Mg/l of sulphate

DISCUSSION

QUESTIONS & ANSWERS

1)What is the source of sulphate in water

Rocks, geological formations, discharges, sea water etc

2)What is the bad effect of high sulphate concentration in water

Sulphate is a disturbing water quality problem due to many reasons given below

Intestinal discomfort, diarrhea and consequent dehydration. Formation of hydrogen sulphide and thus smell of rotten egg. formation of sulphuric acid and thereby lowering of pH .due to these reasons high content of sulphate in drinking water is not desirable

3)The water to be used for the preparation of cement concrete products should be free from excess of sulphates and chlorides. Why?

Both sulphate and chloride are having corrosive effect on concrete

3)Explain the process of H_2S formation in sewers

Under anaerobic conditions sulfate is reduced to sulphide ion and the sulphide ion reaction with hydrogen ion and HS^- is formed and then hydrogen sulphide is formed along with reduction in pH as shown in the equation below

$$SO_4^{2-} + \text{organic matter} \xrightarrow[\text{bacteria}]{\text{anaerobic}} S^{2-} + H_2O + CO_2$$

$$S^{2-} + H^+ \rightleftharpoons HS^-$$

$$HS^- + H^+ \rightleftharpoons H_2S$$

4)Explain the influence of pH on the formation of H_2S

As the pH increases H_2S dissociate to form HS^- and S^-. At lower pH of about 7 formation of H_2S starts and PH of 4 formation of H_2Swill be maximum and severe smell of rotten egg will be maximum and at a pH of above 7 it will be reduced. The figure blow indicates this process

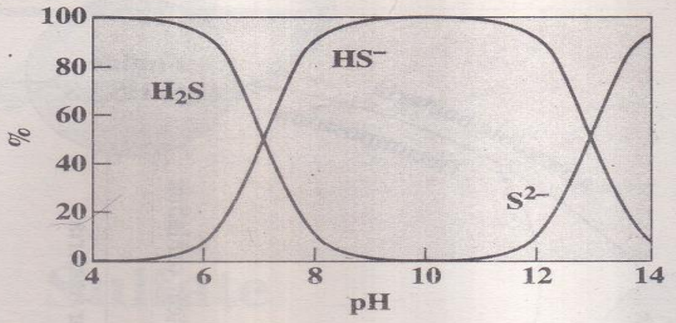


Figure 29.2
Effect of pH on relative distribution of sulfide species in water.

At pH 7 formation of H_2S is 50 %complete and there will be partial disturbance due to H_2S

Experiment No:…… **Date:…………………**

DETERMINATION OF SULPHIDE IN WATER

AIM

To determine the amount of sulphide present in the sample by titrimetric method

PRINCIPLE

Sulphide is Present in ground water, especially in hot springs. Its presence in wastewater comes partly from decomposition of organic matter, sometimes from industrial waste, mostly from bacterial reduction of sulphate. Hydrogen sulphide causes odour, nuisance and is highly toxic. It attacks metals directly and indirectly causing corrosion as it is oxidized to sulphuric acid biologically. Dissolved Hydrogen sulphide is toxic to fish and other aquatic organisms.

IODOMETRIC METHOD

REAGENTS

1.HCl 6N

2.Standard iodine solution 0.025 N

3.Standard sodium thiosulphate solution(0.025 N)

4.Starch solution

PROCEDURE

1. Measure from a burette into a 500ml flask, an amount of iodine solution estimated to be an excess over sulphide present. (say 10ml , 20ml etc)
2. Add distilled water, if necessary, to bring the volume to 20 ml.
3. Add 2ml of 6 N HCl.
4. Pipette 200ml sample into flask discharging sample to the surface of the solution. If iodine color disappears, more iodine until color remains
5. Titrate with $Na_2 S_2 O_3$, adding few drops of starch solution, as the end point is approached and continuing until the blue color disappears

Mg / litre of Sulphide =

A=ml of Iodine Solution

B=Normality of iodine solution

C=ml of sodium thiosulphate solution

D=Normality of sodium thiosulphate Solution

Calculation

Sample No	**Volume of Iodine solution used (a ml)**	**Volume of Sodium thiosulphate(bml)**			**Volume of sample used**	**Sulphide in mg/l**

DISSCUSSION

Experiment No:…… **Date:…………………**

JAR TEST FOR THE DETERMINATION OF OPTIMUM COAGULANT DOSAGE

AIM

To determine the optimum dosage of alum and lime used in a water treatment plant

GENERAL

The very fine and light particles and colloidal matter cannot settle in sedimentation tanks of ordinary detention period.The generally present particles in water with their name size and settling velocity are given below

Sl no	Name of particle	Size in mm	Settling Velocity
1	Pebble	10	0.73m/sec
2	Coarse sand	1	0.23m/sec
3	Fine sand	0.1	0.6m/minute
4	Silt	0.01mm	8.6m/day
5	Large Colloid	0.0001mm	0.3m/year
6	Small colloid	0.000001 mm	3m/million year

It is evident from the above table that settling of large colloid and small colloid is impossible in ordinary conditions coagulation flocculation technique is adopted

By addition of certain chemicals these smaller particles are coagulated into larger ones which posses higher hydraulic settling velocities. Thus the coagulation is the addition of certain chemicals to turbid water in order to produce a gelatinous precipitate known as floc. The coagulation is followed by sedimentation so that the floc, which is formed, may settle at the bottom. The coagulation becomes necessary when the turbidity is more than 30-50 ppm. The detention period in coagulating basins is about 2-2.5 hours.

APPARATUS

1. Jar Test apparatus with six mixers
2. One-liter glass beakers
3. Turbitdy meter
4. Pipettes and other glassware
5. pH meter
6. Stopwatch

REAGENTS

1. Alum solution
2. Lime solution

PROCEDURE

1. Measure the pH,Turbidity of raw water

2. Weigh 250 mg Alum and dissolve in 250 ml of water so that 1ml = 1mg of Alum

3.Weigh 250 mg of lime and dissolve in 250ml of water so that 1ml =1mg of lime

4. Take 1litre of water sample in a beaker, measure the pH ,add 10 ml of Alum solution and note the reduction in pH

5. Add lime solution in drops keeping the pH electrode under the water sample , stir the water and continue it till the pH value is between 7-7.5 and count the quantity of lime added . let it be 8ml . then the ratio between Alum and lime is 10:8 or 5:4

6. Now the ratio between Alum and lime to be added to maintain pH between7-7.5 is obtained and hereafter add Alum and lime in the same ratio throughout the experiment

7. Clean 6 one-litre beakers and fill them with sample of water for which optimum coagulant dose is to be found.

8.Keep each beaker below each paddle and lower the paddles such that each one is about 1 cm above the bottom.

9. Pipette 5,10,13,15, and20 ml of alum solution and corresponding quantity of lime into the test samples. Keep one beaker filled with the sample but without adding any chemical

10. Immediately run the paddles at 100 rpm for 1 minute. The time for this flash mix may be 10-60 seconds.

11. Then the speed of paddles is reduced to 30-40 rpm and at this rate they are run for 20-30 minutes.

12.Then stop the machine, lift out the paddles and allow to settles for 30 minutes.

13.Siphon out the clarifier samples into beakers and test turbidity in each beaker.

14. The characteristic of flocs, rate of settling etc. are observed.

15.If correct results are not obtained the procedure is repeated with still higher doses of alum.

16.Find out turbidities of original sample and flocculated sample.

17.Plot a graph with alum dose along X-axis and turbidity along Y-axis.

18.The dosage of alum, which gives the minimum turbidity, represents the optimum dosage.

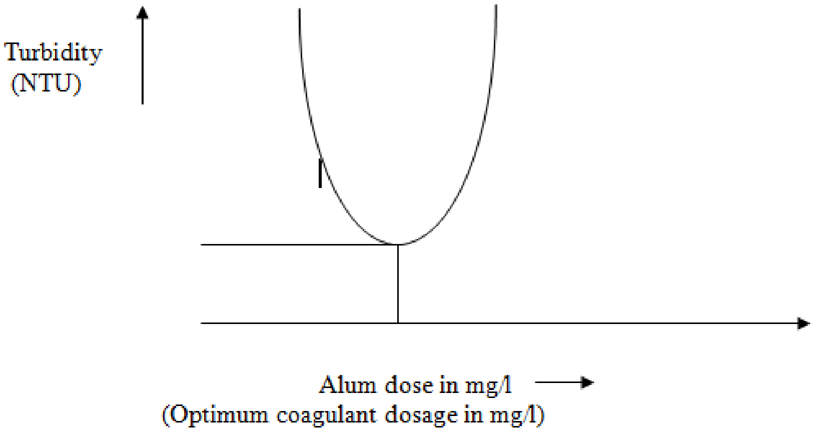
Ratio between Alum and lime to get a pH of about 7.5=10;8

Sample-........Raw water.......................p H-....................... Date-..............Location-Cheruthuruthy..

Colour-.............................Temp-.....................................Sample Size-...........

Jar number	1	2	3	4	5		6
Dosage (mg/l)Alum Lime							
Flash mix time (min)							
Slow mix speed (rpm)							
Slow mix time (min)							
Time of first floc formulation							
Turbidity							
Colour							
pH							

A graph of Alum dose versus turbidity can be drawn and the minimum dose of alum can be estimated by drawing the graph alum dose vs turbidity


Turbidity
(NTU)
Alum dose in mg/l
(Optimum coagulant dosage in mg/l)

DISCUSSION

QUESTIONS AND ANSWERS

1) Describe the use of jar test

Used to find the dose of alum and lime in a water treatment plant

2) Describe coagulation and flocculation?

Colloid is present in water which are negatively charged and the alum is positively charged . When alum is added charge neutralization takes place due to reaction between alum and colloid and this is called coagulation. Flocs are formed due to agglomeration of coagulated particles and this is called flocculation

3) Why do we use CO_2 free distilled water for analysis?

If CO2 is present pH may go low making the water acidic

4) Why is alum preferred over other coagulants ?

Alum is cheap comparatively and its working is effective in coagulation and also readily available

5) Why is it necessary to add lime along with alum in most of the water treatment plants for treatment

When alum is added alum reacts with alkalinity and the pH gets reduced . but effective coagulation to take place optimum ph is to be maintained that to be around 7 and for that lime is added

6) Work out the quantity of Alum and lime in a 6 mld water treatment plant if on jar test the alum lime ratio is 1:2 and the best lime dose is dosage is 9mg/litre

Alum ;lime =1:2=x;9 x=4.5

Alum in a 6mld plant=$6x10^6x4.5x10^{-6}$=27kg

Similarly for lime it is 54 kg

7)In a 5 mld water treatment plant 100 kg of alum and 50 kilogram lime are required per day as per jar test . What is the dosage of Alum and Lime obtained in jar test

$5x10^6$ litres of water to be treated per day

Daily requirement of alum=$5x10^6xAx10^{-6}$ kilograms =100 where A is the Dosage of Alum in mg /litre

A=100/5=20mg /litre

Similarly lime

$5X10^6xBx10^{-6}$=50 B=10mg /litre

DETERMINATION OF RESIDUAL CHLORINE

AIM

To determine the residual chlorine in a given sample of chlorinated water

GENERAL

The chlorination of water supplies accomplishes a number of treatment objectives. The destruction of microorganism is a primary function so as to prevent water born diseases. Overall improvement in the finished water can result from chlorine’s reaction with ammonia, iron, manganese, and sulphide and protein substance. Chlorine in water may be present as a free available chlorine (in the form of hypochlorous acid or hypochlorite ion); as combined available chlorine (chloramines and other derivatives). Several tests have been developed to determine chlorine residuals in water, of which the most common is Orthotoluidine test. Orthotoluidine arsenate method enables the differentiation of free available and combined available chlorine in the presence of colour from common interfering substances. Iodometric method is more precise than colorimetric method where residual concentration exceeds 1mg/l, but for lower concentration it is not so accurate.

ORTHOTOLUIDINE METHOD

PRINCIPLE

Orthotoluidine is an aromatic organic compound that is oxidized in acid solution by chlorine, chloramines and other oxidizing agents to produce yellow coloured compound, holoquinone, at pH values less than 1.8. The intensity of the yellow colour is proportional to the amount of compound produced. Nitrates and oxidized forms of manganese both oxidize orthotoluidine to produce holoquinones, thus producing false indication of residual chlorine samples that contain chloramines are warmed to 20^{o}C and a contact period of 3-5 min are provided before reading the residuals. This method is based on the fact that free chlorine residuals react instantaneously with orthotoluidine to produce the yellow holoquinone, while chloramines react much more slowly. The amount of any additional colour produced by the interferences is deduced to correct the chlorine values.

APPARATUS

1. Colorimeter and comparator

2. Cuvettes
3. Comparator discs

REAGENTS

1. Orth toluidine reagent (OT)

PROCEDURE

1. Fill the water to be tested in transparent glass tubes, keep one at right and another at left hole of the chloroscope.
2. In third tube put 4 drops of OT liquid , shake .
3. If chlorine is present, it will turn yellow.
4. Insert this tube in the middle whole of the tester and close.
5. Obtain yellow color in middle tube. Compare it with standard level and note the reading.
6. Reading is taken as parts per million (ppm) or mg/L.

TABULATION AND CALCULATION

Serial No	Sample	Residual chlorine Mg/litre

APPLICATION OF CHLORINE RESIDUAL DATA

Chlorine residuals are used universally in disinfection practice to control addition of chlorine so as to ensure effective disinfection without waste of chlorine. They are also used to control chlorination of domestic and industrial wastes and usually are the sole criteria immediately available to determine whether or not desired objectives are being attained.

SPECIFICATION

IS-10500-2012 specifies that, to ensure the safety of drinking water, it is necessary to maintain residual Chlorine of Minimum -0.2 ppm and maximum 1ppm after a contact period of 30min.

DISCUSSION

QUESTIONS & ANSWERS

1)What is disinfection? what are the different methods adopted for disinfection in a water supply systems

Disinfection is the method followed for killing of bacteria in water before it is used for drinking , various methods are used for disinfection which includes using chlorine gas through a chlorinator , bleaching powder , ozone , potassium permagnate

2) What is meant by chlorine demand and what are the factors that affect chlorine demand?

Chlorine demand is the quantity of chlorine required for complete oxidation and killing all the bacteria present in water

The level of pollution and the presence of bacteria is the main factor that affect the chlorine demand . if it is more the chlorine demand will also be more . for clean water which contain less organic matter chlorine demand will be less

3)Why is it necessary to maintain residual chlorine in the water supply distribution system at the consumer point ?

It is an indicator that chlorination has been done effectively, residual chlorine is necessary to counteract any subsequent pollution

4**) when chlorine gas is added to water pH is reduced and when bleaching powder is added pH is increased**

When chlorine gas is added to water the following reaction takes place and acids are formed

$H_2O+Cl_2=HOCl+HCl$. These acids are responsible for reducing the pH. When bleaching powder reacts with water alkaline products are formed and hence the pH is increased

Experiment No:…… **Date:…………………**

DETERMINATION OF ALKALINITY

GENERAL

Alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural water is primarily due to the salts of weak acids, although weak or strong bases may also contribute. Bicarbonates represent the major form of alkalinity, since they are formed in considerable amounts from the action of carbon dioxide upon basic materials in the soil. Other salts of weak acids such as borates, silicates and phosphates may be present in small amounts. In polluted or anaerobic waters, salts of weak acids such as acetic, propionic and hydrosulphuric may be produced and would also contribute to alkalinity. In other cases, ammonia or hydroxides may contribute to the total alkalinity. Although many materials may contribute to the alkalinity of water, the major portion of the alkalinity in natural waters is caused by three major classes of materials that may be ranked in order of their association with high pH values as follows :(1) hydroxide, (2) carbonates and (3) bicarbonates. The alkalinity of water is principally due to salts of weak acids and strong bases, and such substances act as buffers to resist a drop in pH resulting from acid addition. Alkalinity is thus a measure of the buffer capacity and in this sense is used to a great extent in wastewater treatment practice.

Alkalinity is measured volumetrically by titration with 0.02N H_2SO_4 and is reported in terms of equivalent $CaCO_3$. For samples whose initial pH is above 8.3, the titration is made in two steps. In the first step the titration is conducted until the pH is lowered to 8.3, the point at which phenolphthalein indicator turns from pink to colourless. The second phase of titration is conducted until the pH is lowered to about 4.5, corresponding to the methyl orange end point. When the pH of a sample is less than 8.3, a single titration is made to a pH of 4.5.

PRINCIPLE

Hydroxyl ion present in a sample as a result of dissociation or hydrolysis of solutes are neutralised by titration with a standard acid. Thus the alkalinity depends on the end point pH used. The end point pH may be 4.5-5.1 for total alkalinity and 8.3 for phenolphthalein alkalinity.

APPARATUS

1.Burette

2.Pipettes

3.Erlenmeyer flasks

REAGENTS

1. Standard H_2SO_4 or HCl 0.02N
2. Methyl orange indicator
3. Phenolphthalein indicator
4. Sodium thiosulphate 0.1N

PROCEDURE

1) Measure the pH of the sample and record

1. A sample of required volume is pipetted into a clean Erlenmeyer flask (V)(say 25ml).

2. A drop of sodium thiosulphate is added, if the sample has residual chlorine.

3. Two drops of phenolphthalein indicator is added. If the pH is above 8.3 the colour is pink.

4. This sample is titrated against standard acid in the burette, till the colour just disappears. The volume of the titrant used is noted (V1).

5. Then two drops of methyl orange indicator is added. The colour turns yellow.

6. This is again titrated against the acid in the burette, till the yellow colour just turns orange yellow. The volume of titrant used is noted (V2)

Tabulation and calculation

Observation

sample No 1	pH value 2	Phenolphthalein titration reading		volume of titrant V1(5)	Methyl orange titration reading		volume of total titrant V2(8)

Phenolphthalein alkalinity as mg/l of $CaCO_3$ =

Total alkalinity as mg/l of $CaCO_3$ =

V = volume of the sample used in ml.

V_1= volume of standard acid in ml used up to phenolphthalein end point

V_2= volume of standard acid in ml used up to methyl orange end point

Phenolphthalein alkalinity as mg/l of $CaCO_3$ =

Total alkalinity as mg/l of $CaCO_3$ for sample 1 =

Total alkalinity as mg/l of $CaCO_3$ for sample 2 =

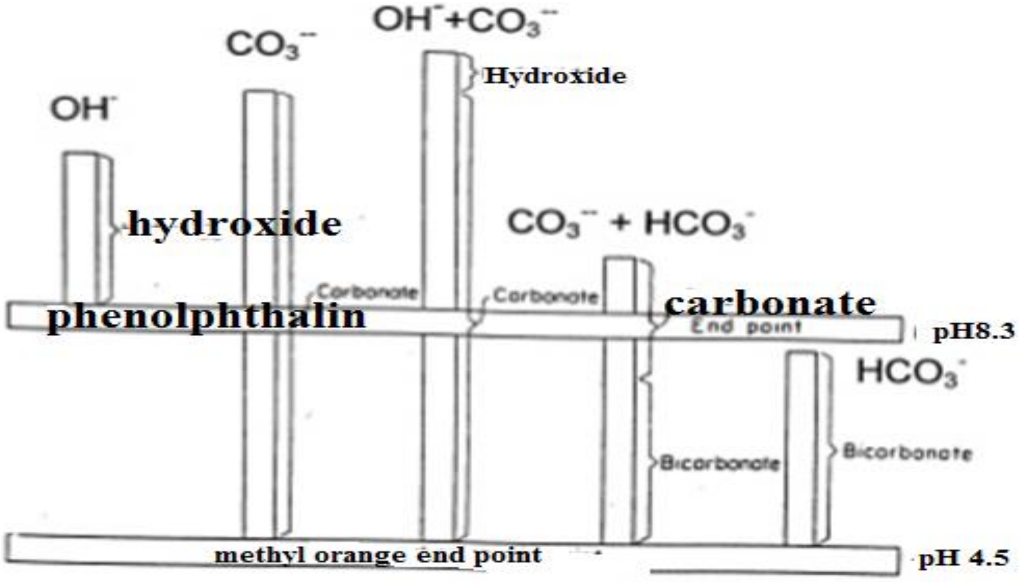


Fig alkalinity relationship

Alkalinity relationship

The alkalinity due to various compartments can be demarcated by (i) empirical relationships (ii) calculation of alkalinity from pH and alkalinity measurements (iii) calculation from equilibrium equations. Out of which the first method is approximate for pH>9, can be used for a quick estimation of various types of alkalinities. It is based on the assumption that bicarbonate and hydroxide alkalinity cannot exist together and also that half the carbonate alkalinity is neutralised when pH is reduced to 8.3.Alkalinity relationships are given below

Results of titration	**Hydroxide alkalinity as mg/l of $CaCO_3$**	**Carbonate alkalinity as mg/l of $CaCO_3$**	**Bicarbonate alkalinity as mg/l of $CaCO_3$**
P=0	0	0	T
$P<\frac{1}{2}T$	0	2P	T-2P
P=1/2T	0	2P	0
P>1/2T	2P-T	2(T-P)	0
P=T	T	0	0

Results of titration	**Hydroxide alkalinity as mg/l of $CaCO_3$**	**Carbonate alkalinity as mg/l of $CaCO_3$**	**Bicarbonate alkalinity as mg/l of $CaCO_3$**

Application of Alkalinity Data

Information concerning alkalinity is used in a variety of ways in environmental engineering practice. In chemical coagulation, alkalinity acts to buffer the water in a pH range where the coagulant can be effective. Alkalinity must be present in excess of that destroyed by the coagulant for effective and complete coagulation of water. Alkalinity is a major item that must be considered in calculating the lime and soda ash requirements in softening water by precipitation methods. Alkalinity is an important parameter involved in corrosion control and as a means of evaluating the buffering capacity of wastewaters and sludge. Alkalinity is an important factor in determining the amenability to wastewaters to biological treatment.

