Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 06
Water quality, testing, treatment
Lecture - 27
Water Quality and Testing Part II

In lecture 27, Water Quality and Testing, Part 2 will be discussed.

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The concepts covered in this lecture include physical analysis for water, chemical analysis, and biological tests for water.

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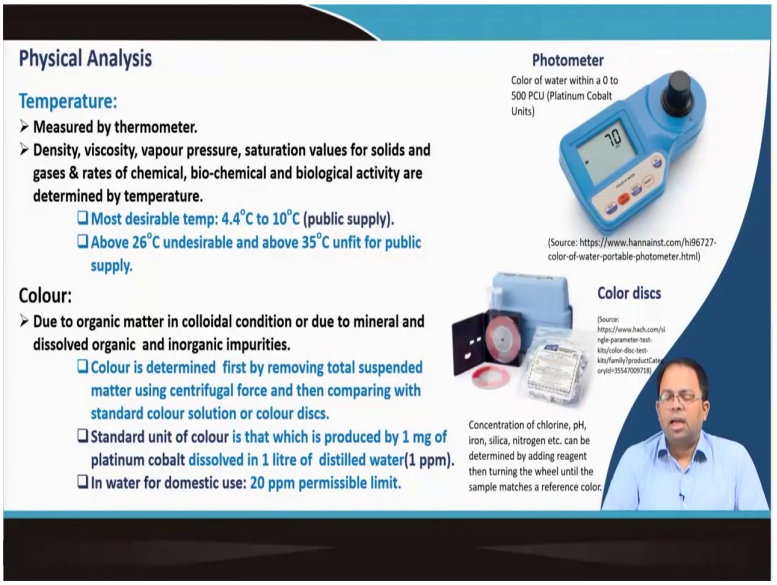

Physical analysis

In physical analysis, one of the most crucial property to check is temperature. Temperature is measured through a thermometer. The determination of temperature of water is very important to understand the density of water, the viscosity of water, vapour pressure, saturation value for solids and gases, and rates of chemical, biochemical, and biological activity in water. This is where temperature plays a very important role. This is the reason whenever a water sample is collected, the temperature of water is also recorded as well. For public supply, the desirable temperature is around 4.4 degree centigrade to 10 degree centigrade, and the water is undesirable above 26 degree centigrade which means that one would not be comfortable to drink that water. Above 35 degree centigrade, it is unfit for public supply.

Another physical test that needs to be checked is the colour of water. The colour of water is because of presence of organic matter particularly in colloidal condition, and due to minerals as well as dissolved organic and inorganic impurities. The colour of the water determines the kind of impurity present in it. To do so, certain other chemicals needs to be mixed in the water. The colour is determined first by removing total suspended matter using centrifugal force and then comparing with standard colour solution or colour discs. The standard unit of colour is that what is produced by 1 milligram of platinum cobalt dissolved in 1 litre of

distilled water so that is 1 ppm. So, 1 milligram of platinum cobalt dissolved in 1 litre of distilled water gives a colour which is called the standard unit of colour. Usually in domestic use, 20 ppm is the permissible limit for the colour. It means that it is a kind of a relative measurement. The concentration of chlorine, pH, iron, silica, and nitrogen can be determined by adding reagent into the water and then turning the wheel until the sample matches the reference colour. Thus, we can mix some reagents with water and can test it using this colour disc. The given water sample can also be tested directly, and based on the colour it matches to the reference colours, of the kind of impurity is determined.

In addition to colour wheels, photometers can also be used which are the portable devices which one can carry along in the field where the colour can be measured directly. This can measure the colour of water from 0 to 500 PCU, which is Platinum Cobalt Units. .

