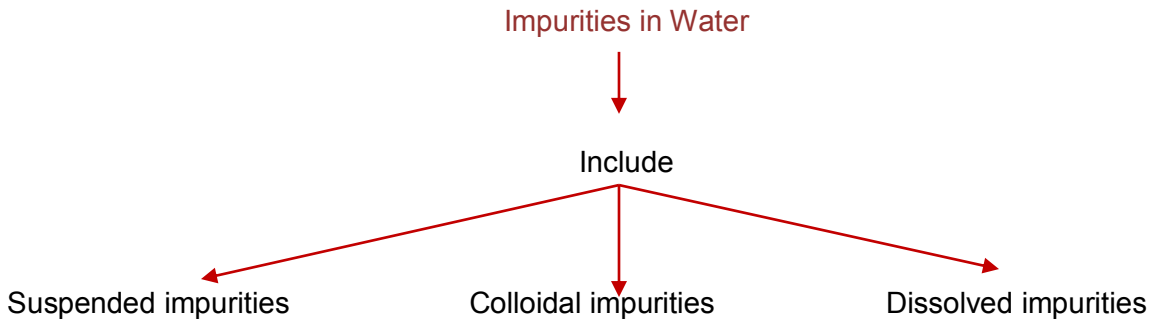
SCI1210 ENVIRONMENTAL ENGINEERING – I

UNIT III QUALITY OF WATER

Analysis of water – physical, chemical & bacteriological characteristics – Coliform Index, Algae toxins and Algae index- Most Probable Number – Sampling – Drinking water standards – Water borne diseases

Impurities in water and their importance

Water impurities



Suspended impurities

- Impurities are dispersion of solid particles that are large enough to be removed by filtration on surface and heavier ones settle down.
- Suspended impurities which have same specific gravity as that of water, are mixed in the water.
- Suspended impurities include
  - Clay, silt (some cause disease)
  - Algae, protozoa (cause odour, turbidity and colour)
  - Fungi
  - Organic (vegetable- colour, taste and acidity, animal – produce harmful disease germs)
  - Inorganic matters
  - Mineral matter etc.,

- These all impurities are macroscopic and cause turbidity in the water.
- The concentration of suspended matter in water is measured by its turbidity.

Colloidal impurities

- It is very finely divided dispersion of particles in water.
- These particles are so small that these cannot be removed by ordinary filters and are not visible to the naked eye.
- As a matter of fact all the colloidal impurities are electrically charged and remain in continuous motion.
- The electric charge is due to the presence of absorbed ions on the surface of the solid
- Acid or neutral materials as silica, glass and most organic particles acquire negative charge in neutral water, whereas basic materials such as metallic oxides Al_2O_3 and Fe_2O_3 are positively charged.
- These electric charges on the surfaces of particles are large enough in comparison with their mass to cause the particles to repel one another when they move within the sphere of action of each other's charge.
- Due to these repelling actions all the colloidal particles remain in motion and do not settle.
- That is why their removal is very difficult.
- These colloidal impurities are generally associated with organic matter containing bacteria's and are the chief source of epidemics.
- Most of the colour of the water is due to colloidal impurities.
- Their quantity is determined by colour testes. The size of colloidal particles is between (1 = 1 micron = 0.001mm) to 1 = 1 milli micron = 0.000001mm) or (10^{-}3 mm to 10^{-}6mm)

Dissolved impurities

- Some impurities are dissolved in water when it moves over the rocks, soil etc.,
- Solids, liquids and gases are dissolved in natural waters.

- These dissolved impurities may contain organic compounds, inorganic salts and gases etc.
- The concentration of total dissolved solids is usually expressed imp pm and is obtained by weighing the residue after evaporation of the water sample from a filtered sample.
- Dissolved impurities include
  - Calcium and magnesium (sulphate cause hardness, fluorides cause mottled enamel of teeth)
  - Sodium (chloride cause taste, manganese cause black or brown colour)
  - Metal (lead cause lead poisoning, arsenic - poisoning , oxygen - corrode the metal)
  - Gases (hydrogen sulphate cause rotten-egg odour, acidity and corrode the metals)
  - Organic impurities – vegetable – produce bacterias, animal cause pollution of water and produce disease germs)

Calcium bicarbonate is a soluble salt. A solution of calcium bicarbonate is clear, because the calcium and bicarbonate are present as atomic sized ions which are not large enough to reflect light. Some soluble minerals impart a color to the solution.

Soluble iron salts produce pale yellow or green solutions; some copper salts form intensely blue solutions. Although colored, these solutions are clear. Suspended solids are substances that are not completely soluble in water and are present as particles.

These particles usually impart a visible turbidity to the water. Dissolved and suspended solids are present in most surface waters. Seawater is very high in soluble sodium chloride; suspended sand and silt make it slightly cloudy.

An extensive list of soluble and suspended impurities found in water is given below.