DISCUSSION

QUESTIONS

1)What are the various type of alkalinity

Hydroxide , carbonate and bicarbonate alkalinity

2)What is the major form of alkalinity ?how is it formed

Major form of alkalinity is bicarbonate alkalinity which are normally seen in water as salt of calcium and magnesium. They impart temporary hardness to water. Their presence is governed by the fact that at lower pH carbonates present in water changes to bicarbonates . At normal pH of 6.6-8.5 only bicarbonate alkalinity is present

3)What is excess alkalinity ?how do you express it

Alkalinity in excess of total hardness is called excess alkalinity

4) Why do we use 0.02N H2S04 for titration

We use a diluted form of acid for titration so that the end point of the titration is clearly visible

5)The water where algae are flourishing is alkaline why ?will there be any diurnal variation in pH

Algae removes carbon dioxide in their photosynthetic activity and due to that pH increases. These activity takes place during day time and during night time respiration n takes place where algae gives out carbon dioxide and hence the pH gets reduced . Hence there is diurnal variation in pH in water bodies where Algae is flourishing

6)Why does pH change during aeration

While aerating carbon dioxide escape from water or absorb it from the atmosphere depending upo n the availability of carbon dioxide in the water . if carbon dioxide is absorbing pH will decrease and if escaping pH will increaser

7)For efficient coagulation water must be alkaline Why

When coagulation takes place coagulant reacts with alkalinity for the formation of hydroxides and that is possible only if sufficient alkalinity is present

8)Why do we use CO2 free distilled water for analysis

If CO2 is present it forms carbonic acid which is not desirable for any chemical analysis

Experiment No:…… **Date:…………………**

DETERMINATION OF HARDNESS IN WATER

AIM

To determine the total hardness of the given samples by EDTA titrimetric method

GENERAL

Hard waters are generally considered to be those waters that require considerable amounts of soap to produce foam or lather and that also produce scale in hot water pipes, heaters, boilers, and other units in which the temperature of water is increased materially. Hardness is caused by divalent metallic ions. Principal cations and anions causing hardness in water are presented in the table given below.

Cations causing Hardness	Ca^{++}	Mg^{++}	Sn^{++}	Fe^{++}	Mn^{++}
Associated anions	HCO_3^-	SO_4^-	Cl^-	NO_3^-	SiO_3^-

As Ca and Mg are present in significant quantities in water hardness is generally attributed due to their presence. When the hardness is numerically greater than the sum of carbonate and bicarbonate alkalinity, the amount of hardness that is equivalent to total alkalinity is called the carbonate hardness and the balance is non-carbonate hardness. When the total hardness is less than the sum of carbonate and bicarbonate alkalinity, hardness is due to carbonate only. Sodium in very large quantities may behave like a hardness producing ion due to common ion effect. Hardness due to such causes is called pseudo hardness.

When alkalinity < total hardness, Carbonate hardness= alkalinity

When alkalinity >= total hardness, Carbonate hardness= total hardness.

Carbonate hardness is called temporary hardness as it can be removed by prolonged boiling while non-carbonate hardness is called permanent hardness.

PRINCIPLE

Ethylene diamine tetra acetic acid (EDTA) method of determination of hardness, involves the use of solutions of EDTA or its sodium salt as the titrating agent. The complexes usually represented as EDTA, are chelating agents and form extensively stable complex ions with Ca^{++}, Mg^{++} and other divalent ions causing hardness, as shown in the equation.

$$M^{++} + EDTA \longrightarrow M.EDTA\ complex$$

The dye called Erichrome black T (EBT) serves as excellent indicator to show when all the hardness producing ions have been complexed. When EBT is added to the aqueous solution containing small calcium and magnesium ions at a pH of 10+/-0.1, the solution becomes wine red. Higher the pH sharper the end point. However, above pH 10, there is a danger of precipitation of calcium carbonate and magnesium hydroxide. When a small amount EBT, having a blue colour, is added to a hard water with a pH of about 10.0, it combines with a few of the Ca^{++} and Mg^{++} ions to form a weak complex ion which is wine red in colour as shown in equation.

$$M^{++} + EBT \longrightarrow M.\ EBT_{\ complex}$$

During the titration with EDTA, all free hardness ions are complexed. Finally the EDTA disrupts the red EBT because it is capable of forming a more stable complex with the hardness ions. This action frees EBT indicator, and the wine red colour changes to a distinct blue colour, indicating the end of the titration. An accurate method of determining hardness is calculation based upon concentration of divalent ions found by separate analysis of each ion.

APPARATUS

1. Burette
2. Pipette.
3. Erlenmeyer flask

REAGENTS

1. 0.01M EDTA
2. Ammonium buffer -2drops.
3. Erichrome black T
4. Litmus paper.

PROCEDURE

1. A sample volume V which requires less than 15 ml EDTA titrant is chosen.
2. Dilute 25 ml of the sample in the Erlenmeyer flask to 50 ml by adding distilled water.
3. One or two ml of the buffer solution is added so as to bring the pH to 10 +/- 0.1.
4. One or two drops of the indicator solution(Eri chrome Black T) are added. If there is Ca or Mg hardness, solutions turn wine red.
5. EDTA titrant is added with vigorous shaking till the wine red colour just turn blue.
6. The volume of the titrant added is noted down (V_1).

Hardness in mg/l as calcium carbonate =

Where V_1 = ml of titrant used.

V= volume of sample

S = mg $CaCO_3$ equivalent to 1 ml of EDTA titrant = 1mg $CaCO_3$

Tabulation and Calculation

Sample No	Repetition N	Volume of sample(V)ml	Burette reading		Volume of EDTA (V_1)	Hardness in (mg/l) as CaCO3
			Initial	Final		

Application of Hardness Data

Hardness of water is an important consideration in determining the suitability of water for domestic and industrial uses. It is used as a basis for recommending the need for domestic process. The relative amounts of calcium and magnesium hardness and of carbonate and non-carbonate hardness present in water are factors in determining the most economical type of softening process to use.

DISCUSSION

QUESTIONS

1How do hardness is classified

Depending upon the presence of hardness , it is classified in to the following

degree of harness	range of hardness in mg /litre
Soft	0-75
moderately hard	75-150
hard	150-300
very hard	Greater than 300

1)What are principal cations causing hardness in water and the major anions associated with them?

Cations – Calcium and magnesium

Anions –carbonates, bicarbonates , chlorides . sulphate

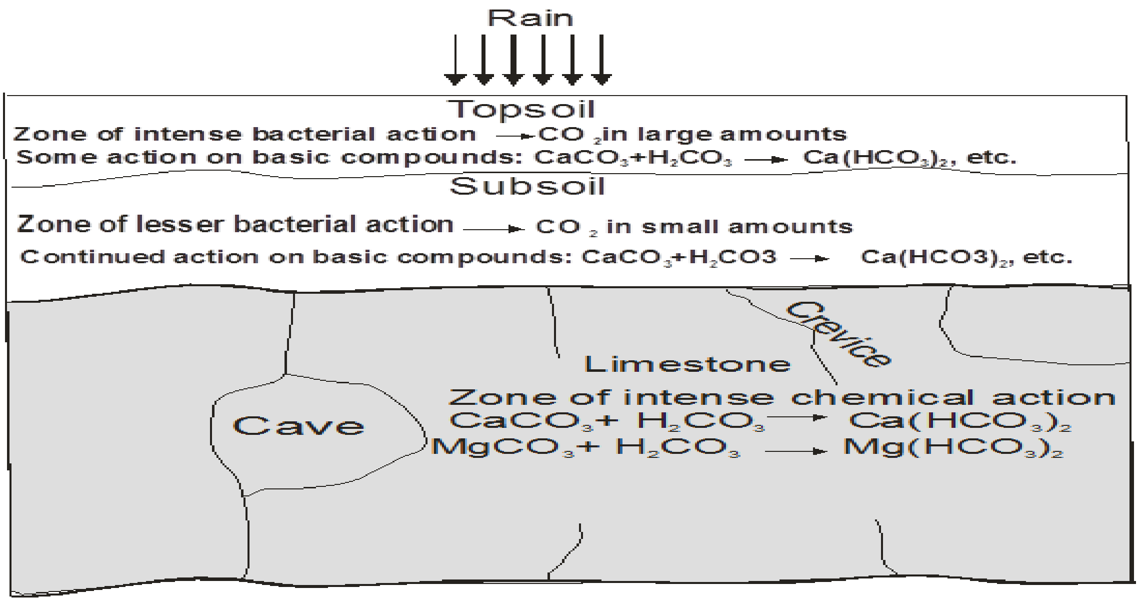
2) Why is softening of water necessary? What are the advantages of soft water?

The process of converting the hard water in to soft water is essential for water having more hardness . softening is essential if the water is reasonably hard in order to avoid the important bad effects of hardness

Soft water is advantageous as it is not having any of the bad effects of hard water

3)What is the source for hardness

Harness is caused by multivalent metallic cations , the principal hardness causing cations are calcium , magnesium ,strontium ,ferrous iron . These ions are mainly dissolved from the crust of the earth by the process shown below . The ability to dissolve minerals from the crust of the earth is mainly obtained from the presence of CO2 in water which is obtained from the crust of the earth by bacterial action. Due to this low pH condition prevails in th water just below the surface of the earth with formation of carbon dioxide in the water . When this water percolates through the earth reaction takes place between carbonic aid and aicum and magnesium carbonate in the earth with formation of bicarbonate and also that results in to dissolution of basic materials from the crust of the earth as shown below



4)Explain the principle of volumetric analysis

Reaction between two mutually reactive chemicals
A chemical of known strength is used which is termed as reagent
End point is denoted by colour change using an indicator
Indicator reacts with the excess chemical added and thus the colour is formed

5)what is pseudo harness

Sodium is present in sea or brackish water . Soap contains sodium as sodium stearate . sodium interfere with normal behavior of soap because of common ion effect . this action will exhibit even though sodium is not hardness causing

6) What is the environmental significance of hardness

Excess Hardness is undesirable since it causes over consumption of soap . scaling in boilers ,incrustation in pipes . softening is decided on the basis of hardness presence . But recent studies revealed that hard water is good to control heart diseases

6)How is hardness classified

Hardness is classified under the following types

1)Permanent hardness and temporary hardness

2)Calcium and magnesium hardness

3) Carbonate and non carbonate hardness

7)Permanent hardness and temporary hardness or carbonate hardness or non carbonate hardness

Sum of Bicarbonate and carbonate alkalinities are called carbonate hardness

When alkalinity is less than hardness carbonate hardness = Alkalinity

When alkalinity is greater than or equal to total hardness

Carbonate hardness = total harness

Permanent hardness is also known as carbonate hardness since it is caused by carbonate and bicarbonate

If $HCO3^-$ and $CO3^-$ of calcium and magnesium are present in water, the water is rendered hard temporarily and such hardness is known as temporary hardness. temporary hardness can b removed by boiling. If sulfate, chloride and nitrate of calcium and magnesium are present such hardness cannot be removed by boiling and it is called permanent hardness

Calcium and Magnesium hardness

Calcium and magnesium are the important cations present in water. For some purpose it is important to calculate the amount of hardness caused by calcium and magnesium by assuming that the complete hardness is caused by calcium and magnesium alone

8) what is the health significance of hardness

By study it is revealed that hardness is effective in reducing heart disease s

7)How do you determine permanent and temporary hardness

Alkalinity is found out separately. Temporary harness is equal to total hardness or alkalinity whichever is less. permanent hardness is the total hardness in excess of alkalinity

8) why do we get white deposit on boiling hard water containing temporary hardness

Temporary hardness means appreciable amount of $Ca(HCO3)_2$. While boiling this dissociates as follows

$Ca(HCO3)_2=CaCO_3 +CO_2 +H_2O$

$CaCO_3$ is the white deposit

9)**Generally hardness is considered as caused by Calcium and Magnesium and hardness is more in deep water sources .What is the real source for calcium and magnesium in such cases**

While rain water reaches the earth CO2 dissolves in it making the water acidic. as it percolates it reacts with caco3 and mgco3 to form CaHco3 and Mg Hco3. Thus, calcium and magnesium reach the water

Experiment No:…… **Date:…………………**

DETERMINATION OF CHLORIDES

AIM

To determine the amount of chloride present in the given water sample by Mohrs method

GENERAL

Chlorides occur in all-natural waters widely varying concentrations. The chloride content normally increases as the mineral content increases. Chlorides gain access to natural waters in many ways. The solvent power of water dissolves chlorides from topsoil and deeper formations. Chlorides in natural water result from chloride breaking rocks or salts and in coastal areas from salt-water intrusion. In addition, agricultural, industrial, and domestic wastes are also sources of chlorides in water. Human excreta and urine contain large amount of chloride. So, the presence of excess chloride in water indicates the possibility of contamination of water by sewage.

PRINCIPLE

Chlorides can be determined by either Mohr method (argentometric) or by mercuric nitrate method, of which former is described here. The method employs a solution of silver nitrate for titration (N/71). This corresponds to a solution of N/71 or one in which each ml is equal to 0.5mg of chloride ion. In the titration, the chloride ion is precipitated as a white silver chloride.

$$Ag^+ + Cl^- \qquad AgCl \qquad \longrightarrow$$

The end point cannot be detected by eye unless an indicator capable of demonstrating the presence of excess Ag+ is present. The indicator used is potassium chromate, which supplies the chromate ions. As the concentration of chloride ions approaches extinction, the silver ion concentration increases to a level at which the solubility product of silver chromate is exceeded and it begins to form a reddish brown precipitate.

$$2Ag^{++} + CrO_4^{2-} \rightleftharpoons Ag_2CrO_4. \downarrow$$

(Reddish brown ppt)

Since excess amount of Ag^+ is needed to produce visible amount of Ag_2CrO_4 the indicator blank must be determined and subtracted from all the titration.

APPARATUS

1. Burette
2. Pipette
3. Erlenmeyer flask

REAGENTS

1. Chloride free distilled water.
2. Potassium chromate indicator solution.
3. Standard silver nitrate titrant 0.0141N
4. Standard sodium chloride 0.0141N
5. Special reagent to remove interference- Aluminium hydroxide suspension.
6. Sodium hydroxide or Sulphuric acid

Bromide, iodide and cyanide register equivalent chloride concentrations. Sulphite, thiosulphate and sulphide ions interfere but can be removed by treatment with hydrogen peroxide

PROCEDURE

1. Take 100ml sample or a suited portion diluted to 100 ml is selected (V).
2. If the sample is coloured 3ml of aluminium hydroxide suspension is added, mixed, settled, filtered, washed and filtered, washed and collected.
3. If sulphide, sulphate or thiosulphate present 1 ml of H_2O_2 is added and stirred for 1min.
4. Sample is brought to a pH of 7-10 by adding H_2SO_4 or NaOH as required.
5. 1ml of chromate indicator solution is added.
6. This is titrated against standard silver nitrate titrant till the pinkish yellow colour is obtained (V1).
7. The procedure is repeated for the blank with distilled water and note down the volume of titrant used (V2).

Tabulation and calculation

Sample number	Trial number	Volume of sample	Burette Reading		Volume of silver Nitrate	Chloride Mg/litre
			Initial	final		

Chloride in mg/l =

Where

V = volume in ml of sample

V1 = ml of titrant for sample

V2 = ml of titrant for blank.

N = Normality of silver nitrate solution

Application of Chloride Data

In many areas the level of chlorides in natural waters is an important consideration in the selection of supplies for human use. Where brackish waters must be used for domestic purposes, the amount of chlorides present is an important factor in determining the type of desalting apparatus to be used. The chloride determination is used to control pumping of ground water from locations where intrusion of seawater is a problem. Chlorides also interfere in the determination of chemical oxygen demand

DISCUSSION

In both the cases the limit for chloride is below the acceptable limit and can be used for drinking purposes

QUESTIONS &ANSWERS

1)What are the sources of chloride in water

The main sources of chloride in drinking water is

a)intrusion of sea water in to coastal water sources
b)brine or industrial waste
c)Domestic waste
d)from rock and soil (saline soil) formations

2) Explain the need for blank correction while titrating for chloride determination

For determining the chloride content in water , it is titrated against silver nitrate using potassium chromate as an indicator .silver nitrate reacts with chloride and silver chloride is formed as given below

$Ag\ NO3 + Cl = AgCL$

When the chloride is extinct Ag NO3 reacts with potassium chromate and silver chromate is formed

$Ag^{+} + CrO4 = Ag\ _{2}CrO4$

And reddish-brown precipitate is formed

But in order to get a clearly visible reddish brown precipitate of $Ag\ _{2}CrO4$ some excess silver nitrate is required . in order to find that quantity of Ag NO3 it is titrated against distilled water to find the requirement of silver nitrate for appearance of reddish-brown precipitate

3)While titration for computing chloride is performed pH should not be too low or too high, Why?

At high pH Ag OH may be formed and also at high pH $CrO4^{2-}$ will be converted as CrO_4^{-1}

4) Why the normality of $AgNO_3$ is taken as 0.0141

Normality is usually taken as 1/equivalent weight =1/35.46 in the case of silver nitrate which is about 0.0282N. This value is higher and the end point may not be clearly visible. In order to get a clear end point ½ of this normality is taken which is equal to 0.0141N

5) Sewage contains less quantity of salt than drinking water why?

Sewage contains domestic and industrial waste water which contains appreciable amount of chloride whereas drinking water contains almost nil chloride

6) What is the effect of quantity of indicator on the end point while titrating for chloride

A definite amount of indicator must be used to provide a certain concentration CrO_4^{2-} or AgCrO4 may either too soon or too late. For example if excess of indicator is used, the volume of $AgNO_3$ used will be less , which will indicate lower value of chloride than actually present

7)What is the significance of chloride in drinking water?

Chloride does not pose a health hazard to humans and the principal consideration is in relation to palatability.

a) Salty taste

b) corrosion

8)Describe the bad effect of chloride in drinking water

Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water. Chloride increases the electrical conductivity of water and thus increases its corrosivity. In metal pipes, chloride reacts with metal ions to form soluble salts , thus increasing levels of metals in drinking-water. No serious health effects due to chloride are noticed except that higher intake may cause blood pressure

Experiment No:…… **Date:…………………**

DETRMINATION OF AVAILABLE CHLORINE IN BLEACHING POWDER

AIM

To determine the available chlorine in the given sample of bleaching powder by using iodometric method

GENERAL

Disinfection of water is essential for preventing the widespread of water borne diseases like cholera; typhoid etc. Chlorination is the most widely accepted method of disinfection. Of the different forms of chlorine used for disinfection, bleaching powder is the one commonly used for small water supply schemes and individual wells. It is produced by passing gaseous chlorine through lime when chlorinated lime or “chloride of lime “is formed.

$$Ca(OH)_2 + Cl_2 \longleftrightarrow Ca(OCl)_2 + H_2O$$

Chlorine will easily escape from bleaching powder. Hence, the determination of available chlorine in bleaching powder is essential for checking its effectiveness in application.

PRINCIPLE

Available chlorine in bleaching powder is measured by Iodometric method. The quality of bleaching powder is measured by the amount of available chlorine in it, which is determined on the basis of reactions given below.

$$Ca(OCl)_2 + 2HCl \longrightarrow CaCl_2 + H_2O + Cl_2$$

$$2KI + Cl_2 \longrightarrow 2KCl + I_2.$$

The iodine liberated, which is equivalent to the amount of active chlorine present. The amount of liberated iodine (thus the amount of chlorine) is quantified by titrating it with standard sodium thiosulphate using starch as an indicator. As lime absorbs certain chlorine compounds, a suspension is used for the determination of available chlorine.

APPARATUS

1. Weighing balance.

2. Mortar and pestle
3. Volumetric flasks
4. Burette
5. Pipettes
6. Erlenmeyer flasks.

REAGENTS

1. Glacial acetic acid- 5mL
2. Potassium Iodide solution 20% strong
3. Sodium thiosulphate solution 0.025N
4. Starch indicator.

PROCEDURE

1. Weigh 1 gm. Bleaching powder and grind it thoroughly in a mortar with 5ml-distilled water.
2. Transfer the content into a 250ml volumetric flask. Rinse the mortar with distilled water and pour into the flask. Make up to 250ml with distilled water and shake well to form a suspension.
3. Pipette out 25ml of the suspension into an Erlenmeyer flask and add 5-7 ml potassium iodide solution and 5ml of glacial acetic acid.
4. Titrate the contents with sodium thiosulphate solution in a burette, using 5 ml starch indicator towards the end of titration (pale yellow).
5. Again titrate till the blue colour disappears.
6. Repeat steps from 3 to 5 three or four times.