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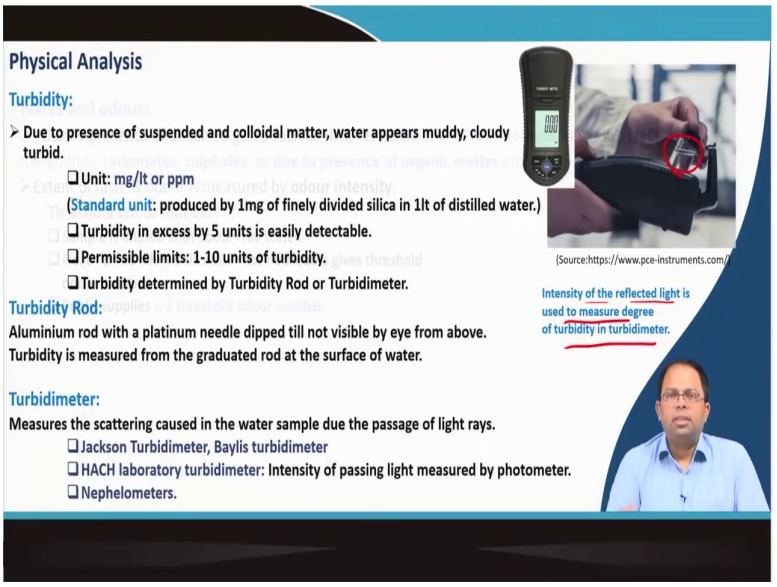

Another physical property is turbidity and it is caused due to the presence of suspended and colloidal matter. The water appears muddy cloudy or turbid. The unit of turbidity is milligram per litre or parts per million. Standard unit is produced by 1 milligram of finely divided silica in 1 litre of distilled water. Turbidity in excess of 5 units is easily detectable which means that when the turbidity limit is more than 5 units, it can be detected. Permitted limit is around 1 to 10 units of turbidity and a turbidity rod or a turbidity meter is used to determine the turbidity of a particular sample. The turbidity rod is an aluminium rod with a platinum needle fitted in

front of it. When we dip this rod into the water, the needle is not visible to the eye at a certain level. Based on the reading of the graduated aluminum rod at a given water level, the value of turbidity of the particular sample can be determined.

In addition, we can also use a turbidity meter and can carry this in the field. Turbidity meter measures the scattering caused in the water sample due to passage of light rays. Because of the presence of this impurities or the suspended particles inside that particular water and colloidal particles inside water, the light rays get scattered and based on the amount of scattering, one can determine the kind of turbidity in the water. There are different kinds of turbidity meters such as Jackson turbidity meter, Baylis turbidity meter, HACH laboratory turbidity meters and nephelometers. In case of the HACH laboratory turbidity meter, intensity of passing light is measured using a photometer. The water is put in this particular container and the system is switched on with a red light or a blue one sometimes and then the intensity of the reflected light on the other side is used to measure degree of turbidity in the turbidity meter.

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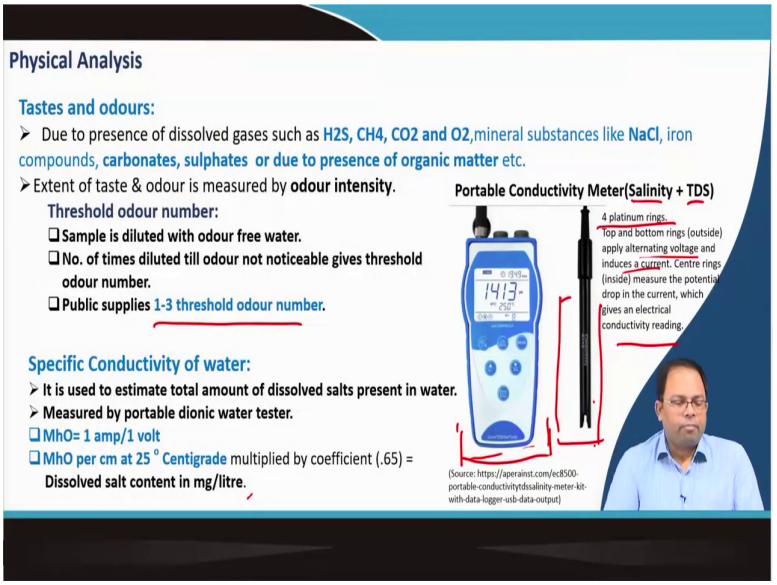

The particular taste and odour of water is because of dissolved gases such as H_2S, CH_4, carbon dioxide, oxygen and mineral substances like sodium chloride, iron compounds, carbonates, sulphates or due to some presence of some other organic matter. Odour is measured by odour intensity. Threshold odour number is one of the methods to measure the

odour of the water. It is measured by diluting a given water sample with odour free normal water and the number of times the sample gets diluted provides the threshold odour number. For example,if a sample requires 3 times its volume to be mixed with fresh water for odour to become undetectable then, 3 is the threshold number of that particular sample. For public supplies 1 to 3 is the threshold odour number for the water that needs to be supplied.