CONSTITUENT	CHEMICAL FORMULA	DIFFICULTIES CAUSED	MEANS OF TREATMENT
Turbidity	non-expressed in analysis as units	✓ Imparts unsightly appearance to water	Coagulation, Settling,

		✓ Deposits in water lines process equipment, etc. ✓ Interferes with most process uses	Filtration.
Hardness	Calcium and magnesium salts, expressed as $CaCO_3$	✓ Chief source of scale in heat exchange equipment, boilers, pipe lines, etc. ✓ forms curds with soap ✓ interferes with dyeing, etc.	Softening; demineralization; Internal boiler water treatment; Surface active agents
Alkalinity	Bicarbonate(HCO_3^-), carbonate (CO_3^{2-}), and Hydroxide(OH^-), expressed as $CaCO_3$	✓ Foam and carryover of solids with steam; ✓ Embrittlement of boiler steel; ✓ bicarbonate and carbonate produce CO_2 in steam, a source of corrosion in condensate lines	lime and lime-soda softening; acid treatment; hydrogen zeolite softening; demineralization dealkalization by anion exchange
Free Mineral Acid	H_2SO_4 , HCl. etc., expressed as $CaCO_3$	✓ Corrosion	neutralization with alkalies
Carbon Dioxide	CO_2	✓ corrosion in water lines, particularly steam and condensate lines	aeration, eaeration, neutralization with alkalies
PH	Hydrogen ion concentration defined as: $pH = \log \frac{1}{[H^+]}$	✓ pH varies according to acidic or alkaline solids in water; most natural waters have a pH of 6.0-8.0	pH can be increased by alkalies and decreased by acids
Sulfate	SO_4^{2-}	✓ Adds to solids content of water, but in itself is not usually significant, combines with calcium to form calcium sulfate scale	demineralization, reverse osmosis, electrodialysis, evaporation
Chloride	Cl^-	✓ Adds to solids content and increases corrosive character of water	demineralization, reverse osmosis, electrodialysis, evaporation
Nitrate	NO_3^-	✓ Adds to solids content, but is not usually significant industrially: ✓ high concentrations cause methemoglobinemia in infants; ✓ useful for control of	demineralization, reverse osmosis, electrodialysis, evaporation

		boiler metal embrittlement	
Fluoride	F^-	✓ Cause of mottled enamel in teeth; ✓ also used for control of dental decay: ✓ not usually significant industrially	adsorption with magnesium hydroxide, calcium phosphate, or bone black; alum coagulation
Sodium	Na^+	✓ Adds to solids content of water: ✓ when combined with OH^-, causes corrosion in boilers under certain conditions	demineralization, reverse osmosis, electrodialysis, evaporation
Silica	SiO_2	✓ Scale in boilers and cooling water systems; ✓ Insoluble turbine blade deposits due to silica vaporization	hot and warm process removal by magnesium salts; adsorption by highly basic anion exchange resins, in conjunction with demineralization, reverse osmosis, evaporation
Iron	Fe^{2+} (ferrous) Fe^{3+} (ferric)	✓ Discolors water on precipitation; ✓ source of deposits in water lines, boilers. etc.; ✓ interferes with dyeing, tanning, papermaking, etc.	aeration; coagulation and filtration; lime softening; cation exchange; contact filtration; surface active agents for iron retention
Manganese	Mn^{2+}	Same as iron	same as iron
Aluminum	Al^{3+}	✓ Usually present as a result of floc carryover from clarifier; ✓ can cause deposits in cooling systems and contribute to complex boiler scales	improved clarifier and filter operation
Oxygen	O_2	✓ Corrosion of water lines, heat exchange equipment, boilers, return lines, etc.	deaeration; sodium sulfite; corrosion inhibitors
Hydrogen Sulfide	H_2S	✓ Cause of "rotten egg" odor; corrosion	aeration; chlorination; highly basic anion exchange
Ammonia	NH_3	✓ Corrosion of copper and zinc alloys by formation of complex soluble ion	cation exchange with hydrogen zeolite; chlorination; deaeration
Dissolved Solids	None	✓ Refers to total amount of dissolved matter (determined by	lime softening and cation exchange by hydrogen zeolite; demineralization,

		evaporation) ✓ High concentrations are objectionable because of process interference and as a cause of foaming in boilers	reverse osmosis, electrodialysis, evaporation
Suspended Solids	None	✓ Refers to the measure of undissolved matter, ✓ Determined gravimetrically; ✓ Deposits in heat exchange equipment, boilers, water lines, etc.	subsidence; filtration, usually preceded by coagulation and settling
Total Solids	None	✓ Refers to the sum of dissolved and suspended solids, ✓ Determined gravimetrically	see "Dissolved Solids" and "Suspended Solids"

Analysis of water -Physical, chemical & bacteriological characteristics

Water Quality

The raw or treated water is analyzed by testing their physical, chemical and bacteriological characteristics:

PHYSICAL CHARACTERISTICS

- Turbidity
- Colour
- Taste and Odour
- Temperature

CHEMICAL CHARACTERISTICS

- Acidity
- Alkalinity
- Hardness
- Chlorides
- Chlorine
- Sulphates
- Iron and manganese
- Total Solids
- Lead and arsenic
- Dissolved gases
- Nitrogen
- Metals and chemical substance

BACTERIOLOGICAL CHARACTERISTICS

- Total count of bacteria
- Bacteria Coli (B-coli) Test

PHYSICAL CHARACTERISTICS*:*

- Temperature
- Colour
- Turbidity
- Taste and Odours
- Specific conductivity of water

TEMPERATURE:

- ✓ The temperature of water is measured by means of ordinary thermometers.
- ✓ From the temperature the MASS density(P=m/v), viscosity, vapour pressure and surface tension of water can be determined.
- ✓ The temperature of surface water is generally same to the atmospheric temperature, while that of ground water may be more or less than atmospheric temperature.
- ✓ The most desirable temperature for public supply is between 4.4 °C to 10 °C.
- ✓ Temperature above 28 °C are undesirable and above 35 °C are unfit for public supply, because it is NOT PALATABLE(NOT ACCECTABLE TO TASTE).