Calculation

Normality of thiosulphate = 0.025

1ml of thiosulphate contains 0.025/1000gm equivalent which corresponds to 1 gm equivalents of chlorine

Gram equivalent of chlorine = 35.45

Therefore gm of chlorine content/ml of thiosulphate = 0.025x35.45/1000

= 0.00088 gm .Cl. /ml

For Xml of titrant used, chlorine content = 0.00088 X gm

This is the quantity of Cl_2 available in 25 ml sample taken for titration.

So the quantity of Cl_2 in 250 ml = 0.00088X x 250/25

As 1gm of bleaching powder is taken originally,

= 0.00880X gm/gm of bleaching powder.

% available chlorine = 0.88X

Where X = ml of sodium thiosulphate used for titration.

TABULATION AND CALCULATION

Sl. no.	Repetition No.	Volume of sample (ml)	Burette reading		Volume of thiosulphatee (ml)	Average (ml)
			Initial	Final		

APPLICATION

Chlorinated lime (or bleaching powder) is being used widely for small water supply schemes and individual wells as disinfectant. As the chlorine can escape very easily from bleaching powder the available chlorine in the bleaching powder can vary drastically. Hence the available chlorine in bleaching powder needs to be ascertained before fixing its dosage.

DISCUSSION

QUESTIONS

1) What is bleaching powder

Bleaching powder is mostly Calcium hypochlorite is $Ca(ClO)_2$ with little lime and calcium chloride, it is marketed as **chlorine powder** or **bleach powder** for water treatment and as a bleaching agent. It is a white solid, although commercial samples appear yellow. It strongly smells of chlorine,

2)How bleaching powder is prepared

Bleaching powder is used for disinfection of water and it is prepared by passing chlorine gas through lime what is meant by water quality standards

3)what is the approximate percentage of chlorine gas in bleaching powder?

25-30%

4) Content of chlorine in a particular bleaching powder is 23%. Comment on the result and estimate the quantity of this bleaching powder required to chlorinate 1.4 mld water @2mg /litre of chlorine

Quantity of chlorine required for treating the water -1.4×10^6 liters x2 mg / litre=$2\times1.4\times10^6$mg=2x1.4 kg=2.8

Percentage chlorine in bleaching powder =23

Quantity of bleaching powder required is =2.8/.23=12.17kg

Experiment No:…… **Date:…………………**

DETERMINATION OF DISSOLVED OXYGEN

AIM

To determine the quantity of dissolved oxygen in the given sample of water

GENERAL

In liquid wastes, dissolved oxygen is a factor that determines whether the biological changes are brought about by aerobic or by anaerobic organisms. Dissolved oxygen (DO) level in natural and wastewater depend on the physical, chemical and biochemical activities in the water body. The analysis for DO is a key test in water pollution and waste treatment process control. Adequate DO is necessary for the life of fish and other aquatic organisms. The DO concentration may also be associated with corrosivity of water, photosynthetic activity and septicity. Analysis shall be carried out preferably at the time of collection. The DO test is used in the Biochemical Oxygen Demand determination. If immediate analysis is not possible, DO shall be fixed by adding the reagents manganese sulphate solution followed by alkali iodide azide to the sample.

PRINCIPLE

The Winkler method or its modifications are based on the fact that oxygen oxidizes Mn^{2+} to a higher state of valence under alkaline condition and that manganese in higher state of valency is capable of oxidizing iodine ion to free iodine under acid conditions. Thus the amount of free iodine released is equivalent to dissolved oxygen present.

Reactions involved are as follows

$Mn^{2+} + 2 OH^- \rightleftharpoons Mn(OH)_2$

$Mn(OH)_2 + 1/2\, O_2 \longrightarrow MnO_2 + H_2O$

When acid is added, under low pH condition MnO_2 oxidizes Iodine to produce free iodine.

$MnO_2 + 2I^- + 4H^+ \longleftarrow Mn^{2+} + I_2 + 2\, H_2O$

The iodine is then titrated with a standard solution of thiosulphate. The titration end point can be detected visually, with a starch indicator.

APPARATUS

1. Burette.
2. Pipette.
3. BOD bottle.
4. Conical flask.
5. Volumetric flask.
6. Erlenmeyer flask.

REAGENTS

1. Manganese sulphate solution
2. Alkali iodide azide
3. Conc. Sulphuric acid
4. Starch solution
5. Standard sodium thiosulphate titrant (0.025N)
6. Standard potassium bi-iodate solution.

PROCEDURE

1. To 300 ml sample in a BOD bottle, add 2 ml manganese sulphate solution.
2. Then add 2 ml alkali iodide azide reagent.
3. Insert the stopper and mix by inverting the bottle 15 times. Precipitate is allowed to settle giving a clear supernatant solution (White precipitate is formed, if there is no DO and a brown precipitate is formed, if DO is present).
4. Add 2 ml concentrated sulphuric acid. Insert stopper and shake well.
5. From the bottle, 203 ml of content is taken out. (This is because 200 ml of original sample must be used for titration. As 2 ml of each manganese sulphate and alkali iodide azide have been added, the quantity corresponds to 200 ml, is, 200 x 300/(300-4)=203ml.)
6. Titrate this against 0.025N sodium thiosulphate solution to get a pale straw yellow colour.
7. 1-2 ml of starch solution is added which turns its colour to pale blue.
8. . Titrate again till the pale blue colour just disappears and note the corresponding reading

Tabulation and Calculation

Sample No	Volume of sample	Burette Reading		Volume of titrant	Dissolved oxygen of saturat
		Initial	Final		

Volume of titrant used, V ml= V mg/l of DO

DISCUSSION

Dissolved Oxygen

1) What is dissolved oxygen

Dissolved Oxygen (DO) is the amount of oxygen dissolved in water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. The amount of oxygen hold bywater can is directly related to partial pressure of oxygen in the atmosphere , temperature,c hloride content and level of pollution . At low temperature , the more dissolved oxygen it can hold.

2)what is the source of dissolved oxygen in water

oxygen in water is generally absorbed from the atmosphere

3)What are the factors that govern the presence of oxygen drinking water

Temperature and chloride presence are two factors that govern the presence of Dissolved oxygen in drinking water .Increased temperature and increased chloride content reduce dissolved oxygen . Excess presence of waste also reduces the absorption of oxygen in to the water

3)Discuss the environmental significance of dissolved oxygen.

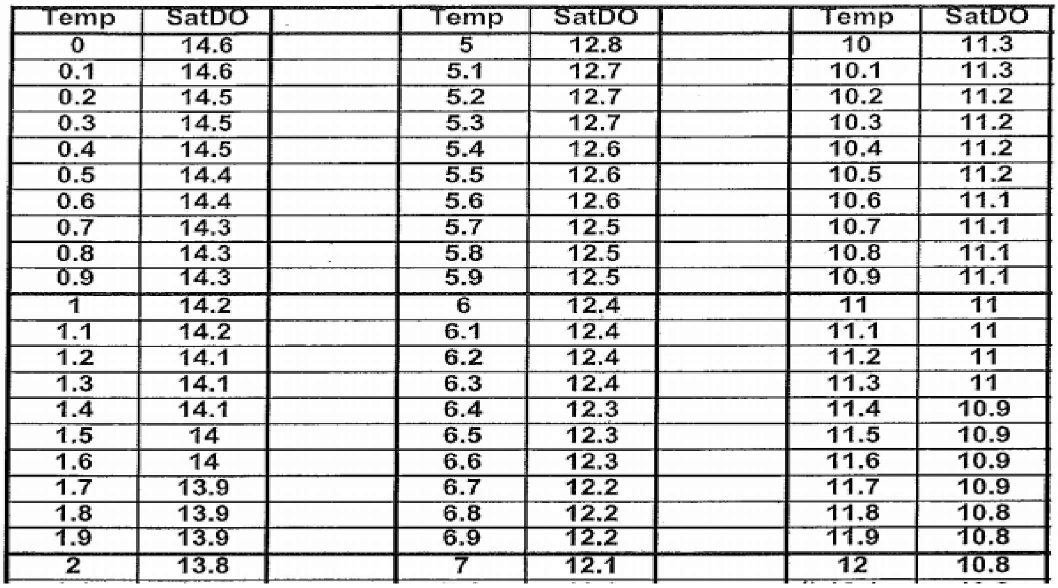
Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

5)Why do we say that flowing water is generally pure

In flowing water more oxygen will b absorbed and that oxygen will help not only to increase the oxygen content to but also it oxidizes waste material s . growth of bacteria will be more and that consumes the organic water in the water and thus reducing pollution

6) what is meant by saturation oxygen

There is a limit for absorbance of oxygen in to the water . IT depends on temperature and chloride and waste . the maximum oxygen that can be freely retained by water at a particular temperature is called saturation oxygen. The Saturation DO at different temperatures are given below



Temp	SatDO		Temp	SatDO		Temp	SatDO
0	14.6		5	12.8		10	11.3
0.1	14.6		5.1	12.7		10.1	11.3
0.2	14.5		5.2	12.7		10.2	11.2
0.3	14.5		5.3	12.7		10.3	11.2
0.4	14.5		5.4	12.6		10.4	11.2
0.5	14.4		5.5	12.6		10.5	11.2
0.6	14.4		5.6	12.6		10.6	11.1
0.7	14.3		5.7	12.5		10.7	11.1
0.8	14.3		5.8	12.5		10.8	11.1
0.9	14.3		5.9	12.5		10.9	11.1
1	14.2		6	12.4		11	11
1.1	14.2		6.1	12.4		11.1	11
1.2	14.1		6.2	12.4		11.2	11
1.3	14.1		6.3	12.4		11.3	11
1.4	14.1		6.4	12.3		11.4	10.9
1.5	14		6.5	12.3		11.5	10.9
1.6	14		6.6	12.3		11.6	10.9
1.7	13.9		6.7	12.2		11.7	10.9
1.8	13.9		6.8	12.2		11.8	10.8
1.9	13.9		6.9	12.2		11.9	10.8
2	13.8		7	12.1		12	10.8

Experiment No:…… **Date:…………………**

BIO CHEMICAL OXYGEN DEMAND

Aim -Determine the BOD of a given sample of water

GENERAL

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by bacteria while stabilising biodegradable organic matter under aerobic conditions. BOD test described herein is an empirical test in which standard laboratory procedures are used to determine relative oxygen requirements of wastewaters, effluents and polluted waters. It is an oxidation process in which diverse group of living organisms serve as the medium for the oxidation of organic matter to carbon dioxide and water.

PRINCIPLE

The BOD test is based on mainly bioassay procedure, which measures the dissolved oxygen consumed by microorganisms while assimilating and oxidising the organic matter under aerobic conditions. The sample is sufficiently diluted using prepared dilution water, which contains nutrients and seeding organisms. It is then incubated for 5 days in an airtight bottle, in a dark at a specified temperature at 20^0 C when the organisms oxidise the organic matter using part of oxygen present in the sample. The oxygen remaining in the sample can be determined. The difference between oxygen remaining and that present in the original sample is the 5-day BOD of the sample. The total or ultimate BOD may be determined using the relation.

$$L_t = L\,(1-10^{-kT})$$

L_t = BOD at any time. T = Time in days.

L = Ultimate BOD. K = Rate constant of the reaction.

K value is usually assumed as 0.1 / day. Actually it is not constant, but depends on the nature of organic matter and the ability of microorganisms in decomposing the organic matter.

APPARATUS

1. BOD incubator, thermostatically controlled at 20 ^{0}C
2. BOD bottles : 250 – 300 ml capacity

3. Pipette
4. Burette
5. Air compressor

REAGENTS

1. Distilled water
2. Phosphate buffer solution
3. Magnesium sulphate solution
4. Calcium chloride solution
5. Ferric chloride solution
6. Acid and alkali solution 1 N
7. Seeding.

PROCEDURE

1. Distilled water is aerated at 20 ^{0}C.
2. Take sample amount of this water and add 1 ml each of phosphate buffer, $MgSO_4$, $CaCl_2$ and $FeCl_3$ solution per litre of water.
3. Seed the sample with 2–5 ml of domestic settled sewage per litre of diluting water. (Seeding not required for surface water samples and domestic sewage)
4. Neutralise the sample with 1 N NaOH or H_2SO_4 to pH 7.0.
5. If residual chlorine is present, that is destroyed by adding $Na_2S_2O_3$ solution.
6. Make several dilutions of prepared samples to obtain the required dilution; 0.1- 1% dilution for strong trade waste, 1-5% for raw and settled sewage, 5-25% for oxidised effluents and 25-100% for polluted waters are the recommended dilutions.
7. Make initial DO determination for each dilution.
8. Determine the oxygen depletion of dilution water, by keeping another two BOD bottles with dilution water, one for initial DO determination and other for fifth day determination.
9. Water seal the tops of BOD bottles by pouring distilled water and incubate at 20^{0}C for 5 days (As per IS 3025, incubate for 3 days at 27^{0}C).

Calculation

$$\text{BOD in mg/l} = \frac{(D1 - D5) - (B1 - B5) * f}{P}$$

D1 = DO of diluted sample in 15 mints after dilution.

D5 = DO of diluted sample after incubation.

B1 = DO of dilution seed control before incubation.

B5 = DO of dilution seed control after incubation.

f = Ratio of the dilution water used for dilution of sample and dilution water used in B1 & B5.

P = decimal volumetric fraction of sample used

If no dilution seed is added BOD in mg/l =

Sl.No.	DO of diluted sample D1 mg/l.	DO of sample after incubation, D3mg/l	P	BOD, mg/l

EXPRESSION OF RESULTS

BOD expressed as mg/l 5 days at 20 ^{0}C and round off to the values as follows.

(1) 0 to 10 up to first decimal.

(2) Above 10 as whole number

Application of BOD

The test has wide application in measuring waste loadings to treatment plants and in evaluating the efficiency of treatment systems. Comparison of BOD values cannot be made unless the results have been obtained under identical test conditions. The test has limited application in measuring the actual oxygen demand of surface waters, since the laboratory environment does not reproduce stream conditions, particularly related to temperature, sunlight, biological population, water movement and oxygen concentrations.

DISCUSSIONS

QUESTIONS AND ANSWERS

1) What is the fundamental principle of BOD measurement

BOD test is based on the oxygen consumption by bio organisms while utilizing organic matter . The basic principle is dissolved oxygen measurement and If reduction in oxygen is observed pr oxygen demand is confirmed and it directly gives the BOD. Such a direct measurement is possible only if the BOD value is less than the saturation Dissolved Oxygen approximately around 7 . if it is more naturally the waste water is to be diluted for BOD measurement . In some cases it is also required add additional bacterial colonies for BOD measurement which is referred as seeds

2)What is the use of BOD test in water pollution control?

If BOD is detected it indicates presence of organic matter –that means the general pollution , it is helpful to detect the pollution source and remove

3) Why is it necessary to dilute water for BOD test when the BOD presence is high

BOD is obtained by DO measurement .The maximum possible DO in a water sample is normally iless than 10mg/litre but for waste water the BOD can be as high as 50,000 or even more than that.in such cases to get correct measurement of DO, it is necessary to dilute the sample for BOD measurement

4)What is meant by 5 day BOD and ultimate BOD

BOD depletion by bacteria is very slow and hence it takes more time for BOD reaction to take place . Normally it takes 20 days for depletion of complete BOD but when the BOD measurement was started in England they fixed the 5 day incubation at 20^0C for measurement of BOD but now in India the incubation period is 3 days and temperature is 27^0 C

Experiment No:…… **Date:…………………**

CHEMICAL OXYGEN DEMAND (COD)

AIM

To determine the chemical oxygen demand of a given sample of water

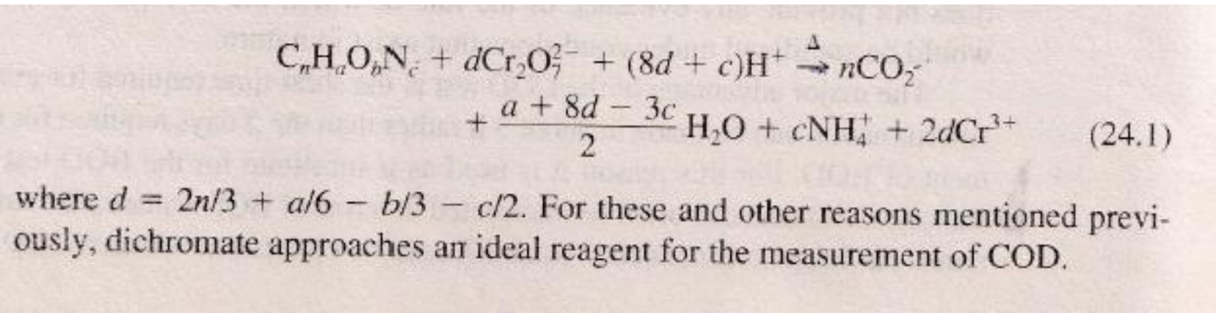
GENERAL

The chemical oxygen demand (COD) determination provides a measure of the oxygen equivalent of that portion of organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. The chemical oxygen demand is widely used as a means of measuring the pollution strength of domestic and industrial wastes. The test allows measurement of a waste in terms of oxygen required for oxidation to CO_2 and water. It is based on the fact that all organic compounds with a few exceptions, can be oxidized by the strong oxidizing agents under acidic conditions. During the determination of COD, organic matter is converted to CO_2 and water regardless of the biological assimilability of the substances. For example, glucose and lignite are both oxidized completely. As a result, COD values are always greater than BOD values and may be much greater when significant amount of biologically non-biodegradable organic matter is present. One of the chief limitations of COD test is its inability to differentiate between biologically oxidizable and biologically inert organic matter. The major advantage of the COD test is the short time required for evaluation. The determination can be done in 3 hours rather than 5 days required in BOD tests. COD data must be correlated with BOD and thus COD values become a useful tool in interpreting BOD values.

PRINCIPLE

Most types of organic matter are destroyed by a boiling mixture of chromic and sulphuric acids. A sample is refluxed with known amounts of potassium dichromate and sulphuric acid, and the excess dichromate is titrated with ferrous ammonium sulphate. The amount of oxidisable organic matter, measured, as oxygen equivalent, is proportional to the potassium dichromate consumed. Potassium dichromate is a powerful oxidising agent in acidic medium and is obtained in a high state of purity.

The reaction involved is



$$C_nH_aO_bN_c + dCr_2O_7^{2-} + (8d + c)H^+ \xrightarrow{\Delta} nCO_2 + \frac{a + 8d - 3c}{2} H_2O + cNH_4^+ + 2dCr^{3+} \qquad (24.1)$$

where $d = 2n/3 + a/6 - b/3 - c/2$. For these and other reasons mentioned previously, dichromate approaches an ideal reagent for the measurement of COD.

Tabulation and calculation

$$\text{mg/l COD} = \frac{(V1 - V2) * N * 8000}{V} \qquad \text{where}$$

V1 = ml of ferrous ammonium sulphate used for titrating against blank.

V2 = ml of ferrous ammonium sulphate used for titrating against sample

N = Normality of ferrous ammonium sulphate.

V = Volume of sample used.

Results are reported in terms of mg of Oxygen. N/8 or 0.125N solution of oxidising agent is used in determination. Normality of double the strength is used. This allows the use of large samples. Thus each ml of 0.25 N solution dichromate is equivalent to 2 mg of oxygen. An excess of oxidising agent is added and the excess is determined by another reducing agent such as ferrous ammonium sulphate. An indicator ferroin is used in titrating the excess dichromate against ferrous ammonium sulphate. Blanks are also treated and titrated to get correct of COD.

APPARATUS

1. Reflux apparatus
2. Burettes
3. Pipettes

REAGENTS

1. Standard potassium dichromate solution 0.025N
2. Sulphuric acid reagent
3. Standard ferrous ammonium sulphate (0.025N)

4. Ferroin indicator solution
5. Mercuric sulphate solution

PROCEDURE

1. Place 50 ml of sample in a 500 ml of refluxing flask.
2. Add 1gm mercuric sulphate and a few glass beads.
3. 5ml of sulfuric acid reagent and dissolve
4. Add 25 ml of 0.025 N potassium dichromate solution and mix well.

5.Add 70 ml sulphuric acid to dissolve the mercuric sulphate and cool.

6.Attach the flask to the condenser and start the cooling water.

7Apply heat and reflux for 2 hour.

5. Cool and wash down the condenser with 150ml distilled water.
6. Titrate the excess dichromate with standard 0.1 N ferrous ammonium sulphate using Ferroin indicator (1 to 3 drops)
7. The color change from blue green to reddish indicates the end point.
8. Reflux in the same manner a blank consisting of distilled water of equal volume as that of sample.

. Sl.no.	Volume of sample ml	V1 ml.	V2 ml.	COD, mg/l

APPLICATION OF COD TEST

The COD test is used extensively in the analysis of industrial wastes. In conjunction with the BOD test, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances. The test is widely used in operation of treatment facilities because of the speed with which results can be obtained.