Similarly, the specific conductivity of water gives us an idea about the kind of dissolved salts that are present in the water. This is done with a portable dynamic water tester. It measures the current inside the water and the unit of measurement is MhO which is opposite of Ohm. 1 MhO is 1 Ampere by 1 Volt and MhO per centimetre at 25 degree centigrade is measured and multiplied with a coefficient which is 0.65 and that gives us the quantity of dissolved salts in the water. Based on the quantity of the salts in the water, the type and dosage of chemicals and type of treatment can be determined for treatment of wastewater. It helps to get rid of all kinds and amounts of salt in the water.

To test the specific conductivity of water, portable conductivity meter can be used where we can test both for salinity and TDS. This instrument has four platinum rings.

The top and bottom rings outside apply alternating voltage and induces a current. Center ring inside measures the potential drop in the current which gives an electrical conductivity reading. This is how we measure conductivity of a sample and the presence of salt can be computed from that. It represents the salinity as well as TDS.

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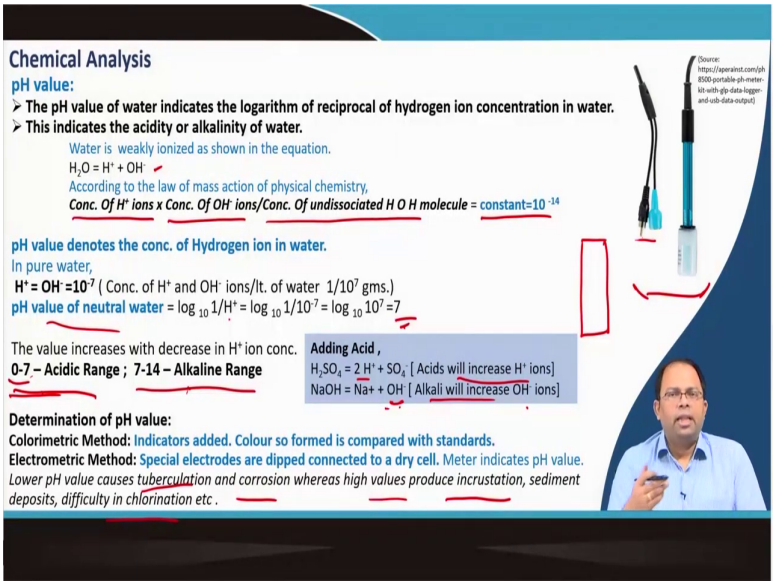

Chemical analysis

Apart from physical analysis, chemical analysis is also done. It is one of the most important parameters which helps to determine the pH value of water because it influences lot of processes. pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration in water. This indicates whether if water is acidic or basic i.e. alkaline,.

The water is weakly ionized as shown in the equation below:

$$H_2O = H^+ + OH^-$$

According to the law of mass action of physical chemistry,

Concentration of H^+ ions * Concentration of OH^- ions/Concentration of undissociated H O H molecule = constant = 10^{-14}

pH value of neutral water is basically where H^+ and OH^- are of same order that is10^{-7}. The pH value is the log of that of the reciprocal of hydrogen ion concentration which is determined to be 7.

Thus, the pH value of neutral water is 7. pH value between 0 to 7 is the acidic range and 7 to 14 is the alkaline range. If it varies between 7 to 14, more amount of OH^- are present that

makes the solution basic or alkaline. If it varies between 0 to 7, less OH^- and more H^+ are present that makes the solution acidic.

Usually when we add acid to water, it becomes acidic, as the solution will have more H^+ ions. Whereas, when NaOH (alkali) is added, it will increase OH^- in the solution and increase alkalinity. . To determine pH values, there are different methods. In colorimetric method, indicators are added. As discussed earlier, we can add some reagents to the water and colors so formed can be compared with standard colors to determine the pH value of the solution.