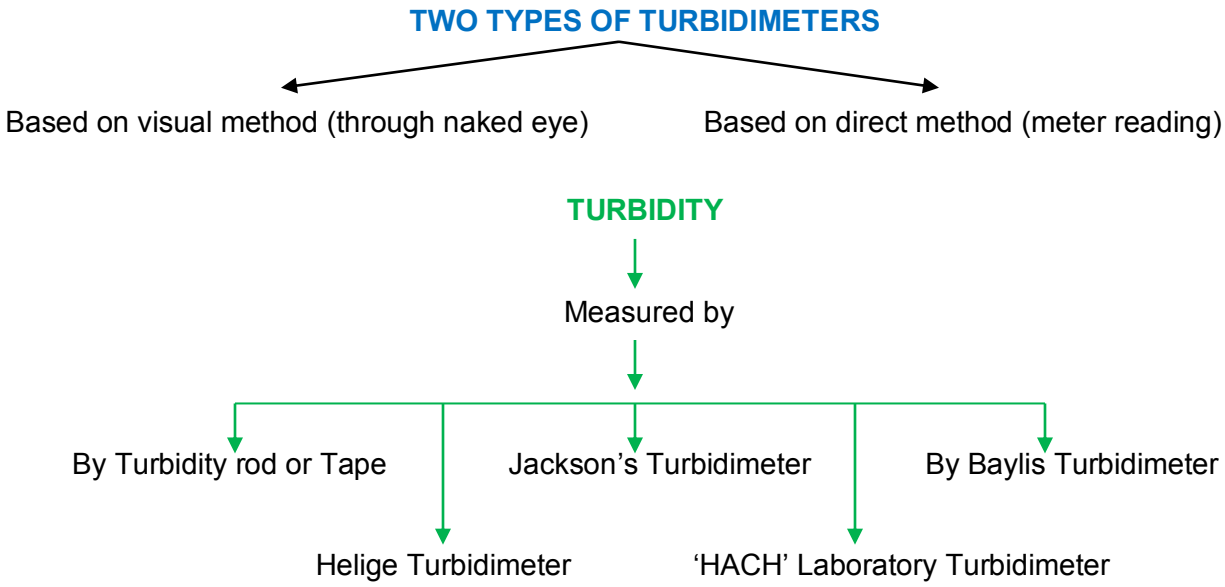
COLOUR:

- ✓ The color of water is usually due to presence of organic matter, but sometimes it is also due to mineral and dissolved organic and inorganic impurities.
- ✓ Before testing the color of the water, first of all total suspended matter should be removed from the water by centrifugal force in a special apparatus.
- ✓ After this the color of water is compared with standard color solution.
- ✓ The permissible color for domestic water is 20 ppm on platinum cobalt scale.
- ✓ The color in water is not harmful but it is objectionable.

TURBIDITY:

- ✓ **I**t is caused due to presence of suspended and colloidal matter in the water.
- ✓ The character and amount of turbidity depends on the type of soil over which the water has moved ground waters are less turbid than the surface water
- ✓ Turbidity is a measure of resistance of water to the passage of light through it.

- ✓ Turbidity is expressed as NTU (Nephelometric Turbidity Units) or PPM (parts per million) or Milligrams per litre (mg/l).



The Sample to be tested is poured into a test tube and placed in the meter and units of turbidity are read directly on the scale by a needle or by digital display.

Drinking water should not have turbidity more than 10 N.T.U. This test is useful in determining the detention time in settling for raw water and to dosage of coagulants required to remove turbidity.

Turbidity rod or Tape:

- Turbidity rod is used for measuring turbidity of water in the field.
- It consists of a graduated aluminium rod, about 20.3 cm in length, at the upper end of which is attached a graduated non-stretchable tape of about 12.2 cm long.
- At the lower end of the aluminium rod, a screw containing a platinum needle and a nickel ring is inserted.
- The graduated tape has a mark at its top end specifying the position of eye during the test.
- In order to find the turbidity, the lower end of the rod is gradually immersed in water whose turbidity is to be determined.
- Eye is kept constantly at the marked position and the platinum needle is watched.

- The rod is moved slowly in water till the platinum needle just disappears from the vision due to turbidity of water.
- The reading of the graduated tape near the water surface directly gives turbidity in p.p.m. the rod gives only rough value of the turbidity of water.

Jacksons Turbidimeter

- This is a laboratory apparatus which is used to measure turbidity when it is more than 100 p.p.m. it consists of a metal stand holding a metal container and a graduated glass tube in it.
- A standard candle is placed below the stand. The water sample is poured in the sample and the image of the flame of the standard candle is seen through the turbid water in the glass tube.
- The level of water in the glass tube is gradually increased till the image of the flame ceases to be seen.
- The height of the water column, measured in the graduated glass tube provides the measure of the turbidity of the water.
- The longer the light path of 21.5 cm corresponds to 11 JTU while light path of 10.8 cm corresponds to 200 JTU where 1 JTU= 1 ppm.