DISCUSSIONS

Questions and Answers

1)What is the purpose of COD test

COD test is an alternate test to BOD for determination of organic strength of domestic or industrial waste water. The test measures oxygen required to oxidise organic waste in a sample by a strong oxidizing agent (potassium dichromate). The basic principle is that under acidic conditions organic matter can be oxidized by strong oxidizing agents

2)What is the difference between BOD and COD ?and how do the analysis method differ

BOD indicate the oxygen demand for bacterial oxidation of organic matter whereas COD indicate the oxygen demand for oxidation of organic matter by using chemicals . Since BOD is a as a result of bacterial activity it is slow process but in the case of COD , chemical oxidation is very fast compared to BOD

3) COD of a well water is high . what do you interpret

The source is polluted with organic matter

4)What is the merit and demerit of COD measurement as compared to BOD

Merit – measurement can be completed within 3 hours

Demerit –Inability to differentiate between biologically oxidisable and biologically inert organic matter

Experiment no **Date**

DETERMINATION OF IRON IN WATER

AIM

To determine the quantity of Iron present in a given sample of water

PRINCIPLE

Iron is brought into solution, reduced to the ferrous state by boiling with acid and hydroxylamine, and treated with 1,10-phenanthroline at pH 3.2-3.3. Phenanthroline combines with Fe^{2+} to form a complex ion, which is orange red in colour. The colour produced conforms to Beer's law and is readily measured by visual or photometric comparison. In the presence of excessive amount of organic constituents, the sample is first digested with sulphuric acid to destroy organic complexes and to ensure complete dissolution of iron. The resulting solution is made up of $FeCl_3$ into after re-extraction of iron into water, it is reduced with hydroxylamine.

$$Fe(OH)_3 + 3H^+ \text{ ------ } Fe^{3+} + 3H_2O \qquad (1)$$

$$4Fe^{3+} + 2NH_2OH \text{ -------- } 4Fe^{2+} + N_2O + H_2O + 4H^+ \qquad (2)$$

(Hydroxylamine)

APPARATUS

1. Spectrophotometer, for use at 510nm wavelength.
2. Acid washed glassware: All glass wares must be washed with concentrated HCl and rinsed with distilled water prior to use to remove any iron oxide present on them.

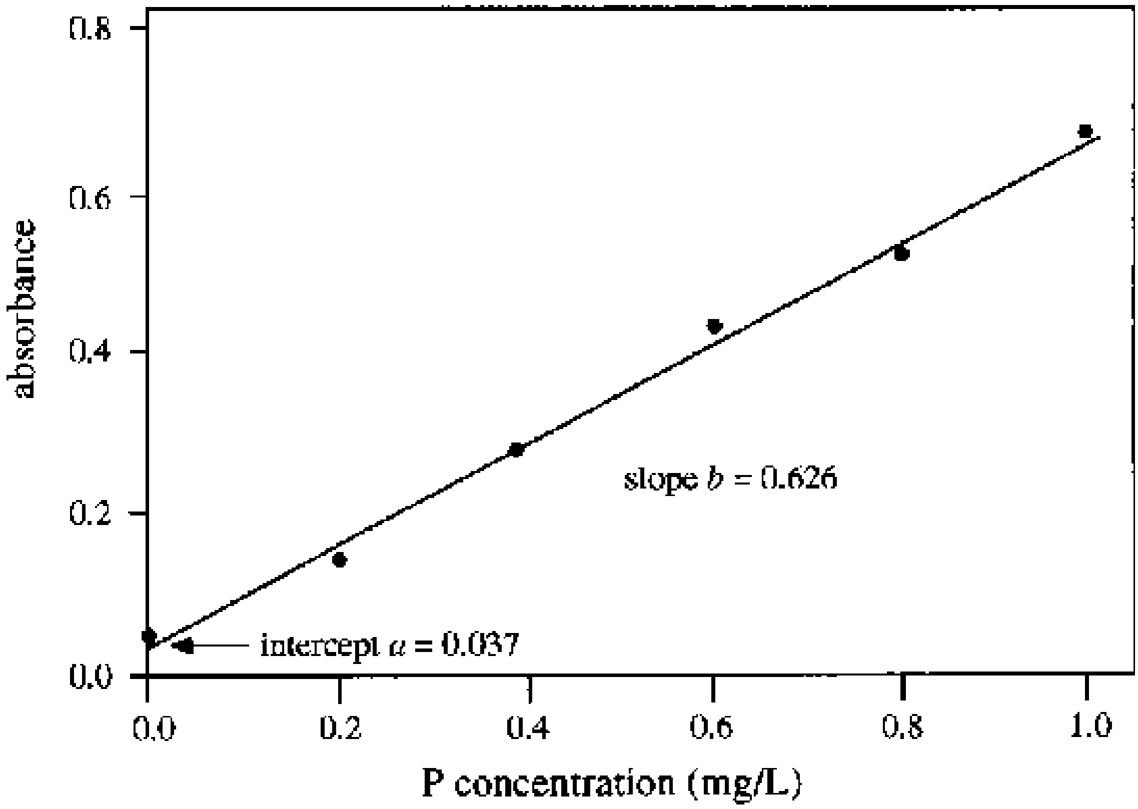
REAGENTS

1. Concentrated Hydrochloric acid
2. Hydroxylamine solution
3. Ammonium acetate buffer solution
4. sodium acetate buffer
5. 1, 10 Phenanthroline solution

Procedure for Standardisation of the Instrument

1. Pipette 10,20,30,40 and 50ml standard iron solution into 100 ml volumetric flasks.

2. Dilute to 50ml except for 50ml stock iron soluition
3. Add 2ml concentrated HCL and 1.0 ml hydroxylamine to each flask.
4. Heat to boiling so that the volume is reduced to 15 to 20ml and cool to room temperature
5. Add 10ml ammonium acetate buffer solution and 4.00ml phenanthroline solution and then dilute to the 100 ml mark and allowed to stand for 10 minutes. For color development
6. The absorbance of each solution is measured at 510nm wavelength
7. A calibration curve is constructed with the data obtained reading along Y axis and concentration along X axis



Analysis of sample

1)The sample is mixed thoroughly and 50 ml is measured into an volumetric flask

2) Add 2 ml of conc. HCl and 1 ml of hydroxylamine solution .

3)Heat to boiling after adding a few glass beads until the volume is reduced to 15 to 20 ml.

4)The contents are cooled. Add10 ml ammonium acetate buffer solution and 4mL of 1,10 phenanthroline solution and diluted with distilled water to 100ml

5)Mix thoroughly and allow at least 10 minutes for maximum colour development.

6)Determine the absorbance using spectrophotometer at 510 nm wavelengths.

7)Obtain concentration from the calibration graph mentioned above

Sample No.	**Sample Volume**	**% Absorbance**	**Iron Content**

DISCUSSION

QUESTIONS AND ANSWERS

1)What are the important bad effects of Iron

No	**Bad effects**	**Reason**
a	iron taste	
b	Change in colour when exposed to atmosphere	(oxidation of ferrous Iron to ferric Iron)- $Fe^{2+} + \ +O_2 + H_2O \ = \ Fe(OH)^3 + H^+$
c	more requirement of milk for preparation of tea to get the minimum flavor	Excess requirement of milk to prepare tea of required flavor(Iron +Tanin = black colour)
d	Staining in vessels	due to oxidation , it is a special property of oxidation to form color
e	Deposition of mud after the water is boiled	More oxidation on heating
f	Oily appearance on the surface of water due to growth of iron bacteria	due to the growth of iron bacteria

3)How do ferrous and ferric iron differ

Fe^{2+} (ferrous)and Ferric (Fe^{3+}) ferrous iron is in dissolved form and ferric iron is in suspended form

4)Explain the principle of colorimetric analysis

Formation of colour due to the reaction of a quality parameter in the water with a predetermined chemical in the prescribed mode.

Formation of colour takes place

Intensity of the colour is proportional to the quantity of chemical present in the water

Intensity of color is measured by using spectrophotometer or calorimeter and the result is obtained from the calibrated graph

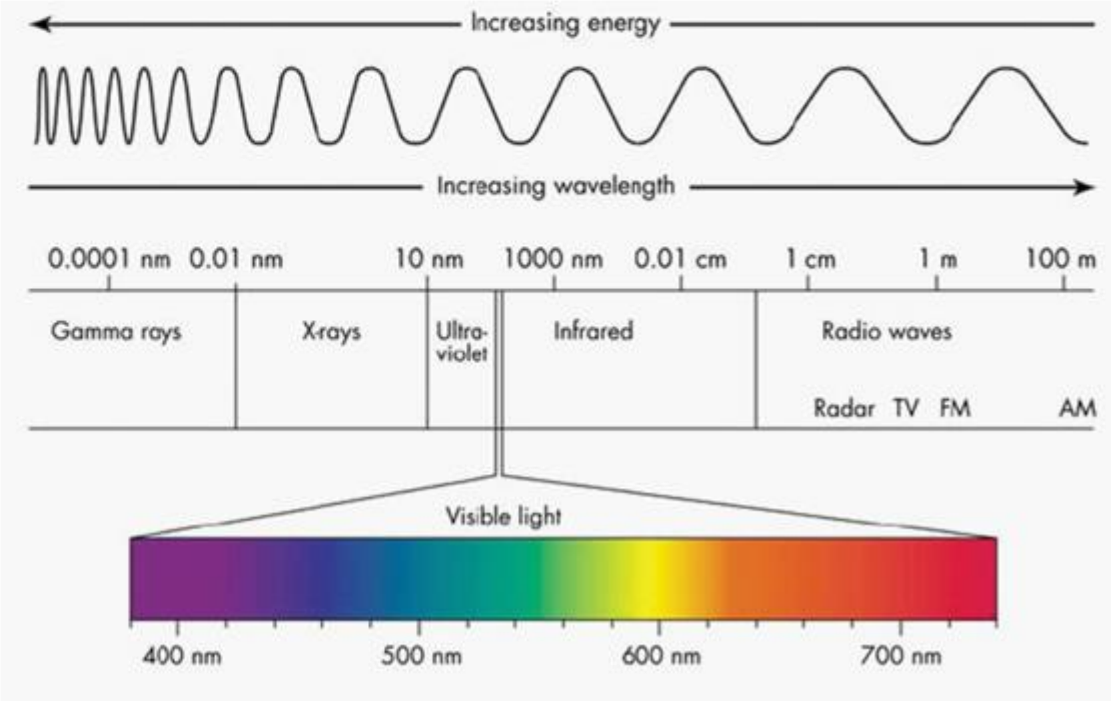
5)What is meant by standardization of a colorimeter for iron measurement

Drawing a graph between concentrations and absorbance is called standardization of the instrument for measurement . The graph is drawn by taking different sample of known concentration of the material and measuring the corresponding absorbance . **Refer item 7 above in the text . Procedure for Standardization of the Instrument**

6)What is the difference between UV -VIS spectrometer and visible spectrophotometer?

In a UV-VIS spectrophotomer , It is possible to produce light with both wavelength in UV range

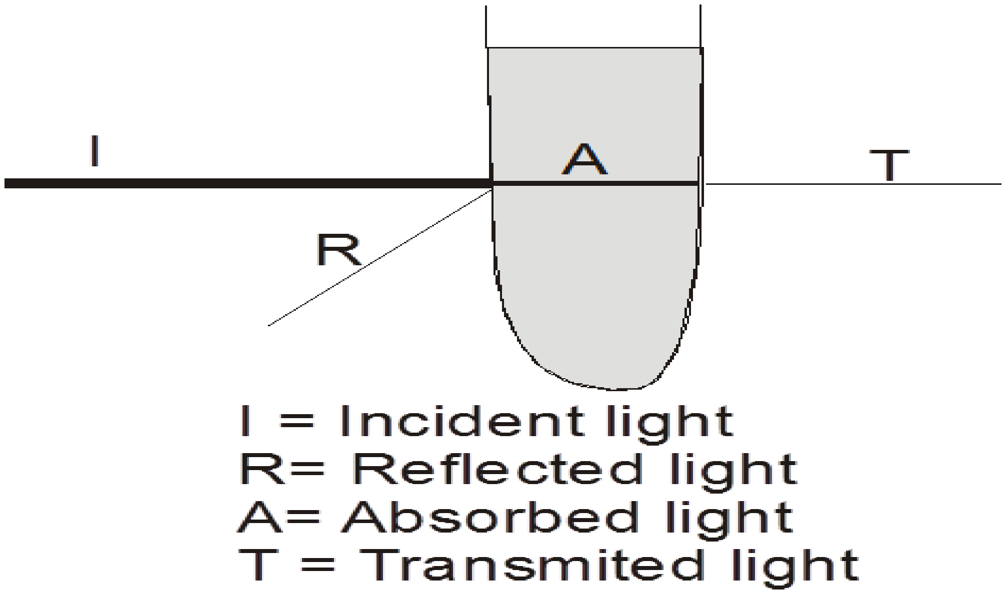
and visible range , you can see the picture in which ,it is marked that approximately between 380-800nm the light is in visible range whereas between 190 -380nm it is in the UV range
in the case of a visible spectrophotometer it is only possible to light having wavelength in the visible range between 380-800nm, which limits its utility



in the case of a visible spectrophotometer it is only possible to light having wavelength in the visible range between 380-800nm, which limits its utility

7)What is the principle of measurement of color intensity

Ray of monochromatic light is passed through the colored liquid, a portion of the light is transmitted, a portion is absorbed another portion is reflected. reflected light is only less and hence either transmittance or absorbance is measured for calibration of the instrument (spectrophotometer, colorimeter). Standardization is performed and the instrument is used for measurement of various water quality parameters.



7)What is common between Iron and manganese

The behaviors of both iron and manganese are almost same

8)How are the iron and manganese removed from water?

Various methods are used for the removal of Iron from drinking water. As we have studied already, upon aeration ferrous iron in the water is oxidised to ferric iron and thus the water becomes turbid. upon sedimentation these particles get settled or filter can be used to remove the oxidised particles. Oxidation of ferrous iron to ferric iron can be accelerated by increasing the pH of the water for which lime can also be used. There are also other commercially methods for removal of Iron from drinking water which are bit costly and is being used by many people

9) Explain the significance of Fe and Mn in environmental engineering

Both iron and manganese are having some aesthetic oriented adverse effect on human beings. So, the limit for iron and manganese has to be strictly maintained in water to limit both within limit

Experiment no **Date**

PRESENCE OF MANGANESE IN DRINKING WATER

AIM

To determine the quantity of manganese in a given sample of water

GENERAL

As far as it is known, humans suffer no harmful effects from drinking water containing manganese. Such waters, when exposed to the air, become turbid and highly unacceptable from the aesthetic viewpoint, owing to the oxidation of manganese to Mn^{4+} by oxygen. It is a state, which forms colloidal precipitates and objectionable colour. Manganese interferes with laundering operations, impart objectionable stains to plumbing fixtures and cause difficulties in distribution systems by supporting growths of iron fixing bacteria.

PRINCIPLE

The method depends on the oxidation of manganese from its lower states of valency to a valency of 7^{+}, where it forms a highly coloured permanganate ion. The colour produced is directly proportional to the concentration of manganese present over a considerable range of concentration and is measured by spectrophotometer or a colorimeter. The persulphate method is suited because pre-treatment of samples is not required. Chloride concentration is reduced by using mercuric sulphate. Sulphate oxidizes manganese to permanganate in the presence of silver nitrate as catalyst. The colour intensity is observed at a wavelength of 525nm in spectrophotometer by measuring its absorbance. The amount of Mn is obtained from the already prepared calibration chart.

APPARATUS

1. Spectrophotometer
2. Acid wash glass wares

REAGENTS

1. Special reagents
2. Ammonium persulphate

3. Standard Manganese solution

PROCEDURE –standardisation

1. Prepare standard Mn solution containing 500, 1500, 2000 micro gram of Mn per litre
2. Take 50 ml.of sample
3. add 5ml of special reagent and one drop H_2O_2
4. Dilute to 90ml.
5. Add 1gm of Ammonium persulphate, boil for 1 min. and then cool under the tap.
6. Dilute to 100ml with distilled water.
7. Measure the absorbance of the standard Mn solution prepared by treating in the same way in spectrophotometer at 525nm and prepare a calibration curve with concentration of Mn along X-axis and absorbance along Y-axis.
8. The absorbance of the unknown sample is now found out and from the calibration curve, quantity of Mn in the solution is obtained.

PROCEDURE –Experiment

1`Take 50 ml.of sample
2)add 5ml of special reagent
3)Dilute to 90ml.
4)Add 1gm of Ammonium persulphate, boil for 1 min. and then cool under the tap.
5)Dilute to 100ml with distilled water.
6)Measure the absorbance at 525nm
7)The absorbance of the unknown sample is now found out and from the calibration curve, quantity of Mn in the solution is obtained.

Operation of spectrophotometer UV-Vis

1)Press enter key

2)select the source lamp

3)select the wave length (single/ multiple)

4)Enter the wavelength e

5)select the measurement mode (abs/transmittance)

Sample No.	**Sample Volume**	**% Absorbance**	**Manganese content**

APPLICATION

In explorations for new water supplies, particularly from underground sources, Mn determination is an important consideration. When supplies containing amounts in excess of 0.05mg/l manganese are developed, engineer must decide whether the treatment is justified or not. The efficiency of treatment unit is determined by routine test for manganese. They are also used to aid in the solution of problems in distribution system where iron-fixing bacteria are troublesome. Corrosion of cast iron and steel pipelines often produces “red water” troubles in the distribution system. Iron and Mn removal are often taken together while treating the water.

DISCUSSIONS

QUESTIONS AND ANSWERS

1) **What is the source of Iron and Manganese in drinking water**
Soil contains appreciable amounts of Iron and Manganese in both soluble (Fe $^{2+}$,Mn^{2+})

and insoluble (Fe $^{3+}$,Mn^{4+})form. When rain water percolates through the earth the soluble from of iron and manganese gets dissolved in the water .if organic matter is present in water bacterial

growth will be more and some bacteria will utilize Fe $^{3+}$ and Mn^{4+} as electron acceptors transforming iron and manganese into soluble form and thus increasing more iron and manganese in water

2)How are the iron and manganese removed from water?

Various methods are used for the removal of Iron from drinking water. As we have studied already, upon aeration ferrous iron in the water is oxidised to ferric iron and thus the water becomes turbid. upon sedimentation these particles get settled or filter can be used to remove the oxidised particles. Oxidation of ferrous iron to ferric iron can be accelerated by increasing the pH of the water for which lime can also be used. There are also other commercially methods for removal of Iron from drinking water which are bit costly and is being used by many people

Experiment no **Date**

ACIDITY

PRINCIPLE

Acidity of liquid is its capacity to donate H^+ ions. Water containing mineral Acidity (due to H_2SO_4 and HCL, HNO_3) are unacceptable. Further Acid waters pose problem of corrosion and interfere in water softening.

APPARATUS

1. Erlenmeyer flakes
2. Pipettes
3. Burette
4. Measuring Cylinder

REAGENTS

a. Standard sodium Hydroxide 0.02 N

   Dissolve 0.8gm NaOH and dilute to 1000ml using Co_2 free distilled water standardize against 0.02 N Potassium biphthalate.

b. Phenolphthalein Indicator.

PROCEDURE

1. Pipette out 100ml of the water sample into a 250ml conical flask.
2. Add two drops of phenolphthalein indicator solution
3. It is titrated against 0.02 N Sodium Hydroxide solution. The end point is the appearance of a faint pink color.

TABULATION AND CALCULATION

0.02 N NaOH x Sample phenolphthalein indicator

Sample No.	Repetition No.	Vol. of Sample (V)ml	Burette Reading		Vol. of NaOH in ml V1	Acidity in mg/L
			Initial	Final		

CALCULATION

Acidity in mg/litre

Discussion

Questions & Answers

1) **What is the significance of acidity in drinking water?**

In addition to harming your body, acidic water can corrode pipes. Due to its high acidity, water with a low pH can start to dissolve metal pipes over time, causing leaks and further increasing the presence of heavy metals in your drinking supply

2) **What are the bad effects of acidity in drinking water?**

The corrosive nature of acidic water causes metal ions such as iron, manganese, copper, lead and zinc to leach into the water, causing elevated levels of toxic metals in your water. Signs of acid water are corrosion of fixtures, blue staining (from copper pipes) or rust staining (from iron pipes). Acidic water can also cause pinhole leaks and pipe failure over time. It may also cause aesthetic problems, such as a metallic or sour taste

3) **How can acidity be removed from water**

Addition of any alkaline substances like caustic soda , lime or calcite increase the acidity of water

Experiment No:… **Date:………………**

NITRATE

GENERAL

Origin of Nitrate is from oxidation of ammonia, agricultural fertilser run off. The nitrate found in natural waters is of mineral origin most coming from organic and inorganic sources0, waste discharges. High nitrate level in waters to be used for drinking will hazardous to infants as these induce the blue baby syndrome. Nitrate itself is not a toxicant. But is a health hazard because of its conversion to nitrite which reacts with blood hemoglobin.

Determination of nitrate (NO_3^-) is difficult because of the relatively complex procedure required, The high probability that interfering constituents will be present, and the limited concentration ranges of the various techniques. An ultraviolet (UV) that measure the absorbance of Nitrate at 220 nm is suitable screening uncontaminated water.