In electrometric metric method, special electrodes are dipped into the water and the meter can determine the pH value. Lower pH value which is acidic causes tuberculation (a form of corrosion) and corrosion of the pipelines, whereas, high pH values produce incrustation, sediment deposit, difficulty in chlorination etc.

This is the reason why one must be careful about pH values.

The tool can get fitted into handheld device. We can change these kinds of sensors, and using this sensor we can determine pH. Similarly using another sensor, we can determine conductivity.

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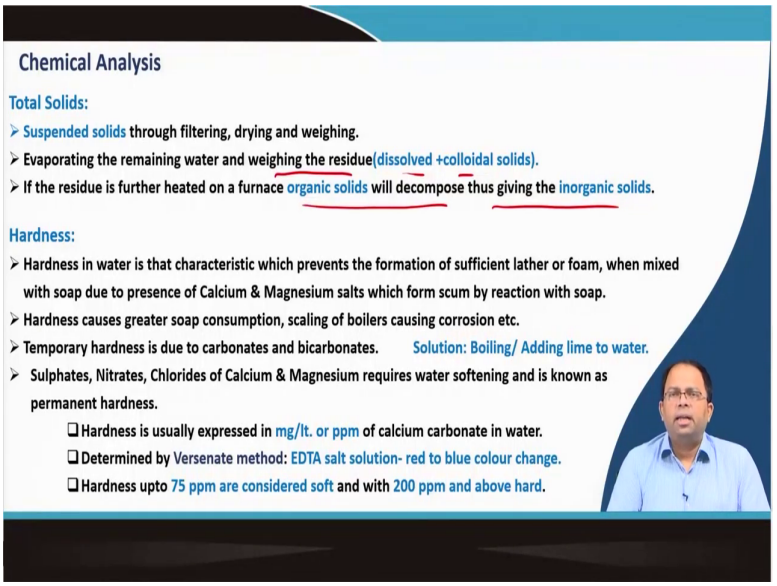

In chemical analysis, determination of the total solids or the total amount of suspended solids is another crucial task. It can be determined through filtering, drying and then weighing. This task can be done using filter paper where the solution is allowed to pass through filter paper. The substance caught on the filter paper is the suspended solids. This substance can be dried and the taken out of the filter paper. The total weight of the suspended solids are then determined. The substance left in the solution which is not being caught by the filter paper can be obtained by evaporating the remaining water and weighing the residue.

This residue contains both dissolved and colloidal solids. It could be further heated on a furnace where organic solids will decompose and only the inorganic solids will be left. Thus, these are the two ways using which one can determine the total amount of solids in a particular sample.

Regarding hardness, it is the characteristics of water which prevents formation of lather or foam when mixed with soap. Hardness results from the presence of calcium and magnesium salts. The foams formed by reacting with soap and that is why the soaps are not effective. Thus, hardness of water causes greater soap consumption. In addition, it also causes scaling of boilers and causes corrosion as well.

There are two kinds of hardness, temporary hardness and permanent hardness. Temporary hardness is because of calcium and magnesium carbonates and bicarbonates. It can be easily removed just by boiling or adding lime to the water. Permanent hardness is mainly because of sulphates, nitrates, chlorides of calcium and magnesium. It is difficult to remove and this requires specialized treatment or water softening treatment.

The hardness is measured in milligram per litre or ppm of calcium carbonate in water. It can be determined by the versenate method where EDTA salt solution is used. When the water is hard, this salt solution converts from red to blue colour. Hardness level up to 75 ppm are considered as soft and with 200 ppm and above is considered hard.