By Baylis Turbidimeter

- This is a very accurate and is preferred when the turbidity of the sample is less than 5 units.
- It consists of a galvanized iron box in which two glass tubes are kept at one end and a 250 watt bulb with reflector is placed at the other end.
- One tube contains standard solution of known turbidity while in the other tube the water sample is kept. The tube is held firmly in a platform with beveled holes at its bottom end.
- The tubes are surrounded on all its four sides by blue cobalt plates and at its bottom by a white opal glass plate.
- Because of blue cobalt plates, blue light is cast in both the tubes, and a comparison is made.
- If the light differs, another tube containing standard solution of different turbidity is introduced in the place of the first one till the color in both the tube matched.
- The standard solution at this stage give the turbidity of the given water sample. The turbidity is expressed either as p.p.m or BTU both being equivalent.

TASTE AND ODOURS

Taste and odours in water may be due to the presence of dead or alive micro-organisms, dissolved gases such as hydrogen sulphide, methane, carbon dioxide or oxygen combined with organic matter, mineral substance such as sodium chloride, iron compounds, and carbonate and sulphates of other substances.The test of these are done by sense of smell and taste because these are present in such small proportions that it is difficult to detect them by chemical analysis.

The odour of water also changes with temperature. The odour may be classified as fishy, mouldy, sweetish, vegetable, greasy etc. The odour of both cold and hot water should be determined. The water having bad smell or odour is objectionable and should not be supplied to the public,

The intensities of the odours are measured in terms of threshold number.

SPECIFIC CONDUCTIVITY OF WATER

The total amount of dissolved salts present in water can by easily estimated by measuring the specific conductivity of water. The specific conductivity of water is determined by means of portable *dionic* water tester and it expressed in micro-,hoes per cm at 25° C (Mho is the unit of conductivity and equals *lampr/wolt*).The specific conductivity of wate in micro-mhoes per cm at 25° C is multiplied by a coefficient (generally 0.65) so as to directly obtain the dissolved salt content in mg/litre or ppm. The exact value of this coefficient depends upon the type of salt present in water.

CHEMICAL CHARACTERISTICS:

- pH-value
- Acidity
- Alkalinity
- Hardness
- Chlorides
- Chlorine
- Sulphates
- Iron and manganese
- Total Solids
- Lead and arsenic

- Dissolved gases
- Nitrogen
- Metals and chemical substance

pH value

Denotes the concentration of hydrogen ions in the water and it is a measure of acidity or alkanity of a substance.

PH = - log 10[H +] or 1 / log 10[H +]

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Acidity ← Neutral→ Alkalinity

Depending upon the nature of dissolved salts and minerals, the PH value ranges from 0 to 14. For pure water, pH value is 7 and 0 to 7 acidic and 7 to 14 alkaline ranges.

For public water supply pH value may be 6.5 to 8.5. The lower value may cause tuberculation and corrosion; whereas high value may produce incrustation, sediment deposits and other bad effects.

pH value of water is generally determined by pH papers or by using pH meter. pH can read directly on scale or by digital display using pH meter.

Measurement of pH: pH measurement is important since it provides means of classifying and of correlating other characteristics or behaviors such as corrosive activity or other interrelated factors controlling biological function in a body of water.

Its knowledge is also helpful in controlling softening and coagulation processes in water treatment.

There are two methods of determine pH value of water:

(i) Colourimetric method,

(ii) Electrometric method

1. Colourimetric method

This is probably the most single method in which some indicator is added to the water sample, and the colour of the solution of known pH value. These standard colours may be in the form of coloured liquids in glass tubes, coloured glass discs or coloured charts supplied by the manufacturers, with each indicator. For acidic range, the common indicators are thymol blue (acid range) bromophenol blue, methyl red and chlorophenol red. For alkaline range, the common indicators are thymol blue (alkaline range), phenolphthalein red and toyl red.

2. Electrometric method

In this method, a pH meter is used. The specimen of water is kept in a beaker and the two electrodes of the instrument are dipped in water connected to a dry cell. The current passing through the circuit indicates the pH value which is read directly on the dial. The electrodes commonly used are made of calomel, glass or quinhydrone. In some of the latest pH meters, the pH value is displayed electronically on the dial, upto second decimal place of the value.

Total solids and suspended solids

Total solids

- Includes the solids in suspension colloidal and in dissolved form. The quantity of suspended solids is determined by filtering the sample of water through fine filter, drying and weighing.
- The quantity of dissolved and colloidal solids is determined by evaporating the filtered water obtained from the suspended solid test and weighing the residue.
- The total solids in a water sample can be directly determined by evaporating the filtered water obtained from the suspended solid test and weighing the residue.
- The total solids in a water sample can be directly determined by evaporating the water and weighing the residue of the residue of total solids is fused in a muffle furnace the organic solids will decompose where as only inorganic solids will remain. By weighing we can Hardness of water
- It is a property of water, which prevents the lathering of the soap. It is caused due to the presence of carbonates and sulphates of calcium and magnesium in the water.
- Sometimes the presence of chlorides and nitrates of calcium and magnesium also cause hardness in the water

Hardness is of two types.

1. Temporary hardness:

It is caused due to the presence of carbonates and sulphates of calcium and magnesium. It is removed by boiling.

2. Permanent hardness:

It is caused due to the presence of chlorides and nitrates of calcium and magnesium. It is removed by zeolite method.

Hardness is usually expressed in mg/litre or ppm. of calcium carbonate in water.