Ultraviolet Spectro photo metric screening method

PRINCIPLE

Measurement of UV absorption at 220 nm enables rapid determination of Nitrate. Because dissolved organic matter also may absorb at 220 nm and Nitrate does not absorb at 275 nm, A second measurement made at 275 nm may be used correct the Nitrate value. Sample filtration HCL is designed to prevent interference from hydroxide or Carbonate concentration up to

1000mg $CaCO_3$/litre is intended to remove possible interference from suspended particles. Acidification with 1N

APPARATUS

1. Acid wash glass wares (beaker 250ml, glass rod)
2. UV Spectro photometer for use at 220 nm,270nm wave length

REAGENTS

1. Hydrochloric acid solution 1N
2. Stock nitrate solution
3. Intermediate nitrate solution

PROCEDURE

1. Take 50ml of the solution add 1ml 1N HCL and mix thoroughly.
2. Read absorbance at 220nm to obtain nitrate reading.
3. Read absorbance 275nm to determine interference due to dissolved organic matter.
4. A calibration curve is constructed with the data obtained
5. prepare nitrate calibration standards in the ranges 0-7 mg No_3^- by diluting appropriate quantity of the intermediate nitrate solution to 100ml.
6. Take 50ml of the above intermediate nitrate solution add 1ml 1N HCL and mix thoroughly.
7. Read absorbance at 220nm to obtain nitrate reading and at 275nm to determine interference due to dissolved organic matter.

For sample and standard subtract two times the absorbance reading at 275nm

From the reading at 220nm to obtained absorbance due to nitrate (NO_3^-). construct a standard curve by plotting absorbance due to No_3^- against No_3^- concentration of standard.

Using this absorbance value obtained sample concentrations directly from standard curve.

Sample no.	**Sample Volume**	**Absorbance**	**Nitrate concentration**

DISCUSSION

Questions & Answers

1)What is the source of nitrogen in water

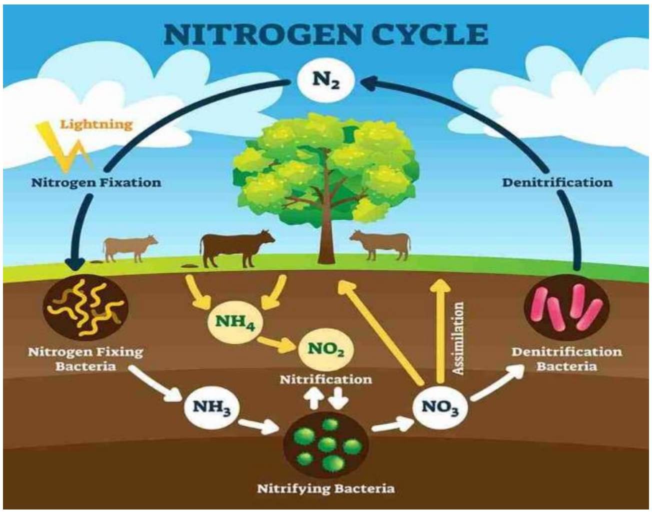
Sources of nitrogen and nitrates may include runoff or seepage from fertilized agricultural lands, municipal and industrial waste water, refuse dumps, animal feedlots, septic tanks and private sewage disposal systems, urban drainage and decaying plant debris.

2)How is nitrate removed from water

Ion exchange units, reverse osmosis, or distillation all remove nitrate from drinking water. Note that boiling water does not remove nitrates and is not a treatment alternative. In fact, it increases nitrate concentrations as water evaporates. An ion exchange unit operates much like a household water softener

3)What is nitrification and denitrification in the atmosphere

Nitrogen, the most abundant element in our atmosphere, is crucial to life. Nitrogen is found in soils and plants, in the water we drink, and in the air we breathe. It is also essential to life: a key building block of DNA, which determines our genetics, is essential to plant growth, and therefore necessary for the food we grow. But as with everything, balance is key: too little nitrogen and plants cannot thrive, leading to low crop yields; but too much nitrogen can be toxic to plants, and can also harm our environment. Plants that do not have enough nitrogen become yellowish and do not grow well and can have smaller flowers and fruits. Farmers can add nitrogen fertilizer to produce better crops, but too much can hurt plants and animals, and pollute our aquatic systems. Understanding the Nitrogen Cycle—how nitrogen moves from the atmosphere to earth, through soils and back to the atmosphere in an endless Cycle—can help us grow healthy crops and protect our environment



Animals secure their nitrogen (and all other) compounds from plants (or animals that have fed on plants). Four processes participate in the cycling of nitrogen through the biosphere: (1) nitrogen fixation, (2) decay, (3) nitrification, and (4) denitrification. Microorganisms play major roles in all four of these.

Nitrogen Cycle is a biogeochemical process through which nitrogen is converted into many forms, consecutively passing from the atmosphere to the soil to organism and back into the atmosphere. It involves several processes such as nitrogen fixation, nitrification, denitrification, decay and putrefaction.

Experiment no **Date**

PHOSPHATE (PO_4^-)

GENERAL

Phosphorus occurs widely in nature in plants, in microorganisms, in animal waste and so on. It is widely used as an agricultural fertilizer and as a major constituent of detergents.

METHOD OF ANALYSIS

The phosphate in water with ammonium molybdate and form ammonium molybdo-phophoric acid (complex heteropoly acid) which gets reduced by stannous chloride ($SnCl_2$) to intensely

colored molybdenum blue. The color intensity is measured photometrically at 690nm and compare with a calibration curve. particularly those for domestic use. Runoff sewage discharges are thus important contributors of Phosphorus to surface waters.

APPARATUS

1. Acid wash glassware (beaker 250ml, glass rod)
2. UV Spectro photometer for use at 220 nm,270 nm wave length

REAGENTS

1. Ammonium molybdate reagent
2. Stannous chloride reagent
3. Standard phosphate solution

PROCEDURE - Stannous Chloride Method

1. Take 100ml sample add with through mixing after each addition, 4ml ammonium molybdate reagent and 0.5ml stannous chloride reagent to it.
2. After 10mints but before 12 mint read the absorbance at 690nm spectrophotometrically.
3. A calibration curve is constructed with the data obtained
4. It is prepared by carrying PO_4^- standard through the entire procedure.
5. Space standards in between 0.3 to 2.0mg/L PO_4^-
6. Read the absorbance at 690nm and construct a standard curve by plotting absorbance due to PO_4^- against PO_4^- concentration of standard.

7. The PO_4^- concentration is determined directly from the calibration curve

TABULATION AND CALCULATION

Sample no.	**Sample Volume**	**Absorbance**	**Phosphate concentration**

Mg of phosphate per liter = mg /liter

DISCUSSION

Questions

1. **Explain the significance of PO_4^- in environmental engineering**

If an excess of phosphate enters the waterway, algae and aquatic plants will grow wildly, choke up the waterway, and use up large amounts of dissolved oxygen. This condition is known as eutrophication or over-fertilization of receiving waters.

2. **What is the source of PO_4^- in drinking water?**

Phosphorus occurs naturally in rocks and other mineral deposits. During the natural process of weathering, the rocks gradually release the phosphorus as phosphate ions, which are soluble in water, as the mineralized phosphate compounds break down. Phosphates PO_4^{-3} are formed from this element.

Experiment No:…… **Date:…………………**

BREAK POINT CHLORINATION

AIM

To find out the break point of chlorination in a given water sample.

GENERAL

Chlorination of water supplies and wastewater treatment plant effluents are mainly done for the destruction of disease-producing microorganisms. Chlorine has many other uses in water and wastewater treatment due to its reaction with many other likely constituents in water like organic matter, Ammonia etc .It is also useful for odor control , Algae treatment etc and in that way it aid both water and waste water treatment

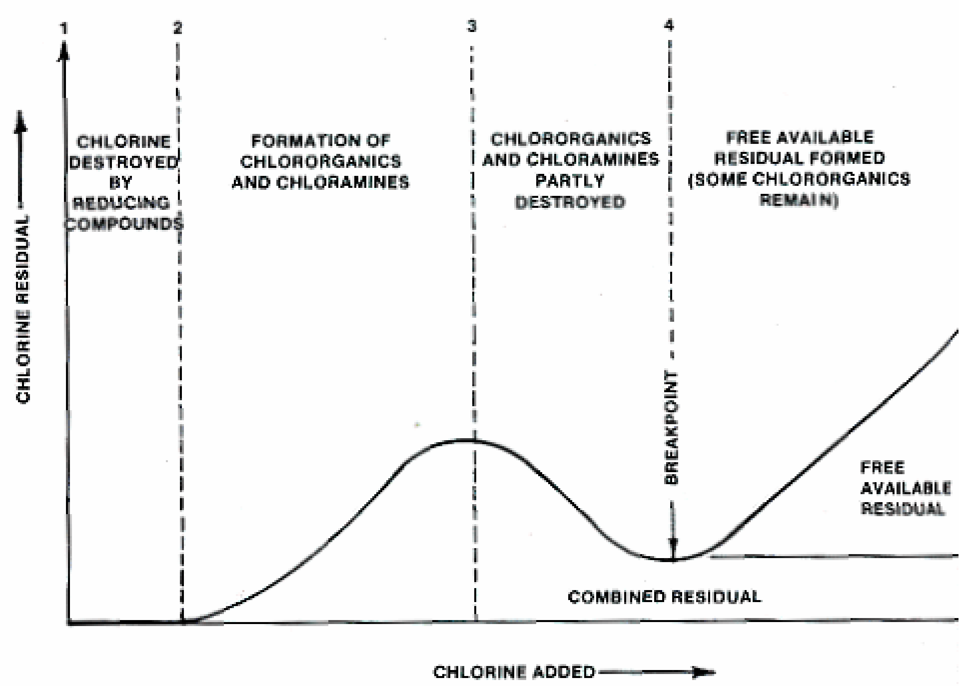
Residual Chlorine is the chlorine remaining in water after contact period (of 30 minutes). During chlorination process, sufficient quantity of chlorine must be added to reach 0.2mg/litre of residual chlorine and it may not exceed 1.00 mg /litre in public water supplies. Residual chlorine will help to destroy any possible contamination of water during transit and handling

Chlorine Demand: The chlorine demand of water is the difference between the amount of chlorine applied and the amount of free, combined or total available chlorine remaining after the contact period. The chlorine demand of any water varies with the quality of water, amount of chlorine applied, time of contact, pH and temperature. As 0.2 mg/l of residual chlorine is desirable at the consumers end, this quantity plus the actual demand will give the chlorine demand figures (for drinking water analysis).

Breakpoint Chlorination

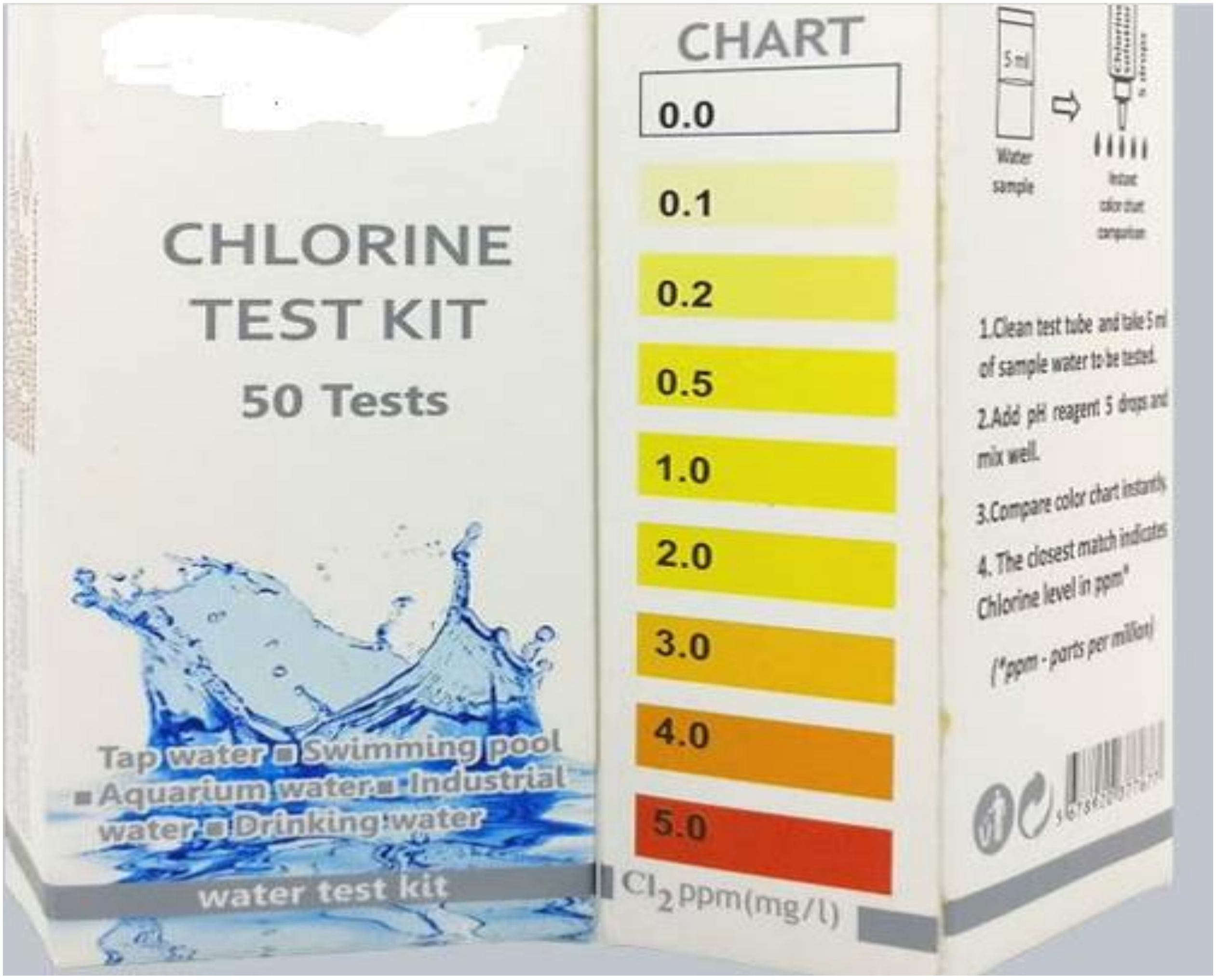
Breakpoint chlorination is defined as the point where enough chlorine has been added to a quantity of water to satisfy its total disinfecting demand. In other words, it is the point where all undesirable contaminants have been removed from the water by reaction with chlorine. At breakpoint chlorination, all chlorine added to the solution is consumed by chemical reactions with the contaminants and bacteria. Breakpoint oxidizes complete organic matters, dissolved ammonia and other reducing particles. It removes color (which is due to the presence of organic compounds). (3) It destroys (~ 100%) all the bacteria. (4) It removes bad odor and bad taste.

When chlorine is added to water, it is used for different reactions like oxidation of oxidizable substance, chlorination of organic substance, destructive oxidation of organic substances and disinfection of pathogens. Initially all the chlorine added is consumed by reducing compound and there is no free chlorine. This is due to complete oxidation of oxidizable substances. As the applied chlorine increases, there is steady increase in amount of residual chlorine. This stage corresponds to formation of chloro-organic compounds and chloramines due to reaction with organic matter and Ammonia. When the dose of chlorine increase, destruction of chlororganic and chloramines take place and reaches the breakpoint. The reactions are illustrated in the graph given below



Determination of Residual chlorine(RC)

RC is determined by many methods and the easiest method is by using field test kit in which readymade modules are used for field determination. Colorimetric principles are used for this purpose also . RC is determined by mere comparison. Color is developed in the chlorinated water by addition of orthotoduline solution .Picture below shows such a field test kit



Procedure for determination of break point chlorination

Apparatus:

1. Burette
2. Pipette
3. Erlenmeyer flask
4. Chlorine test kit

Reagents:

1. Waste water
2. Ammonia
3. Bleaching powder solution

Procedure

1)Prepare raw water sample for the analysis by adding waste water and ammonia to normal well water

2) Prepare Bleaching powder solution by dissolving 250 mg of Bleaching powder in 250 ml of water

3) Measurement of Samples - Take 1litre of the water sample in 9 measuring jars

4) Addition of Chlorine -. Add chlorine to each jar @0.5mg/litre, 1mg/litre,2mg/litre 2.5mg/litre , 3mg/litre,4mg/litre,4.5mg /litre 5mg/litre ,and 7mg/litre , by using bleaching Solution prepared by step2

5) Provide a contact time of 20- 30 min after covering the jar in order to avoid escape of chlorine gas

6) Determination of Residual Chlorine of each sample and tabulate in the table given below

7) Plot a graph chlorine added along X axis and residual chlorine along y axis and find out the break point

Observations and Calculations:

Sl No.	**Sample Number**	**Residual chlorine in the sample**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Result:

Plot graph applied chlorine Vs residual chlorine and obtain the break point

Discussion:

Questions

1)What is the significance of residual chlorine in water treatment?

The presence of chlorine residual in drinking water indicates that:

a)A sufficient amount of chlorine was added initially to the water to inactivate the bacteria and some viruses that cause diarrheal disease; and,

b) The water is protected from recontamination during storage and transportation

2)What are different forms of chlorination?

a)Pain chlorination
b)Pre chlorination
c)Post chlorination
d)Double chlorination
e)Super chlorination
f)Break point chlorination
g)Dechlorination

3)What is the effect of pH on chlorination?

When the pH increases above pH 7.4, a form of chlorine known as hypochlorite ion (OCl-) increases. This form of chlorine is 100 time less effective at killing bacteria as compared to the other form of chlorine known as hypochlorous acid (HOCl).

4)What is the significance of break point chlorination?

The break point point is the point beyond which any further addition of chlorine will appear equally as free chlorine, nothing of it will be utilized. This Point “C” is called as breakpoint as any amount of chlorine added beyond this point will appear as residual chlorine. The addition of chlorine be this point is known as break-point chlorination

Break point indicate

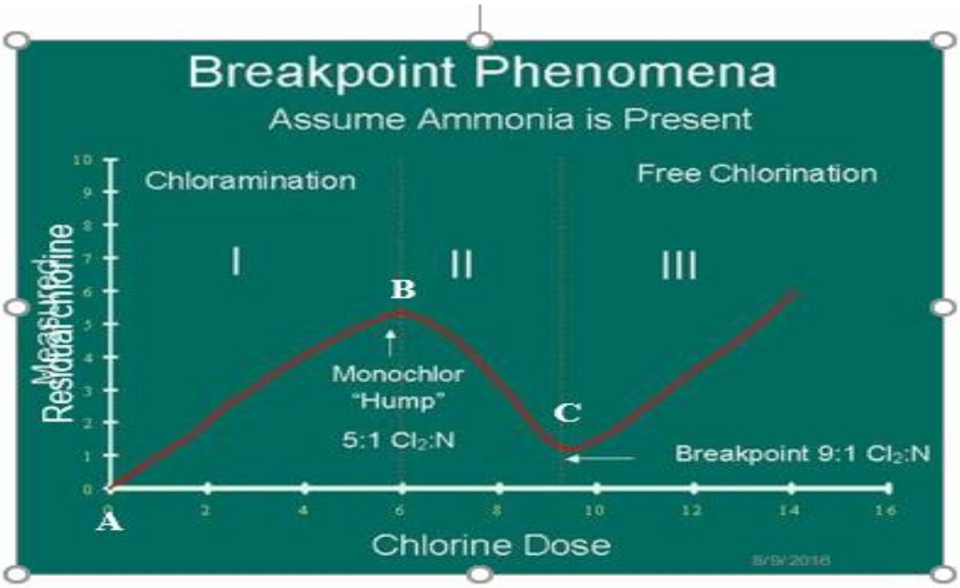


Fig Break Point Chlorination

1) **What does break point indicate?**

   It is a term which gives an idea of the extent of chlorine added to the water. It represents, that dose of chlorination, beyond which any further addition of chlorine will appear as free residual chlorine

2) **Why chlorine demand differs for different water samples?**

   Chlorine demand varies with the quality of water. If the water quality is bad chlorine demand will be more and less if the water quality is good

3) **Why do we insist to have presence of Residual chlorine in public water supplies?**

   Residual chlorine in drinking water is compulsory to counteract any contamination on its travel . RC also ensures the complete eradication of all the bacteria present which is helpful to us

Experiment No:…… **Date:…………………**

TEST FOR COLIFORM GROUP IN WATER

A. MPN TEST

The aim of the experiment is to determine the most probable number (MPN) index of coliform in the given sample of water by the multiple tube fermentation technique. The coliform group has been accepted as the indicator organism for biological contamination in water .The coliform group of organism further confirms the presence of biological contamination in the water tested. Since water borne infections are essentially caused by sewage contamination, the detection of coliform organisms in water which indicates the presence of biological contamination.