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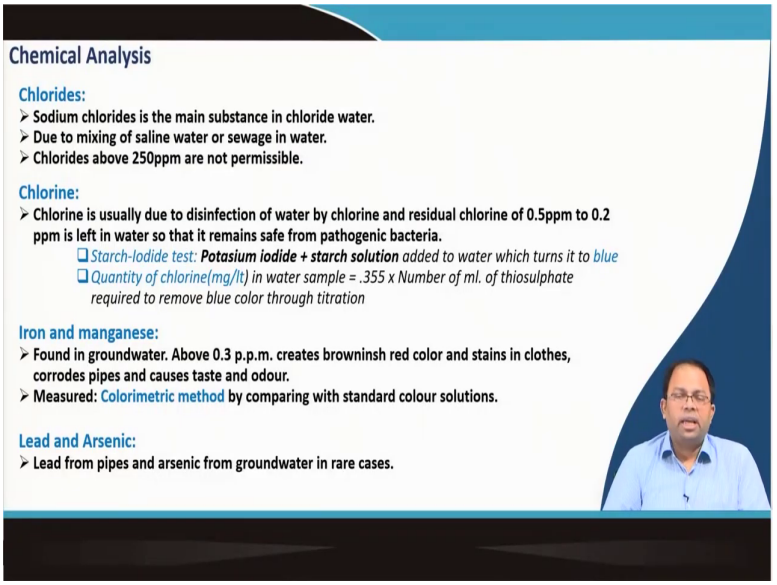

Another chemical analysis involves testing of chlorides. Sodium chloride is the main substance in chloride water. Sodium chlorides give that results in presence of chlorides and this could be because of mixing of saline water or because of mixing of sewage in water. Thus, if we find chlorides in water, then it can be indicative of either saline water or sewage mixed with water. The chlorides above 250 ppm are not permissible and one should be careful about.

Another element is chlorine which is used as a disinfectant and there is residual chlorine in water in distributed water. It means that after treatment, when water gets distributed, residual chlorine is found in levels around 0.5 ppm to 0.2 ppm that is left in water to make the water bacteria free or pathogen free. This can be determined through a starch-iodide test and where the quantity of chlorine in milligrams per litre in water sample is equal to 0.355 times the millilitre of thiosulphate required to remove blue colour through titration. In this test, when the potassium iodide and starch solution is added, the water turns into blue, and then we keep on mixing the thiosulphate. Gradually, through titration, the blue colour is removed.

Too much of chlorine in water gives a bad taste and sometimes results in other health issues. Thus, too much amount of chlorine is also not suggested.

Another chemical analysis involves testing of iron and manganese. These are usually found in ground water. The levels above 0.3 ppm, particularly for iron creates brownish red colour and create stains in cloth. It also corrodes pipe and causes taste and odour issues. This could be measured using the colorimetric method by comparing with standard colour solutions as discussed earlier.

Other elements include lead and arsenic. Lead from pipes and arsenic from ground water, is found sometimes in very rare cases. In some districts of West Bengal, arsenic is found in the pumped ground water. Thus, appropriate testing should be conducted before water consumption.

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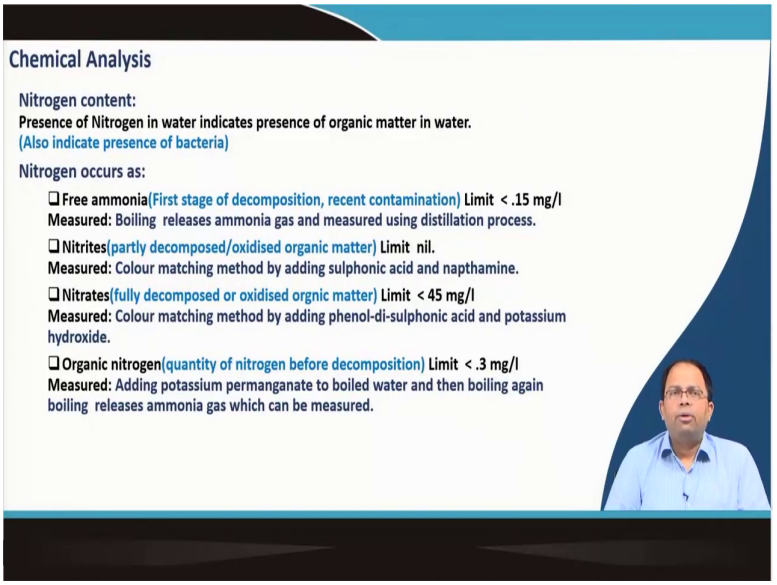

Regarding nitrogen, its presence in water indicates the presence of organic matter in water and this also indicates the presence of bacteria. There are different forms in which nitrogen is present in water.