Hardness of water is determined by EDTA method.

For potable water hardness ranges from 5 to 8 degrees.

There are three methods of determining total hardness of water

a. Clarke‟s method

b. Hehner‟s method

c. Versenate method

Clarke’ s method

This method is based on the premise that hardness-producing substances react with soap and form insoluble compounds before latter is produced. Hence total hardness is found by determining the standard soap solution required to obtain a permanent lather with the water sample of known volume with constant shaking. this method has become obsolete.

Hehner’s method

in this method the temporary hardness is determined by titration with a standard solution of sulphuric acid, using methyl orange indicator. To determine the permanent hardness, standard sodium carbonate solution is added to the water sample and evaporated to dryness. The amount of sodium carbonate in excess over that required to convert the sulphates and chlorides into carbonates gives the permanent hardness.

Versenate method

in this method, hardness is determined by titrating against Ethlene diamine tetra citic acid (EDTA) solution using Eri chrome black T as indicatot at pH 8.5 to 11.

For potable water, hardness is objectionable because

(i) great deal of soap is required for washing clothes etc.,

(ii) scale is formed in boilers and hot water heating systems and

(iii) corrosion and incrustation of pipe lines and plumbing fixtures is promoted.

Chloride content

The natural waters near the mines and sea dissolve sodium chloride and also presence of chlorides may be due to mixing of saline water and sewage in the water.Excess of chlorides is dangerous and unfit for use. The chlorides can be reduced by diluting the water. Chlorides above 250p.p.m. are not permissible in water. Chlorides are estimated by titration with standard silver nitrate solution using potassium chromate as indicator. For this 50 c.c. of water sample is taken by a pipette, in a porcelien dish, and two or three drops of potassium chromate solution is

added to the water in the dish. The water sample is then titrated with standard solution of silver nitrate.

Nitrogen content

The presence of nitrogen in the water indicates the presence of organic matters in the water. The nitrogen may be present in the water may be in one or more of the following forms.

1. Nitrates
2. Nitrites
3. Free ammonia
4. Albuminoidal nitrogen.

Excess presence of nitrogen will cause “MATHEMOGLOBINEMIA” disease to the children.

Nitrate

Nitrate constitutes the final stage in the oxidation of nitrogen compounds, and normally reaches important concentrations in the final stages of biological oxidation. The nitrate contained in pure well water derived from an extensive catchment is largely the result of biological activity in the surface layers of the soil, enhanced by cultivation and the application of manures. When the nitrate in in the excessive amounts, t contributes to the illness known as infant methemoglobinemia. Nitrate is measured either by reduction to ammonia or by matching the colours produced with phenoldisulphonic acid.

Nitrites

Nitrite in water is either due to oxidation of ammonium compounds or due to reduction of nitrate. As an intermediate stage in the nitrogen cycle, it is unstable. A usual concentration in natural water is in the range of some tenths of mg/L. Higher concentrations are present in industrial wastes, sewage and in biologically purified effluents and in polluted streams. In chlorinated supplies, levels of nitrite are often less than the limit of detection, i.e. 0.005mg/L NO2-N but high levels may occur in unchlorinated water. Very high nitrite levels are usually associated with water of unsatisfactory microbiological activity.

Nitrites can be determined by the following methods

1. Colorimeter or spectro-photometer that can be operated at 543nm.
2. Nessler tubes or 100mL capacity volumetric flask.

Free ammonia

Ammonia is produced by the microbiological degradation of organic nitrogenous matter. It appears, therefore, in many groundwaters as well as surface waters. Concentrations of

ammonia above a certain level in water polluted either due to sewage or industrial waste is toxic to fish. The proportions of the two forms of ammonia nitrogen in surface water depend on pH. For accurate results, it is generally preferable to distill off ammonia from the sample, and absorb in boric acid. It is then determined either by titration or colorimetrically using Nessler reagent.

Dissolved gases

Oxygen and carbondi-oxide are the gases mostly found in the natural water. The surface water contain large amount of dissolved oxygen because they absorb it from the atmosphere. Algae and other tiny plant life of water also give oxygen to the water. The presence of oxygen in the water in dissolved form keeps it fresh and sparkling. But more quantity of oxygen causes corrosion to the pipes material. Water absorbs carbon-dioxide from the atmosphere. If water comes across calcium and magnesium salts, carbon-dioxide reacts with the salts and converts them into bicarbonates, causes hardness in the water. The presence of carbon-dioxide is easily determined by adding lime solution to water gives milky white colour.

Bacteriological Characteristics:

- Total count of bacteria
- Bacteria coli (B-coli) test

- Bacterial examination of water is very important, since it indicates the degree of pollution.
- Water polluted by sewage contains one or more species of disease producing pathogenic bacteria.
- Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as ***E.Coli***, a member of coliform group, also live in the intestinal tract of human beings.
- ***Coliform*** itself is not a harmful group but it has more resistance to adverse condition than any other group.
- So, if it is ensured to minimize the number of coliforms, the harmful species will be very less.
- So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.

  The methods to estimate the bacterial quality of water are:

  - ✓ Standard Plate Count Test
  - ✓ Most Probable Number

- ✓ Membrane Filter Technique

Total count of bacteria

In this method total number of bacteria present in millimeter of water is counted. The sample of water is taken; 1 ml of sample water is diluted in 99ml of sterilized water.