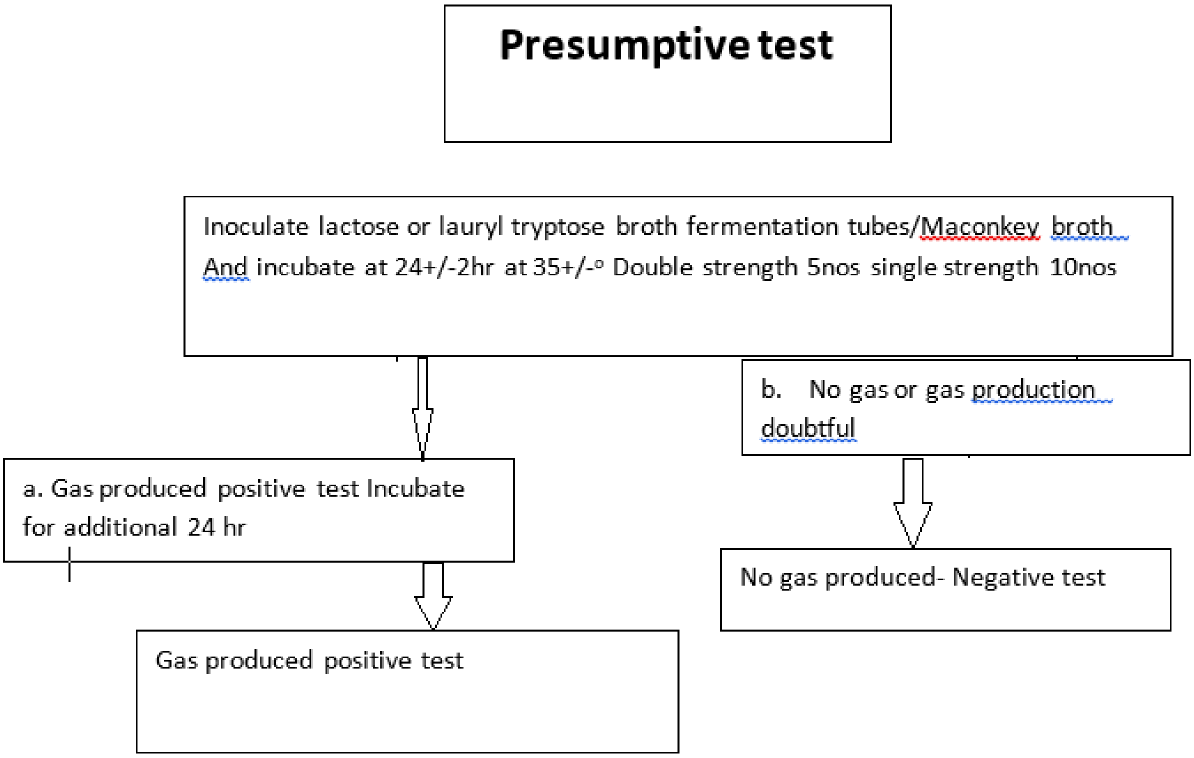
Coliform group may be defined as comprising all the aerobic, facultative, anaerobic, gram negative, non spore forming, rod shaped bacteria which ferment lactose with gas formation within 48 hours at 35^0 C. Water is considered to be safe when these organisms are absent. The results are expressed in terms of MPN (Most Probable Number), which is based on certain probability formulae. The estimate may give a value greater than the actual number of coliform present. The accuracy of any single test depends on the number of tubes fermented. This method provides a tool to describe the sanitary quality of water.

PRINCIPLE

The MPN test procedure is based on the most probable number of the coliform organism. The coliform group has the ability to ferment lactose or lauryl tryptose broth or macconkey both and produce gas. This offers a simple test of the presence of coliform. However some other organisms also ferment the broth under certain conditions and therefore additional growth reactions must be carried out to confirm the presence of coliform group. After presumptive test the production of gas in the brilliant green lactose bile confirms the presence of coliform. The general pattern of presumptive test is given below

PROCEDURE

See the flow diagram below



1. PRESUMPTIVE TEST

LACTOSE BROTH OR LAURYL TRYPTOSE BROTH OR MACCONKEY BROTH TO BE USED IN THE PRESUMPTIVE TEST.

1. Inoculate a series of fermentation tubes with appropriate graduated quantities (multiples and submultiples of 10)of the water to be tested. The concentration of nutritive ingredients in the mixture of the medium should confirm to the specifications.
2. The portions of the water sample used for inoculating lactose or lauryl tryptose or MacConkey broth fermentation tubes will vary in size and number with the character of water under examination.
3. Usually decimal multiples and sub multiples of 1 ml of the sample is selected. Inoculate 10 ml portion of each water sample provided into different one or five large tubes containing 10 ml of lactose or lauryl tryptose or MacConkey broth which has been prepared with twice the normal concentrations of constituents for allow for dilution.

Inoculate 1 ml and 0.1 ml of water into small tubes (two sets of five each) of single strength broth.

4. Incubate the inoculated fermentation tubes at 35+/-.5^0 C. At the end of 24+/-2hr shake each tube gently and examine and if no gas has formed, repeat this test at the end of 48+/-3 hr.
5. Record the presence or absence of gas formation at each examination of the tubes.
6. Formation within 48+/- 3 hr of gas in any amount in the inverted fermentation tubes constitutes a positive presumptive test. Active may be shown by the continued appearance of small bubbles of gas throughout the medium outside the inner vial in the fermentation tubes. A negative result indicates that water is fit for drinking.
7. Presumptive test without confirmation should not be used routinely except in the analysis of heavily polluted water

2. CONFIRMED TEST

1. Lactose or lauryl tryptose broth may be used for primary fermentation in presumptive test to avoid false positive results.
2. Brilliant green lactose bile broth fermentation tubes are used in the confirmed test.
3. Submit all primary fermentation tubes showing any amount of gas at the end of 24 hr incubation to the confirmed test.
4. Gently shake primary fermentation tube showing gas formation and with a sterile metal loop, transfer one loop full of medium to a fermentation tube containing brilliant green lactose bile.
5. Incubate the inoculated brilliant green lactose bile broth tube for 48+/-3hrs at 35+/-0.5 degree Centigrade
6. The formation of gas in any amount in the inverted vial of the brilliant green lactose bile broth fermentation tube at any time within 48+/-3hrs constitute a positive confirmed test.
7. If no gas is formed, it is negative confirmed test and coliforms are absent.

COMPLETED TEST

Completed test is the next step following the confirmed test. It is applied to brilliant green lactose bile broth fermentation tubes showing gas in the confirmed test.

1. Streak one or more endo or eosin methylene blue (EMB) agar plates from each tube of brilliant green lactose bile showing gas.
2. While streaking it is essential to ensure the presence of some discrete colonies separated by atleast 0.5 cm from one another.
3. Insert the end of the streaking needles into the liquid in the tube to a depth of 5 mm.
4. Streak the plate by bringing only the curved section of the needle in contact with the agar surface so that the latter will not be scratched or torn
5. Incubate the petri dishes (inverted) at 35+/-0.5^{0}c for 24+/- 2hr
6. The colonies developing on Endo or eosin methylene blue agar may be typical (opaque, un nucleated, mucoid after incubation for 24 hrs) or negative (all others)
7. From each of these plates fish out one or two colonies and transfer to lauryl tryptose broth fermentation tube and to nutrient agar slants.
8. Incubate the secondary broth tubes and near slants at 35+/-0.5Cfor24+/- 2 hrs or 48+/-3 hrs and if gas is not produced in 24 hrs, Gram stained preparation from these agar slant cultures are made.
9. The gas formation in the secondary lauryl tryptose broth tubes and the demonstration of gram- negative no-spore forming rod shaped bacteria in agar culture may be considered a satisfactory positive completed test.
10. If after 48+/- 3 hrs gas is produced in the secondary fermentation tubes and no spores of gram positive rods are found on the slant, the test may be considered a positive completed test and this demonstrates the presence of coliform organisms.

COMPUTATION OF MPN

The number of positive findings coliform group organisms resulting from multiple portion decimal dilution plantings should be computed as the as the combinations of positives and recorded in terms of the Most probable Number (MPN). The MPN for a variety of planting series are presented in Table. The values are at the 95%confidence limits for each of the MPN determined. These values are prepared for 10,1,0.1 ml combination. If however the combination is 10,10 and 1 ml the MPN is 0.1 times the value in the table. If on the other hand, a combination corresponding properties at 1, 0.1and 0.01 ml is planted; record 10 times the value shown in the table.

The MPN for combination not appearing in the table or for other combination of tubes and dilutions, may be estimated by Thomas's simple formula,

MPN /100ml =

Value of MPN can be obtained from the table given in annexure 3which is prepared based on the probability concept

Annexures

Number	Name
Annexure 1	Drinking Water Quality Standards IS 10500-2012
Annexure 2	Preparation of Reagents and media
Annexure 3	MPN table for bacterial Analysis
Annexure 4	Adverse impact and remedial measure due to the presence of various contaminates in water

Annexure 1

DRINKING WATER QUALITY IS 10500-2012 — SPECIFICATION

Table 1 Organoleptic and Physical Parameters

Sl No	Characteristics	Acceptable Limit	Permissible Limit
1	Colour,Hazen units ,Max	5	15
2	odour	Agreeable	Agreeable
3	pH value	6.5-8.5	No relaxation
4	Taste	Agreeable	Agreeable
5	Turbidity, NTU, Max	1	5
6	Total dissolved solids, mg/l,Max	500	2000

Table 2 General Parameters Concerning Substances Undesirable in Excessive Amounts

Sl No	Characteristics	Acceptable Limit	Permissible Limit
1	Aluminium (as Al). mg/l. Max	0.03	0.2
2	Ammonia (as total ammonia-N). mg/l. Max	0.5	No relaxation
3	Anionic detergents (as MBAS) mgn/l,Max	0.2	1.0
4	Barium (as Ba), mg/l,Max	0.7	No relaxation
5	Boron (as B),mg/l,Max	0.5	1.0
6	Calcium (as Ca),mg/l,Max	75	200
7	Chloramines (as Cl2),mg/l,Max	4.0	No relaxation
8	Chloride (as Cl),mg/l,Max	250	1 000
9	Copper (as Cu),mg/l,Max	0.05	1.5
10	Fluoride (as F),mg/l,Max	1.0	1.5
11	Free residual chlorine, mg/l,Min	0.2	1
12	Iron (as Fe),mg/l,Max	0.3	No relaxation

13	Magnesium (as Mg),mg/l,Max	30	100
14	Manganese (as Mn), mg/l,Max	0.1	0.3
15	Mineral oil,mg/l,Max	0.5	No relaxation
16	Nitrate (as NO3),mg/l,Max	45	No relaxation
17	Phenolic compounds (as C6H5OH),mg/l,Max	0.001	0.002
18	Selenium (as Se),mg/l,Max	0.01	No relaxation
19	Silver (as Ag),mg/l,Max	0.1	No relaxation
20	Sulphate (as SO4),mg/l,Max	200	400
21	Sulphide (as H2S),mg/l,Max	0.05	No relaxation
22	Total alkalinity as calcium carbonate,mg/l,Max	200	600
23	Total hardness (as CaCO3),mg/l,Max	200	600
24	Zinc (as Zn),mg/l,Max	5	15

Table 3 Parameters Concerning Toxic Substances

Sl No	Characteristics	Acceptable Limit	Permissible Limit
1	Cadmium (as Cd),mg/l,Max	0.003	No relaxation
2	Cvanide(as CN),mg/l,Max	0.05	No relaxation
3	Lead(as Pb),mg/l,Max	0.01	No relaxation
4	Mercury(as Hg),mg/l,Max	0.001	No relaxation
5	Molybdenum(as Mo),mg/l,Max	0.07	No relaxation
6	Nickel(as Ni),mg/l,Max	0.02	No relaxation
7	Pesticides,ugl,Max	See table 5	No relaxation
8	Polychlorinated bi –phenyls mg /litre	0.0005	No relaxation
9	Polynuclear aromatic hydrocarbons (as PAH),mg/l,Max	0.000 1	No relaxation
10	Total arsenic(as As),mg/l,Max	0.01	0.05
11	Total Chromium (as Cr),mg/l,Max	0.05	No relaxation

12	Trihalomethanes: a)Bromoform, mg/l,Max	0.1	No relaxation
	b)Dibromochloromethane, mg/l,Max	0.1	No relaxation
	c)Bromodichloromethane, mg/l,Max	0.06	No relaxation
	d)Chloroform, mg/l,Max	0.2	No relaxation

Table 4 Parameters Concerning Radioactive Substances

Sl No	Characteristics	Acceptable Limit	Permissible Limit
1	Radioactive minerals:		
	a)Alpha emitters Bq/l,Max	0.1	No relaxation
	b)Beta emitters Bq/l,Max	1.0	No relaxation

Table 5 Pesticide Residues Limits and Test Method

Sl No	Pesticide	Limit ug/L
1	Alachler	20
2	Alkazine	2
3	Aldrin/Dieidrin	0.03
4	Alpha HCH	0.01
5	Beta HCH	0.04
6	Butachlor	125
7	Chloropyriphos	30
8	Delta HCH	0.04
9	2,4- Dichlorophenoxyacetic acid	30
10	DDT (o,p and p,p – Isomers of DDT, DDE and DDD)	1
11	Endosulfan (alpha ,beta and sulphate)	0.4
12	Eddon	3

13	Gamma- HCH (Lindane)	2
14	Isoproturon	9
15	Malathion	190
16	Methyl parathion	0.3
17	Monocrotophos	1
18	Phorate	2

Table 6 Bacteriological Quality of Drinking Water

Sl No	Organisms	Requirements
1	All water intended for drinking a)E.Coli or thermotolerant coliform bacteria2)3)	Shall not be detectable in any 100 ml sample.
2	Treated water entering the distribution system: a)E.Coli or thermotolerant coliform bacteria2)	Shall not be detectable in any 100 ml sample
	b)Total Coliform bacteria	Shall not be detectable in any 100 ml sample
3	Treated water in the distribution system: a)E.Coli or thermotolerant coliform bacteria	Shall not be detectable in any 100 ml sample
	b)Total Coliform bacteria	Shall not be detectable in any 100 ml sample

Annexure 2

Preparation of Reagents and media

Preparation of Reagents and Media

Reagents for various determinations are prepared as follows:

Alkalinity:

1 . *0.02 N standard sulphuric acid:* Prepare stock solution approximately 0.1 N by diluting 2.5 mL concentrated sulphuric acid to 1 litre.dilute 200 mL of the 0.1 N stock solution to 1 litre **CO_2** free distilled water. Standardize the 0.02 N acid against a 0.02 N sodium carbonate solution which has been prepared by dissolving 1.06 g anhydrous **Na_2CO_3** and diluting to the mark of a 1 litre volumetric flask.

2 . *Methyl Orange Indicator:* Dissolve 500mg methyl orange powder in distilled water and dilute it to 1 litre. Keep the solution in dark or in an amber coloured bottle.

3 . *Phenolphthalein indicator :* Dissolve 500 g phenolphthalein in 500 mL ethyl alcohol And add 500 mL distilled water.Then add 0.02 N sodium hydroxide dropwise until a faint-pink colour appears.

4 . *Sodium thiosulphate 0.1 N :* Dissolve 25g **$Na_2S_2O_3 \cdot 5H_2O$** and dilute to 1 litre.

Hardness:

5 . *Ammonia buffer solution:* Dissolve 16.9g ammonium chloride (**NH_4Cl**) in 143 mL concentrated ammonium hydroxide (**NH_4OH**) .Add 1.25 magnesium salt of EDTA and dilute to 250 mL with distilled water. Do not store more than a month’s supply. Discard the buffer when 1 or 2 mL added to the sample fails to produce a pH of 10.0 +_ 0.1 at the end point of titration. Keep the solution in a plastic or resistant glass container.

6 . *Erichrome black T indicator:* Mix 0.5g Eriochrome black T dye with 4.5g hydroxylamine hydrochloride. Dissolve this mixture in 100ml of 95% ethyl or isopropyl alcohol.

7 . *Standard EDTA titrant 0.01M:* Weigh 3.723g analytical reagent grade EDTA disodium salt (**$Na_2H_2C_{10}H_{12}O_8N_2$**) and dissolve in disyilled water and dilute to 1 litre.

Chloride:

8 . *Potassium chromate indicator:* Dissolve 50g potassium chromate (**$K_2Cr_2O_4$**) in a Little distilled water. Add silver nitrate solution until a definite red precipitate is formed. Let stand for 12 hrs, filter and dilute the filtrate to 1 litre with distilled water.

9 . *Standard silver nitrarte solution 0.0141N:* Dissolve 2.395g **$AgNO_3$** in distilled water and dilute to 1 litre.

10 . *Standard sodium chloride 0.0141N:* Dissolve 824.1 mg **NaCl** (dried at 140oC) in chloride free water and dilute to 1 litre. 1mL=500ug **Cl_2 .**

11 . *Aluminium hydroxide suspension:* Dissolve 125g aluminium potassium sulphate in 1 litre water.Warm to 60 oC and add 55 mL concentrated **NH_4OH** slowly with stirring. Let stand for 1 hr, transfer the mixture to a large bottle. When freshly prepared the suspension occupies a volume of approximately 1 litre.

Iron:

12 . *Hydrochloric acid:* **Concentrated HCl.**

13 . *Hydrooxylamine solution:* Dissolve 10g hydroxylamine hydrochloride salt (**$NH_2OH.HCl$**) in 100 mL distilled water.

14 . *Ammonium acetate buffer solution:* Dissolve 250g ammonium acetate (**$NH_4C_2H_3O_2$**) in 150 mL distilled water.Add 700mL concentrated(glacial)acetic acid.

15 . *Sodium acetate solution:* Dissolve 200g sodium acetate (**$NaC_2H_3O_2.3H_2O$**) in 800 mL distilled water.

16 . *Phenanthroline solution:* Dissolve 100mg 1, 10-phenanthroline monohydrate (**$C_{12}H_8N_2.H_2O$**) in 1oo ml distilled water by stirring and heating to 80 oC. Do not boil. Discard the solution if it darkens.Heating is unnecessary if two drops of concentrated **HCl** are added to the distilled water. 1 mL of this reagent is sufficient for no more than 100ug **Fe.**

17 . *Stockiron solution:* Add slowly 20 mL concentrated **H_2SO_4** to 5 mL distilled water and dissolve

1.404g ferrous ammonium sulphate [**$Fe(NH_4)_2(SO_4)_2.6H_2O$**]. Add 0.1 N **$KMnO_4$** drop wise until a faint pink colour persists. Dilute to 1 litre with iron free distilled water. Each 1 mL of this solution contains 200 ug **Fe.**

18 . *Standardiron solution:* Pipette 50 mL stock solution in to 1 litre volumetric flask and dilute to the mark with distilled water. 1 mL= 10 ug **Fe.**

Manganese:

19 . *Special reagent :* Dissolve 75g mercuric sulphate (**$HgSO_4$**) in 400 mL concentrated nitric acid (**HNO_3**) and 200 mL distilled water. Add 200 mL 85% phosphoric acid and 35mg silver nitrate to the above solution. Dilute the cooled solution to 1 litre.

20 . *Ammonium per sulphate :* (**$NH_4)_2S_2o_3$** solid.

21 . *Standard manganese solution:* Prepare a 0.1 N potassium permanganate (**$KMnO_4$**) solution by dissolving 3.2g of **$KMnO_4$** in distilled water and making it up to 1 litre. Age for several days in sunlight or heat for several hours near the boiling point and then filter through fritted glass filter crucible and standardize against sodium oxalate. Calculate the volume of this solution necessary to prepare 1 litre solution of such strength that 1mL = 50 ug **Mn** as follows:

$$\text{mL } KMnO_4 = 4.55/\text{Normality of } KMnO_4$$

To this solution add 2 to 3mL concentrated **H_2SO_4** and sodium bisulphate solution (10g **$NaHSO_3$**+100 mL distilled water). Boil to remove excess **SO_2**, cool and dilute to 100 mL with distilled water.

Sulphate:

22. Buffer SolutionA Dissolve 30g magnesium chloride ($MgCl_2 . 6H_2O$), 5g sodium ascetate ($CH_3COONa. 3H_2O$), 1g potassium nitrate (KNO_3) and 20ml ascetic acid (CH_3COOH- 99%) in 500ml distilled water and make up to 1000ml.

Buffer solution B Dissolve 30g magnesium chloride ($MgCl_2 . 6H_2O$), 5g sodium ascetate ($CH_3COONa. 3H_2O$), 1g potassium nitrate (KNO_3) 0.111g sodium sulpahte Na_2SO_4 and 20ml ascetic acid (CH_3COOH- 99%) in 500ml distilled water and make up to 1000ml

23 . *Barium Chloride:* Barium chloride crystals.

24 . *Standard sulphate solution:* Prepare a standard sulphate solution such that 1mL = 100 ug **SO_4**. Dissolve 147.9 mg anhydrous **Na_2SO_4** in 500 mL distilled water and dilute to 1 litre. 1mL = 100ug **SO_4**.

Sulphide:

25 . *Hydrochloric acid :* Prepare a 6 N solution.

26 . *Standard iodine solution 0.025N:* Dissolve 20-25g potassium iodide in a little water and add 3.2 g iodine. After the iodine has dissolved,dilute to 1 litre and standardize against 0.025 N sodium thiosulphate using starch as indicator.

27 . *Standard sodium thiosulphate 0.025N:* Dissolve 6.205g sodium thiosulphate (**$Na_2S_2O_3$. $5H_2O$**) in freshly boiled and cooled distilled water and dilute to 1 litre. Preserve by adding 5mL chloroform or 0.4g **NaOH/L** or 4g borax and 5-10 mg **HgI_2/L.** Standardize this with 0.025 N potassium dichromate solution which is prepared by dissolving 1.226 g potassium dichromate in distilled waterand diluted to 1 litre.

28 . *Startch indicator:* Add cold water suspension of 5g soluble startch to approximately 8oomL boiling water with stirring. Dilute to 1 litre,allow to boil for a few minutes and let settle overnight. Use supernatant liquor. Preserve with 1.25g salicylic acid/ 1 litre or by the addition of a few drops of toluene.

Dissolved oxygen:

29 . *Manganous sulphate solution:* Dissolve 480g **$MnSO_4$. $4H_2O$, $MnSO_4$. $2H_2O$** or 364g **$MnSO_4.H_2O$** in distilled water, filter and dilute to 1 litre.