1. Sterilized Water (absence of any bacteria in the water).
2. Distilled water (that has many of its impurities removed through distillation. Distillation involves boiling the water and then condensing the steam into a clean container).
3. This mixture is kept in incubator at 37°c for 24hrs
4. After it the sample will be taken out from incubator and counted by means of microscope.

Bacteria coli (b-coli) test

There are 2 tests B-coli first is presumptive and second confirmative.

1. In the presumptive test definite amount of diluted sample of the water in standard fermentation tubes is kept in incubator at 37°c for 24hrs. If some gas is produced in the fermentation tube, it indicates the presence of B-coli. If not vice versa.
2. In the confirmation test same sample from the presumptive tube is taken and placed in another fermentation tube containing “brilliant green lactose bile” as culture medium.
3. And it again kept in incubator at 37°c for 48 hrs, if there is formation of gas in the tube, it confirms the presence of B-coli and the water is unsafe to use.

Membrane filter technique

1. Now a days a new technique of finding out the B-coli
2. Alternative to MPN
3. Membrane contains microscopic pores which are capable of retaining bacteria
4. Water is filtered through the membrane and it is then incubated for a period of 20 hours along with nutrients.
5. The colonies of bacteria can then be counted

Coliform Index, Algae toxins and Algae index

Coliform Index

- Coliforms are the rod, shaped, non-pathogenic bacteria whose presence or absence in water indicates the presence or absence of fecal pollution.
- The total coliform group consists of members whose normal habitat is the – (lower portion of intestines) of humans and warm and cold blooded animals and soil.
- Some members which are not found in soil and vegetation constitute about 96% of all the coliforms of human fecal. Such members are called fecal coliforms and recently named by WHO ad thermo tolerant coliform.
- The total coliform group is widely used as a indicator organism of choice for drinking water
- Escherichia coli (E-Coli) is the predominant member of the fecal coliform group
- Used to measure coliform bacteria present in water sample
- C.I is defined as the reciprocal of the smallest quantity of a sample which would give a positive B-coli test.
- Should be preferably less than 3 and should not exceed 10

Algae toxins and Algae index

Blue-green algae (also known as cyanobacteria) are microscopic organisms that naturally occur in Illinois lakes and streams. Blue-green algae can reproduce very quickly in warm, shallow, undisturbed-surface water that receives a lot of sunlight.

This rapid growth of algae is referred to as a “bloom.” Algal blooms can discolor the water or produce floating scums on the surface of the water, especially along shorelines. These blooms are primarily a concern during the summer months.

Certain types of blue-green algae are capable of producing toxins that pose a health risk to people and animals when they are exposed to them in large quantities. When a blue-green algal bloom is producing toxin(s), the bloom is referred to as a Harmful Algal Bloom (HAB).


Surface water affected by blue-green algae often is strongly colored such that it can develop a paint-like appearance.

- Algae is a type of plant that grows in water and flourished in the presence of sunlight
- 7 type of algae have been distinguished by colour and shape.
- Different type of algae can be divided into the three group

  -Diatomaceae group

  -Chlorophylceae group

  -Cyanophycea group

- Health effects can occur when surface scum's or waters containing high levels of **algal toxins** are swallowed, come in contact with skin, or when airborne droplets containing **toxins** are inhaled.
- The most common symptom from exposure to algal toxins is skin irritation with onset occurring after direct contact with the water.
- Other symptoms can include: nausea, vomiting, throat irritation, allergic reactions, or difficulty breathing.
- The toxins produced by blue-green algae may also affect the liver and nervous system if water is ingested in sufficient quantities.
- The safest thing to do is to treat every algal bloom as if it could be dangerous.
- Recreational contact with water (swimming, bathing, or showering) that is not visibly affected by a blue-green algae bloom is not expected to cause adverse health effects.

- Children may be more susceptible to the effects of algal toxins due to lower body weight. Children tend to have more sensitive skin than adults, so a skin rash or reaction is more likely.
- Also, children are more likely to engage in activities that allow water to be swallowed or inhaled. Children should always be supervised when swimming in any body of water.
- Avoid contact with water that is discolored or has scum on the surface. This includes, but is not limited to: swimming, water skiing, tubing, boating, etc.
- If contact does occur, immediately wash with soap and water or rinse thoroughly with clean water to remove algae.
- Never drink untreated surface water, whether or not algae blooms are present. Water from lakes, rivers, or streams may contain other bacteria, parasites or viruses, as well as toxins that could cause illness if consumed.

Most Probable Number(MPN)

- The most probable number (MPN) method is a useful, if underutilized, tool for the microbiologist.
- Estimate the concentration of viable microorganisms in a sample by means of replicate liquid broth growth in 10-fold dilutions.
- It is particularly useful with samples that contain particulate material that interferes with plate count enumeration methods.
- Serial dilution tests measure the concentration of a target microbe in a sample with an estimate called the most probable number (MPN).
- The MPN is particularly useful for low concentrations of organisms (<100/g), especially in milk and water, and for those foods whose particulate matter may interfere with accurate colony counts
- Only viable organisms are enumerated by the MPN determination. If, in the microbiologist's experience, the bacteria in the prepared sample in question can be found attached in chains that are not separated by the preparation and dilution, the MPN should be judged as an estimate of growth units (GUs) or colony-forming units (CFUs) instead of individual bacteria. For simplicity, however, this appendix will speak of these GUs or CFUs as individual bacteria. If a confirmation test involves selecting colonies to test, then a statistical adjustment not discussed in this appendix should be used

- MPN of water will be 7/100 ml means 7 coliform per 100 ml of water.

ASSUMPTIONS (necessary to support the MPN method)

- The bacteria are distributed randomly within the sample.
- The bacteria are separate, not clustered together, and they do not repel each other.
- Every tube (or plate, etc.) whose inoculums contains even one viable organism will produce detectable growth or change. T
- he individual tubes of the sample are independent.

MAJOR WEAKNESS (MPN methods) s

- Need for large numbers of replicates at the appropriate dilution to narrow the confidence intervals. However, it is a very important method for counts when the appropriate order of magnitude is unknown *a priori* and sampling is necessarily destructive.

Sampling

(A) Assessment of Sampling Location

Please take note of the conditions of the environment, sampling taps and pipes at the sampling location. If the following situation(s) is/are encountered, do not take samples.

1. Unsatisfactory environmental condition e.g. surroundings dusty, covered with debris, or poorly ventilated;

2. Leaking taps;

3. Taps connected to anti-splash nozzles, rubber tubing's or other accessories;

4. Taps connected to heaters or water filters (that cannot be detached); or

5. Taps with sand strainers that cannot be detached.

(B) Sampling Method

1. Detach sand strainer or water filter from tap with appropriate tools

2. Check for the correct sample bottle and label

3. Turn on cold water tap at maximum flow and start timing;

4. Let water flow for 2 to 5 minutes depending on how often the tap is used (If the internal plumbing system has not been used for a long period of time, flush the system thoroughly before sampling)

5. After flushing, open cap of the sample bottle

6. Keep holding the sample bottle cap in one hand while sample is being collected to ensure it does not come into contact with anything to avoid contamination

7. Fill the sample bottle carefully to prevent overfills

8. Carefully put the cap back on the sample bottle

9. The following should be noted during sampling:

i. Never rinse the bottle; the sampling bottle shall be so held that the water does not come in contact with the hand before entering into the bottle

ii. Make sure that all samples are correctly labeled (sampling point, date and flushing time)

iii. Reinstall tap sand strainer or water filter with tools

iv. Store water samples in ice-boxes with freezer packs and deliver to laboratory on the same day.

(C) CLEANING PROCEDURE FOR SAMPLING BOTTLES

Please follow the procedure below for cleaning polyethylene bottles (250 ml) and caps:

1. Rinse bottles and caps once with tap water.

2. Fill bottles to just overflowing with diluted ‘Deacon 90 (5%)’ and put caps on bottles.

3. Shake bottles slightly and let them stand for at least 2 hours.

4. Remove caps and empty bottles.

5. Rinse bottles and caps in flowing tap water until no foam is observed.

6. Rinse bottles and caps once with deionised water.

7. Fill up bottles with 1:1 nitric acid (HNO3) and put caps on bottles.

8. Shake bottles slightly and let them stand for at least 2 hours.

9. Remove caps and empty bottles.

10. Rinse bottles and caps 3 times with deionised water. 1

1. Dry bottles and caps in oven at 50 o C.

Drinking water standards

Drinking water is water intended for human consumption for drinking and cooking purposes from any source.it includes water supplied by pipes or any other means for human consumption by any supplier.

WATER QUALITY PARAMETERS AND DRINKING WATER STANDARDS

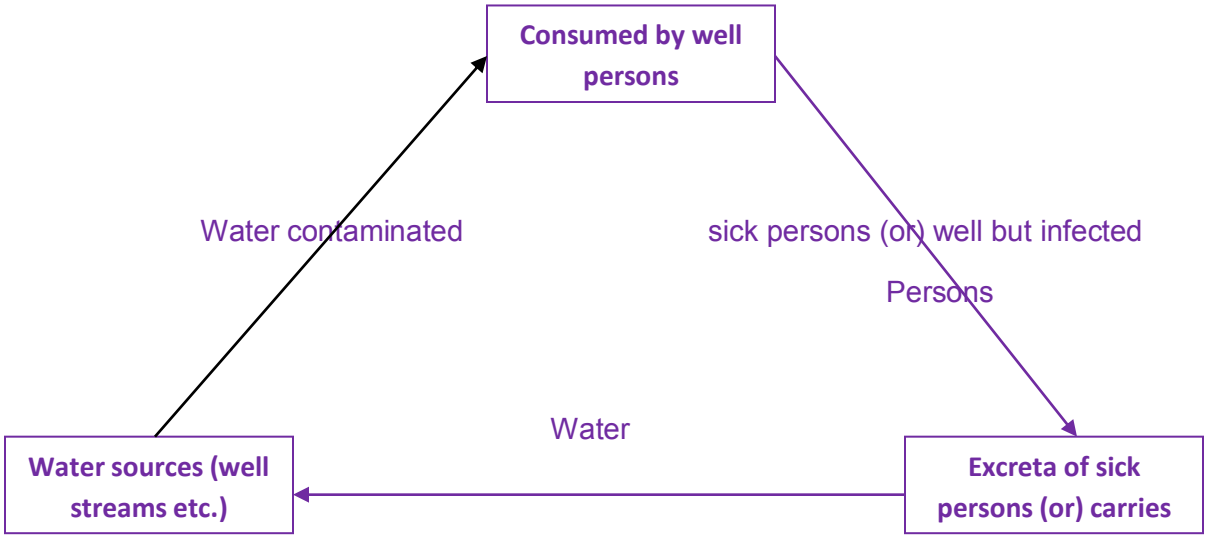
SL. NO.	PARAMETERS	UNITS	DRINKING WATER IS: 10500 - 1991	
			DESIRABLE	MAXIMUM
1.	Colour	Hazen units	5	25
2.	Odour	-	Unobjectionable	-
3.	Taste	-	Agreeable	-
4.	Turbidity	NTU	5	10
5.	pH value	-	6.5 to 8.5	No relaxation
6.	Total hardness (as $CaCO_3$)	mg/l	300	600
7.	Iron	mg/l	0.3	1.0
8.	Chlorides	mg/l	250	1000
9.	Residual, free Chlorine	mg/l	0.2	-
10.	Dissolved Solids	mg/l	500	2000
11.	Calcium	mg/l	75	200
12.	Copper	mg/l	0.05	1.5
13.	Manganese	mg/l	0.1	0.3