30 . *Alkali- iodide- azide reagent:* Dissolve 500g **NaOH** or 700g **KOH** and 135g **Nal** or **KI** in distilled water and dilute to 1 litre. Add 10g sodium azide (**NaN_3**) dissolved in 40 mL distilled water. The reagent should not give colour with startch when diluted and acidified.

31 . *Sulphuric acid concentrated:* 1mL is equivalent to about 3mL alkali-iodide-azide reagent.

32 . *Standard sodium thiosulphate:* 0.025 N dissolve 6.205g sodium thiosulphate **$Na_2S_2O_3.5H_2O$** in freshly boiled and cooled distilled water and dilute to 1 litre. Preserve by adding 5 mL chloroform or 0.4g**NaOH/L** or 4g borax and 5-10 mg **HgI_2/L**. Standardise this with 0.025 N potassium dichromate solution which is prepared by dissolving 1.226g potassium dochromate in distilled water and diluted to 1L.

33 . *Standard potassium dichromate solution 0.025 N:* A solution of potassium dichromate equivalent to 0.025 N sodium thiosulphate contains 1.226g/L **$K_2Cr_2O_7$**. Dry **$K_2Cr_2O_7$** at 103 oC for 2 hours before making solution.

Standarisation of 0.025 N sodium thiosulphate solution: Dissolve approximately 2g **KI** in an Erlenmeyer flask with 100-150mL distilled water. Add 10 mL of **H_2SO_4** followed by exactly 20 mL 0.1 N potassium dichromate solution. Place in the dark for 5 minutes, dilute to approximately 400mL and titrate with 0.025 N sodium thiosulphate solution, adding starch towards the end of the titration. Otherwise the thiosulphate solution should be suitably corrected.

34 . *Starch indicator:* Add cold water suspension of 5g soluble starch to approximately 800 mL, boiling water with stirring. Dilute to 1L,allow to boil for a few minutes and let settle overnight. Use supernatant liquor. Preserve with 1.25g salicylic acid/L or by addition of a few drops of toluene.

BOD:

35 . *Phosphate buffer solution:* Dissolve 8.5g potassium dihydrogen phosphate (**KH_2PO_4**),21.75g dipotassium hydrogen phosphate (**K_2PHO_4**),33.4g disodium hydrogen phosphate hepta hydrate (**$Na_2HPO_4.7H_2O$**) and 1.7g **NH_4Cl** in about 500 mL distilled water and dilute to 1L.the pH of this buffer solution should be 7.2 without further adjustments. Discard the reagent if there is any sign of biologicalgrowth in the stock bottle.

36 . *Magnesium sulphate solution:* Dissolve 22.5g **$MgSO_4.7H_2O$** in distilled water and dilute to 1litre.

37 . *Calcium chloride solution:* Dissolve 27.5g anhydrous calcium chloride in distilled water and dilute to 1 litre.

38 . *Ferric chloride solution:* Dissolve .25g **$FeCl_3.6H_2O$** in distilled water and dilute to 1 litre.

39 . *Sodium sulphate solution0.025 N:* Dissolve 1.575g anhydrous **Na_2SO_3** in 1 litre distilled water. This is to be prepared daily.

40 . *Seeding:* The standard seed material is settled domestic waste water that has been stored at 20 oC for 24 to 36 hrs. A seed concentration of 1to 2 mL/L is usually adopted

COD:

Potassium dichromate ($K_2Cr_2O_7$) – 0.025N dried at 103^0C for 24 hours. Dissolve 1.2259 g $K_2Cr_2O_7$ in distilled water and dilute to 1000ml

Standard ferrous ammonium sulphate- 0.025N. Dissolve 9.8g FAS in 400ml distilled water. Add 20ml concentrated H_2SO_4 and dilute to 1000ml

Standardization- Dilute 10 ml std $K_2Cr_2O_7$ to 100ml with distilled water. Acidify by adding 30ml conc H_2SO_4 and allow to cool. Titrate with FAS using 2-3 drops of ferroin indicator.

Residual chlorine(OTA):

41 . Dissolve 1.35g orthotolidine dihydrochloride in 500mL distilled water. Add the solution with constant stirring to a mixture of 350 mL distilled water and 150 mL concentrated hydrochloricacid. Store the solution in brown bottle.

Always use an automatic, dropping or safety pipette to measure the necessary volume. Avoid inhalation or exposure to the skin.

Coliform test

42 . *Lactose broth:* Beef extract 3g, peptone 5g, lactose 5g and reagent grade distilled water 1 litre. Add these ingredients to reagent grade distilled water, mix thoroughly and heat to dissolve pH should be 6.8 to 7.0 after sterilization.

43 . *Lauryl tryptose broth:* Tryptose 20g,lactose 5g, **K2HPO4** 2.75g, **NaCl** 5g, sodium lauryl sulphate .1g, reagent grade distilled water 1 L,sterilize and use. Add dehydrated ingredients to water ,mix thoroughly and heat to dissolve,pH should be 6.8 +_ 2 after sterilization.

44 . *Endo agar:* Peptone 10g, lactose 10g, **K2HPO4** 3.5g, agar 15g, sodiumsulphate 2.5g, basic fuchsin .5g, distilled water 1L pH 7.4 after sterilization.

45 . *EMB agar:* Peptone 10g, lactose 10g, **K2HPO4** 2g, agar 15g, eosin .4g,methylene blue 0.065g, distilled water 1L pH should be 7.1 after sterilization.

46 . *Brilliant green lactose bile broth:* Peptone 10g, lactose 10g, oxgall 20g, brilliant green 0.0133g, distilled water 1L pH should be 7.2 after sterilization and is then ready for use. Store away from direct sunlight to extend the reagent stability to 6 months.

Annexure 3

MPN table for bacterial Analysis

TABLE

MPN Index and 95% confidence limits for various combinations of positive and negative results when five 10 ml portions ,five 1 ml portions and five 0.1 ml portions are used.

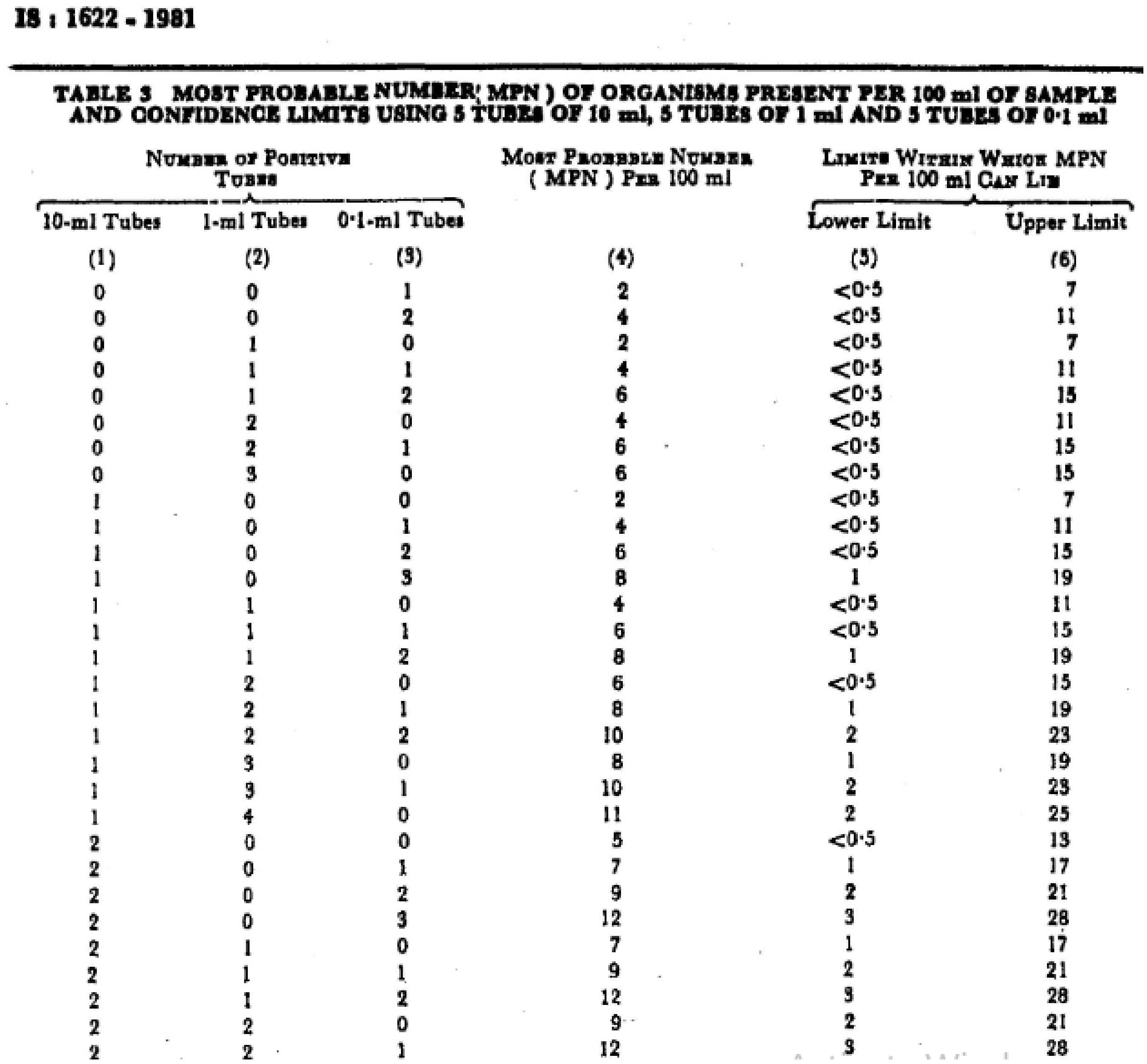


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TABLE 3 MOST PROBABLE NUMBER(MPN) OF ORGANISMS PRESENT PER 100 ml OF SAMPLE AND CONFIDENCE LIMITS USING 5 TUBES OF 10 ml, 5 TUBES OF 1 ml AND 5 TUBES OF 0·1 ml

Number of Positive Tubes			Most Probable Number (MPN) Per 100 ml	Limits Within Which MPN Per 100 ml Can Lie	
10-ml Tubes	1-ml Tubes	0·1-ml Tubes		Lower Limit	Upper Limit
(1)	(2)	(3)	(4)	(5)	(6)
0	0	1	2	<0·5	7
0	0	2	4	<0·5	11
0	1	0	2	<0·5	7
0	1	1	4	<0·5	11
0	1	2	6	<0·5	15
0	2	0	4	<0·5	11
0	2	1	6	<0·5	15
0	3	0	6	<0·5	15
1	0	0	2	<0·5	7
1	0	1	4	<0·5	11
1	0	2	6	<0·5	15
1	0	3	8	1	19
1	1	0	4	<0·5	11
1	1	1	6	<0·5	15
1	1	2	8	1	19
1	2	0	6	<0·5	15
1	2	1	8	1	19
1	2	2	10	2	23
1	3	0	8	1	19
1	3	1	10	2	23
1	4	0	11	2	25
2	0	0	5	<0·5	13
2	0	1	7	1	17
2	0	2	9	2	21
2	0	3	12	3	28
2	1	0	7	1	17
2	1	1	9	2	21
2	1	2	12	3	28
2	2	0	9	2	21
2	2	1	12	3	28

2	2	2	14	4	34
2	3	0	12	3	28
2	3	1	14	4	34
2	4	0	15	4	37
3	0	0	8	1	19
3	0	1	11	2	25
3	0	2	13	3	31
3	1	0	11	2	25
3	1	1	14	4	34
3	1	2	17	5	46
3	1	3	20	6	60
3	2	0	14	4	34
3	2	1	17	5	46
3	2	2	20	6	60
3	3	0	17	5	46
3	3	1	21	7	63
3	4	0	21	7	63
3	4	1	24	8	72
3	5	0	25	8	75
4	0	0	13	3	31
4	0	1	17	5	46
4	0	2	21	7	63
4	0	3	25	8	75
4	1	0	17	5	46
4	1	1	21	7	63
4	1	2	26	9	78
4	2	0	22	7	67
4	2	1	26	9	78
4	2	2	32	11	91
4	3	0	27	9	80
4	3	1	33	11	93
4	3	2	39	13	106
4	4	0	34	12	96
4	4	1	40	14	108
4	5	0	41	14	110
4	5	1	48	16	124
5	0	0	23	7	70
5	0	1	31	11	89
5	0	2	43	15	114
5	0	3	58	19	144
5	0	4	76	24	180
5	1	0	33	11	93
5	1	1	46	16	120
5	1	2	63	21	154
5	1	3	84	25	197
5	2	0	49	17	126
5	2	1	70	23	168
5	2	2	94	28	219
5	2	3	120	33	281
5	2	4	148	38	366
5	2	5	177	44	515
5	3	0	79	25	187
5	3	1	109	31	253
5	3	2	141	37	343
5	3	3	175	44	503
5	3	4	212	53	669
5	3	5	253	77	788
5	4	0	130	35	302
5	4	1	172	43	486
5	4	2	221	57	698
5	4	3	278	90	849
5	4	4	345	117	999
5	4	5	426	145	1 161
5	5	0	240	68	754
5	5	1	348	118	1 005
5	5	2	542	180	1 405

Annexure 4

Adverse impact and remedial measure due to the presence of various contaminates in water

Sl No	Name	Source	Adverse impacts	Remedial measures
1	Turbidity	Many materials contribute turbidity- Clay particles, sewage solids, silt and sand washings, organic and biological sludge and presence of iron etc.	Aesthetically unpleasant, difficulty in chlorination	Removal by filtering , coagulation , sedimentation
2	Low pH	Mainly due to the presence of carbon dioxide from the crust of the earth or any other mineral acids ***Refer the picture given in Annexure 5 which illustrates the change in pH while percolating water through the earth***	Sour taste ,corrosive nature	Increase the pH by aeration, Addition of alkaline substances like lime , soda ash etc
3	High pH	Refer the picture given in Annexure 5 which illustrates the change in pH while percolating water through the earth	Alkaline taste ,deposit in pipes	Reducing the pH by adding weak acids
4	Conductivity	Dissolved ions from the various sources such as from the crust of the earth ,salts intruded from sea water etc	Presence of dissolved solids Change the water quality significantly , taste will change , use	Distillation ,reverse osmosis , electro dialysis etc

			for drinking and agricultural will be affected	
5	Dissolved solids	Conductivity and dissolved solids are mutually related . when the dissolved solids increase conductivity also increases and vice versa	Do	Do
6	Sulphate	Dissolved from soil and rock formations that contain sulfate minerals,. Minerals that contain sulfate include magnesium sulfate (Epsom salt), sodium sulfate (Glauber's salt), and calcium sulfate (gypsum . Decaying plant and animal matter. Numerous chemical products including ammonium sulphate fertilizers contain sulphate in a variety of forms .water treatment using aluminum sulphate (alum) or copper sulphate also introduces sulphate into a water supply.	Intestinal discomfort, diarrhea and consequently dehydration. Formation of hydrogen sulphide and thus smell of rotten egg . by formation of sulphuric acid and therby lowering of pH	distillation or reverse osmosis. *ion exchange*. activated carbon filtration, oxidizing filters, oxidization followed by filtration, and de-aeration
7	Sulphide	From anaerobic decomposition of organic matter in water or in waste, and from bacterial reduction of sulphate.	Toxicity and odour problems-smell of rotten egg .Corrossion especially to sewers	distillation or reverse osmosis. ion exchange. odour problems can be reduced by increasing the pH

7	Alkalinity	Mainly from natural sources ,chemical reaction between ions in the crust of the earth with CO2from the crust of the earth which is penetrated downwards Refer the figure given in Annexure 5	As Alkalinity increases pH value also increases	Alkalinity can be reduced by adding weak acids
8*	Hardness	Hardness is caused by multivalent metallic cations . they are mainly calcium ,magnesium , strontium Iron,Manganese and predominant are Calcium and magnesium which enter the water by chemical reaction between caco3&mgco3 in the crust of the earth with carbonic acid formed by dissolution of CO2 from the crust of the earth formed by bacterial synthesis . Refer the figure given in Annexure 5	1)Excess consumption of soap for formation of lather 2) white deposit on boiling (caco3) 3)Alkaline taste	1)Softeners are available in the market 2)lime soda process 3) heating removes hardness to a certain extent

9	Chloride	Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l Cl). In fresh waters the sources include soil and rock formations, sea spray and waste discharges.	Chloride does not pose a health hazard to humans and the principal consideration is in relation to palatability. 2)Salty taste 2)corrosion	Distillation Reverse osmosis Electro dialysis
11	Available chlorine in bleaching powder **Used for chlorination of water**	Chlorine gas is absorbed in lime with the formation of bleaching powder which is used for disinfection		
12	Dissolved oxygen	Mainly absorbed from the atmosphere . the absorbtion is governed by partial pressure of oxygen in the atmospheric	Removal or absorption takes place in accordance with	
13	Biochemical oxygen (BOD)	When organic matter is discharged into a watercourse it serves as a food source for the bacteria present there. These will sooner or later commence the breakdown of this matter to less complex organic substances and	Indication of pollution in water and depletes the oxygen level	Removal can be done by waste water treatment methods

		ultimately to simple compounds such as carbon dioxide and water. For this process oxygen is required and that is called BOD and estimated by providing facilities for bacterial growth and and measuring the DO before and after		
14	Chemical oxygen demand(COD)	Same as above but the only difference is method used for analysis ie by oxidation by chemicals		
13	Iron	Dissolved form the crust of the earth .earth contains about 6% of Iron and out of that 3% in ferrous form and 3% in ferric form	1)Taste of iron(***From dissolved iron)*** 2)On keeping in the open(on contact with air) increase in turbidity ***The dissolved iron(Fe 2+) reacts with oxygen (oxidation) and convert to the precipitate form(Fe 3+) form with formation of increased turbidity)***	2)The dissolved iron(Fe2+ in contact with air react with oxygen (oxidation) and convert it to the precipitate form(Fe 3+).Due to this change colur of water will change to muddy 4) 5)As temperature increases oxidation increases and more insoluble form of iron (Fe 3+) is produced.

			3)More milk is needed to get the usual colour and taste to tea. ***(Iron react with tannin present in tea and produce an inky colour. so more milk is needed to get the usual colour and taste)*** 4)Cause colour change to utensils, fabric and tanks in contact with water.***(It is the habit of iron to impart reddish yellow stain on articles upon which it comes into contact)*** 5)Water becoming more turbid on heating and sedimentation of mud at the bottom.	6)The oil slick is formed as a result of the action of the iron bacteria growing in water containing excess of iron

			6)Appearance of oil slick on the surface of water.	
14	Manganese	As with iron, manganese is found widely in soils and is a constituent of many ground waters.	No particular toxicological effects. the objections to manganese - like iron - are aesthetic. Background Information:	Treatment same as for Iron stated above .