14.	Sulphate	mg/l	200	400
15.	Nitrate	mg/l	50	No relaxation
16.	Fluoride	mg/l	1.0	1.5
17.	Phenolic compounds	mg/l	0.001	0.002
18.	Mercury	mg/l	0.001	No relaxation
19.	Cadmium	mg/l	0.01	No relaxation
20.	Selenium	mg/l	0.01	No relaxation
21.	Arsenic	mg/l	0.05	No relaxation
22.	Cyanide	mg/l	0.05	No relaxation
23.	Lead	mg/l	0.05	No relaxation
24.	Zinc	mg/l	5	15
25.	Anionic detergents	mg/l	0.2	1.0
26.	Chromium	mg/l	0.05	No relaxation
27.	Polynuclear aromatic Hydrocarbons	mg/l	-	-
28.	Mineral oil	mg/l	0.01	0.03
29.	Pesticides	mg/l	Absent	0.001
30.	Radioactive materials (a) Alpha emitters (b) Beta emitters	Bq/l Pci/l	- -	0.1 0.037
31.	Alkalinity	mg/l	200	600
32.	Aluminlum	mg/l	0.03	0.2
33.	Boron	mg/l	1	5

NTU = Nephelometric Turbidity Unit

Water borne diseases

When water contains certain harmful and disease producing matter, it may lead to many disease on being consumed by healthy persons



Spread of water - borne diseases

Water – borne diseases may cause by following factors:

1. Presence of micro organisms
2. Presence of parasite ova
3. Presence of inorganic matter
4. Presence of organic mater

Presence of Micro organisms

- ✓ Bacteria (Cholera, typhoid, paratyphoid dysentery, diarrhea)
- ✓ Virus diseases of poliomyelitis (infective hepatitis (Jaundice)
- ✓ Protozoa infection (amoebic dysentery)

Presence of Parasite ova

- ✓ Egg or developed embryos of the eggs of round worms and tape worms, mosquito eggs.
- ✓ Malaria nematodes flukes, guinea worm and hook worm infections.

Presence of Inorganic matter

- ✓ Fluriodes >1.5 mg/l causes – erupting teeth
- ✓ Nitrate – blue babies

Presence of organic matter

- ✓ Excess of vegetable matter
- ✓ Sewage effluents (diarrhea and gastric disturbance)

Water borne diseases

- Common Cold and Flu The disease that catches people across the age lines. You will get wet, constant sneezing, throat and fever are the severe symptoms of common cold and flu. Prevention: Avoid getting in rain. And if it is caught, the best homemade remedy is hot turmeric milk.
- Dengue The very common disease during rainy seasons. The virus is spread by the Aedes mosquito. The symptoms include high fever, pain in joints & muscles, vomiting, bleeding from nose, gums & even under skin due to hemorrhagic fever. Prevention: Stay away from mosquitoes & clean your surroundings so that the mosquitoes doesn't multiply
- Chikungunya Another mosquito transmitted disease. The virus is spread by the Aedes Aegypti mosquito. The symptoms include fever, swelling & stiffness of joints, muscular pain, headache, fatigue & nausea. Prevention: Protect yourself from mosquito bites.
- Cholera It spreads through contaminated food, water & poor hygienic conditions. The symptoms include diarrhea, vomiting, low blood pressure, dry mouth etc. Prevention: Keep drinking boiled water and maintain personal hygiene
- Typhoid fever The disease that spreads during the monsoon season. The disease is spread through contaminated food & water. The symptoms include prolonged fever, abdominal pain & headache. Prevention: Getting a vaccination in advance. Get high intake of fluid to prevent dehydration

Prevention: Waterborne Disease

- Improve quality and quantity of drinking at source, at the tap, or in the storage vessel.
- Interrupt routes of transmission by empting accumulated water sources
- Chlorinate water

- Change hygiene behavior, like hand washing
- Breastfeeding first 6 months of life
- Proper use of latrines
- Careful disposal of all waste products
- Proper maintenance of water supply, sanitation systems, pumps and wells
- Good food hygiene-wash before eating, protect from flies
- Improved immunizations practices, especially rotavirus
- Develop or enhance public health surveillance system
- Faster responses to emergent and dangerous pandemic strains of pathogenic infections.
- Health education programs across the country