Water quality issues in Kerala State and remedial measures

The important water quality issues affecting traditional water sources of Kerala are listed below

1)Presence of Bacteria (indicator organism coliform)

2)Variation in pH value a) Low pH and high pH

3)Excess Iron

4) Excess Turbidity

5)Excess Fluoride

6) Excess chloride

7)Pollution due to organic matter

8)Excess hardness

10)Growth of Algae

1) Presence of Bacteria (indicator organism coliform)

Coliform is a group of bacteria present in human excreta

It comprises of 10 % of all the bacteria in human excreta

In water analysis it is used as an indicator of presence of human excreta in water supply

Coliform is present in more than 80 % of our traditional water sources

Reason for selecting coliform as an indicator

Its presence in human excreta is significant

Out of all the bacteria in the human excreta, it is the long lived

Its analysis is simple

Limitations of Coliform as an indicator

In addition to human being, it is present in the excreta of all the hot blooded animals

A strict indicator should not reproduce after discharging in to the surface of earth but in favourable conditions coliform reproduces

Treatment for coliform is effective disinfection by using bleaching powder or any other disinfectant

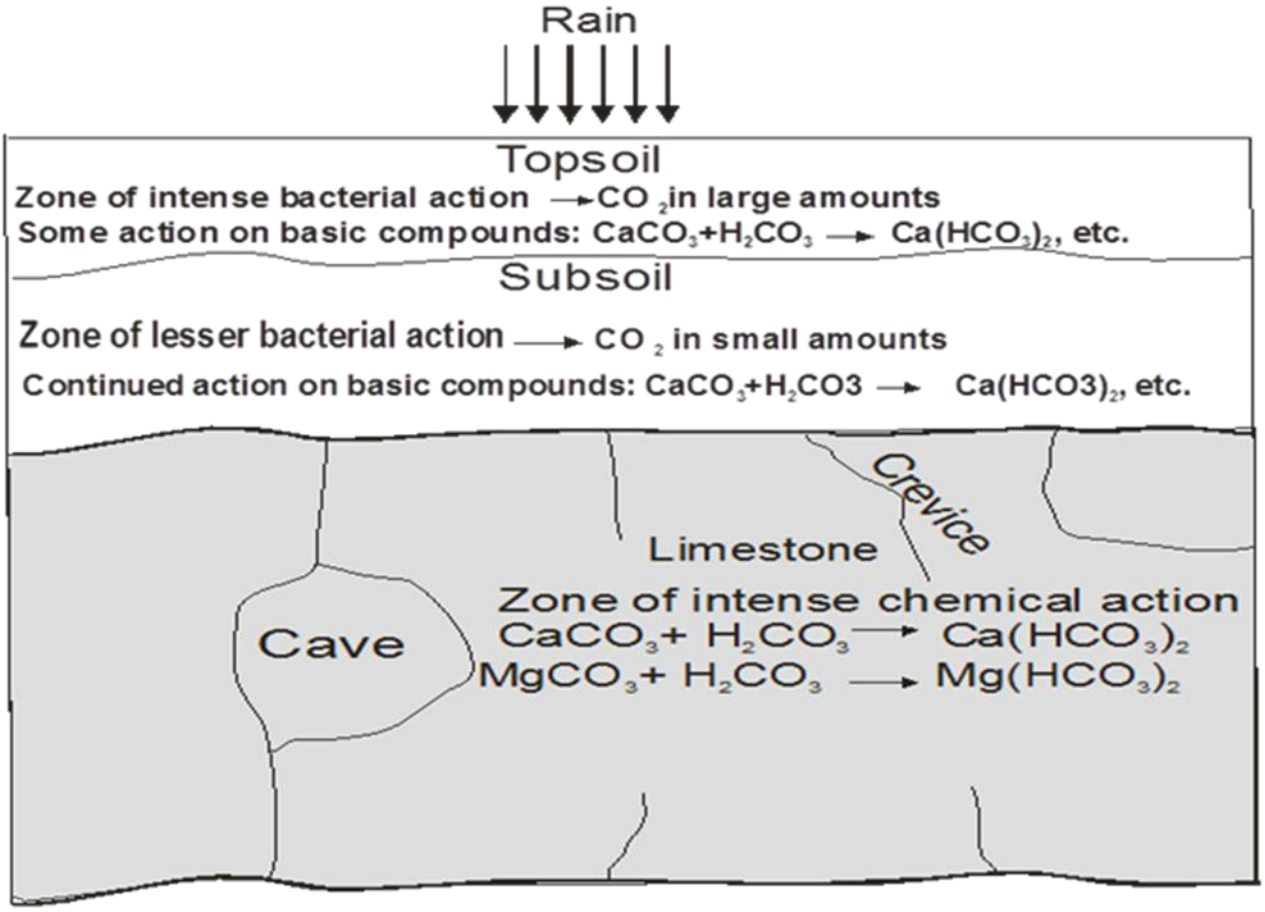
2)Variation in pH value a)Low pH and high pH

About 60 % of well water samples are having low pH

High pH occurs in limited places

Low pH imparts sour taste and corrosive nature

Carbon dioxide dissolution from the surface of the earth and subsequent chemical reaction



is the cause for variation in pH value while rainwater is percolating through the earth. refer fig above

from the top of the earth CO2 dissolve in water and thereby carbonic acid is formed – this reduces the pH Value in a shallow well

When water percolate through the earth carbonic acid reacts with the calcium carbonate and calcium bicarbonate is formed and thereby pH increases alkalinity ,hardness etc also increases

As it go deeper magnesium carbonate also comes in to picture and reaction takes place as given above in the figure abovev

That means in shallow well acidity will be more pH will be more and in deep wells and borewells pH will be more alkalinity and hardness will be more

Treatment for pH variation

Low pH can be increased by adding any suitable alkaline substances say lime

High pH can be reduced by adding acidic substa**nces**

3)Presence of excess Iron

Iron constitutes approximately 6% of the earth crust

3% in soluble Fe^{2+} form and 3% in insoluble Fe^{3+} form

While rain water is percolated through the earth Fe^{2+} dissolves in the water

Organic pollution of water increases presence of Iron since some bacteria use Fe^{3+} as an Electron acceptor

Important bad effect of presence of iron are as follows

No	Bad effects	Reason
a	iron taste	
b	Change in colour when exposed to atmosphere	(oxidation of ferrous Iron to ferric Iron)- $Fe^{2+} + O_2 + H_2O = Fe(OH)^3 + H^+$
c	more requirement of milk for preparation of tea to get the minimum flavor	Excess requirement of milk to prepare tea of required flavor(Iron +Tanin = black colour)
d	Staining in vessels	due to oxidation , it is a special property of oxidation to form color
e	Deposition of mud after the water is boiled	More oxidation on heating
f	Oily appearance on the surface of water due to growth of iron bacteria	due to the growth of iron bacteria

Treatment for excess iron

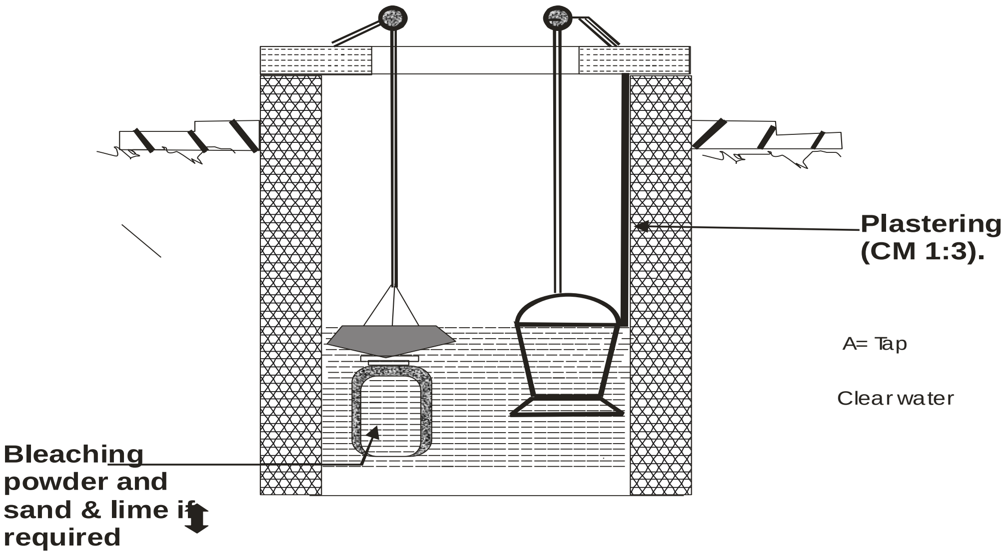
Increase the pH of water by adding suitable alkaline materials (lime , Soda ash, bleaching powder)

Aerate the water for oxidation to take place

$Fe^{2+} + O_2 + H_2O$ -------- $Fe(OH)3^{+} + H^{+}$

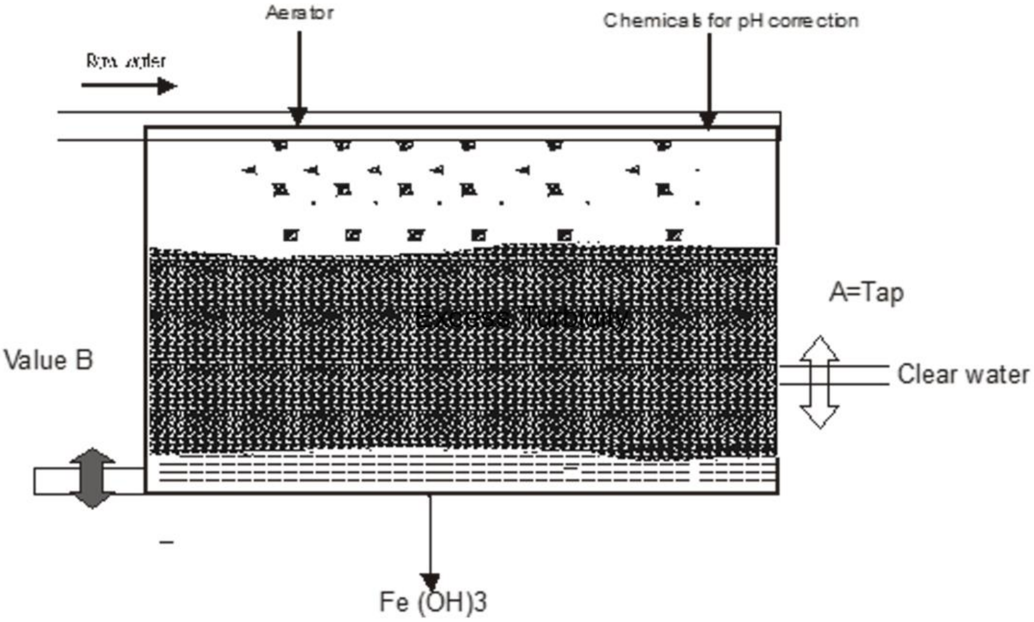
Allow for settling and thereafter for filtering

Disinfect to make it potable



Iron treatment in a well

We can add bleaching powder in the well directly as given in the figure and mix properly. This can be done say in the evening and pump water from just below the top water level in the next day



Treatment in a tank

Construct the tank in such a way that cleaning and sedimentation is easy as given in the figure above. Pump water and add bleaching powder and keep it as such for say 10 hours . With draw water from the outlet valve

Other domestic treatment systems are available

4) Excess Turbidity

It occurs in certain wells and in certain water sources

Treatment is plain sedimentation /coagulation, sedimentation/ Filtration etc

5)Excess fluoride

Fluoride dissolves from the crust of the earth

Fluoride presence will be more in water sample with less calcium

$$Ca+F_2 \longrightarrow CaF_2$$

There is affinity between fluoride and calcium so the fluoride gets removed from the water

In kerala Alappuzha and Palakkad is mainly affected

Domestic kit using activated Alumina is suitable for removal of Fluoride

Equipment using the principles of Reverse Osmosis can also be used

Fluoride presence will not show any apparent effect other than the diseases caused fluorosis

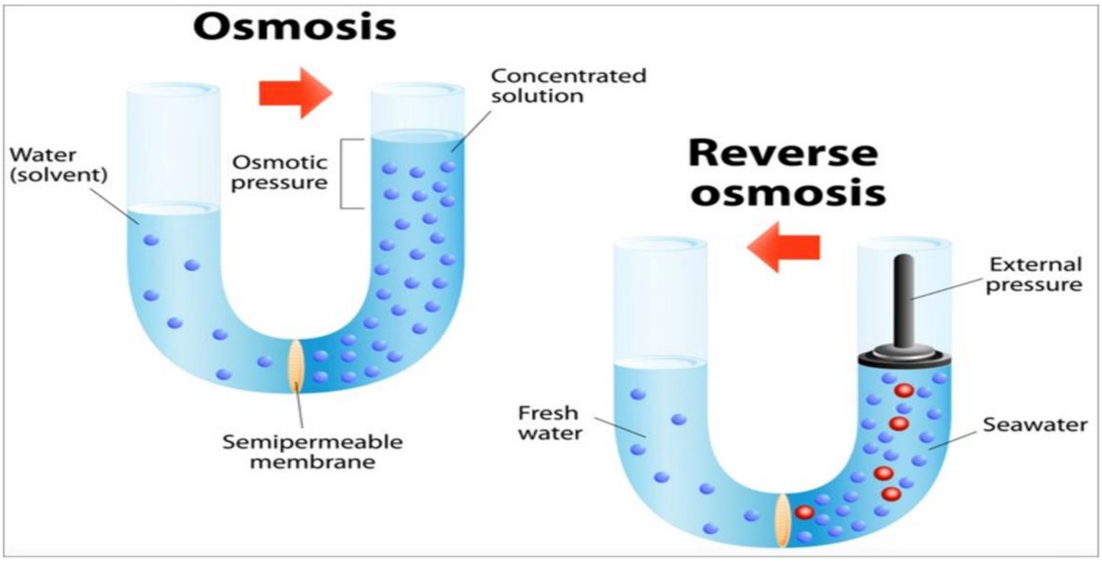
Water Filters: One way of avoiding the fluoride from tap water is to purchase a water filter. The three types of filters that can remove fluoride are reverse osmosis, deionizers (which use ion-exchange resins), and activated alumina

The Berkey systems are our pick for a simple, ecological fluoride solution.

Reverse osmosis kits

Reverse osmosis (RO) is a water purification process that uses a semi-permeable membrane to separate water molecules from other substances. RO applies pressure to overcome osmotic pressure that favors even distributions. RO can remove dissolved or suspended chemical species as well as biological substances (principally bacteria), and is used in industrial processes and the production of potable water. RO retains the solute on the pressurized side of the membrane and the purified solvent passes to the other side. Picture below gives

Reverse Osmosis based equipments



Reverse osmosis process

6)Organic Pollution

Organic pollution occurs when large quantities of organic compounds, which act as substrates for microorganisms, are released into water sources. Organic wastes from people and their animals may also be rich in disease-causing (pathogenic) organisms

Intrusion of waste in to water sources causes pollution

Black colour and death of fish / uneasiness for the fish is manifested

Identify such sources and remove it

Always remove such waste sources from near the water sources and chlorinate the water source / well

7)Presence of Chloride in Drinking water

Sea water intrusion in coastal area

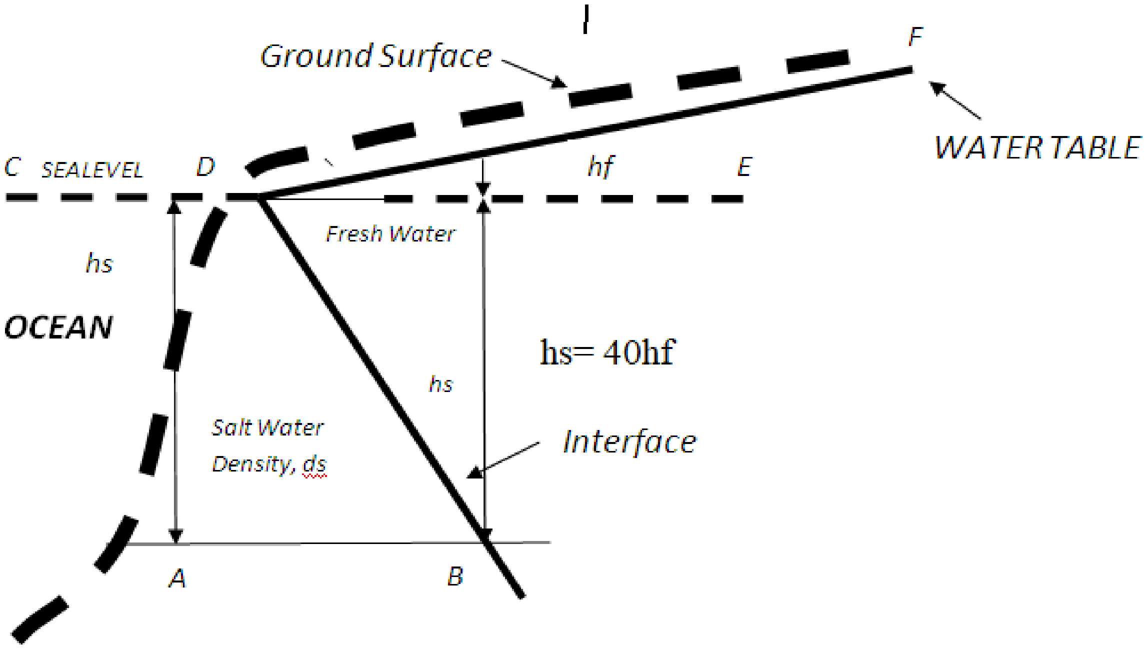
In certain open wells in Palakkad district

Ghyben – Hertzberg equation for intrusion of sea water

In coastal area withdrawal of fresh water results in to intrusion of sea water

Above the water level in the sea if fresh water is available for a height of hf in the nearby land area there must be 40hf of fresh water below the water level in the sea to prevent sea water intrusion

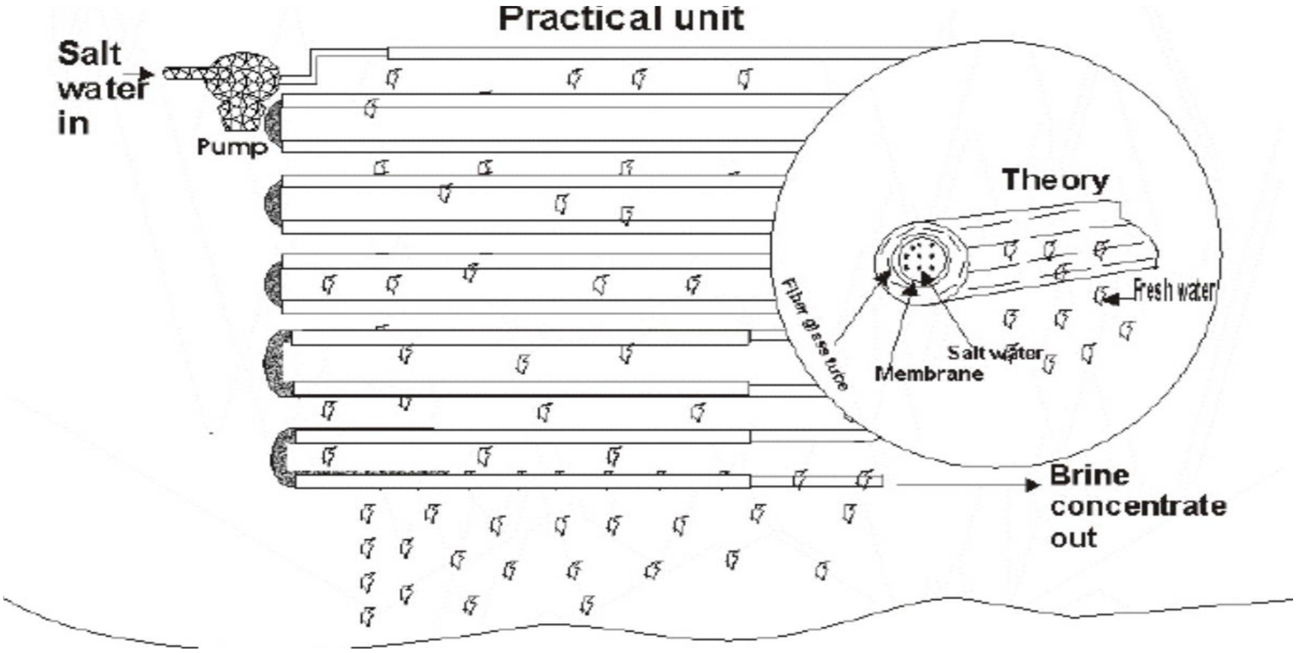
Rain water harvesting is essential in coastal area



Pictorial representation of ghyben – Herzberg equation

Commonly used method for treatment for removal of Chloride is Reverse osmosis (RO)

Some (RO) units are being used in coastal area of Kerala



RO practical Unit

RO plant in Jubail Saudi arabia

8)Hardness

Hardness is caused by multivalent metallic cations mainly calcium and magnesium

Deep water sources are generally hard

If topsoil is thick hardness will be more

Softeners are that equipment which remove calcium and magnesium are commonly used for its removal

Hardness will be more in deep water sources like borewells

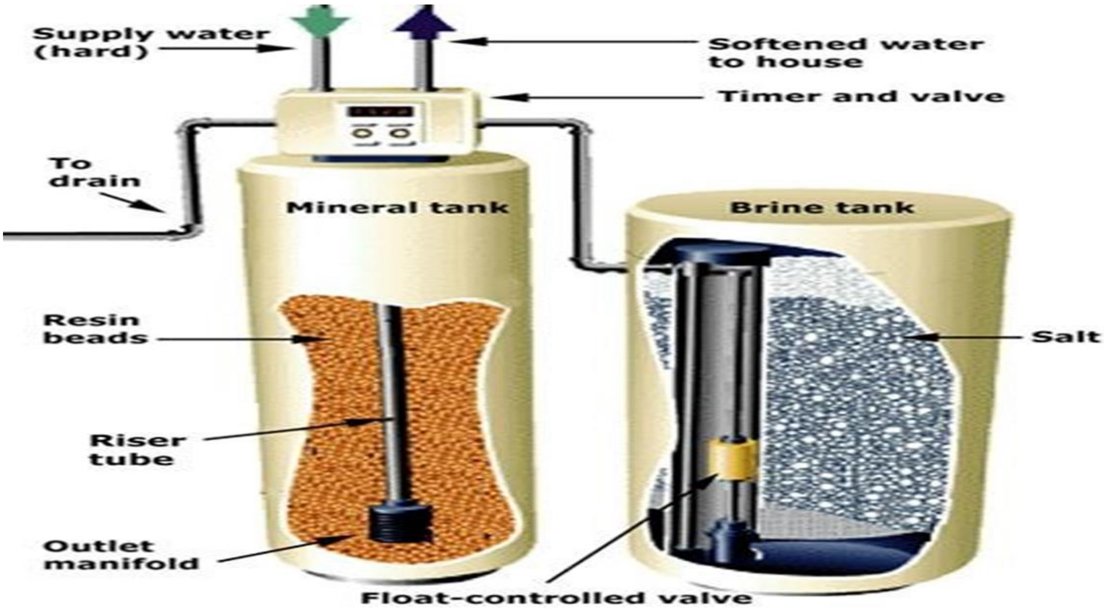
to a certain extent Presence of hardness in drinking water is considered as good for heart diseases

hardness produces white deposit on boiling

reason is dissolution of calcium bicarbonate

$Ca(HCO3)_2$------- $Caco_3+CO2+H_2O$

Softeners for hardness removal



9)Growth of Algae

In wells water is good in the morning but as sunlight falls color change occurs

Water sources gets polluted due to algae growth

Algae is water plant which requires sunlight for its growth

Treatment for algae growth is prevention of sunlight, chlorine or copper sulphate

Algae growth in wells