For example, there could be free ammonia which indicates the first stage of decomposition. Its tolerance limit is around less than 0.15 milligram per litre. When the solution is boiled, the ammonia gas is released, and this quantity can be measured using the distillation process..

The presence of nitrites indicates partly decomposed or oxidised organic matter. It should not be present in the water. Thus, the limit is nil. It is determined through colour matching method by adding sulphonic acid and napthamine.

The presence of nitrates indicates fully decomposed or oxidised organic matter. Its tolerance limit is lesser than 45 milligrams per litre. It is determined through colour matching method by adding phenol-di-sulphonic acid and potassium hydroxide.

Organic nitrogen is the quantity of nitrogen before decomposition. Its limit is 0.3 milligram per litre and this could be determined by adding potassium permanganate to boiled water. The boiling will release ammonia gas which could be measured and thus the quantity of nitrogen can be measured.

All the different tests for different forms of nitrogen has to be done at the laboratory level. Sometimes, small kits which is easily available in the market can be carried to the site for water testing. . This saves the time because sometimes we might not have a buffer of 72 hours to perform the tests in laboratory. Also, there is no need to perform all the tests, some tests can be done which can indicate the nitrate level as nil. Thus, one will probably not find the other nitrogen values as well, other kind of nitrogen as well. So, these kind of test could be better conducted in the field directly..

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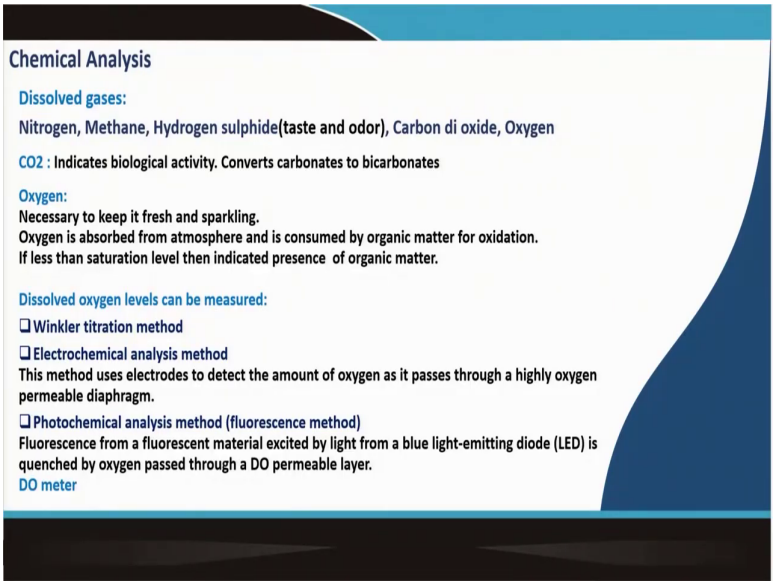

Other chemical analysis involves testing of dissolved gases such as nitrogen, methane, hydrogen sulphide, carbon dioxide, oxygen. CO_2 indicates biological activity Which converts carbonate to bicarbonates. Oxygen usually keeps the water fresh and sparkling. Oxygen is usually absorbed from atmosphere and is consumed by organic matter for oxidation. If its quantity is less than saturation level, then this indicates presence of organic matter. It indicates the Biological Oxygen Demand (BOD) or some amount of biological oxygen demand has to be at to be satisfied. Thus, whenever there are biological impurities in water, the treatment is required and the BOD levels help us to determine if the water is completely treated or not. We measure the dissolved oxygen in water and that is very important which provides an understanding about if the water is safe for drinking or is it contaminated with certain kind of impurities which needs to be first treated.

So, if less than saturation level(oxygen) is present, then this indicates that there is organic matter; that means,. So, Dissolved oxygen levels can be measured using Winkler titration method or electrochemical analysis method. In this method, we use electrodes to detect the amount of oxygen when it passes through a highly permeable diaphragm. The diaphragm permits oxygen which can be measured. It can also be measured using photochemical analysis. It utilizes the method of florescence. Fluorescence happens when a material gets excited by light, and we usually use a blue light emitting diode and when oxygen passes through dissolved oxygen (DO) permeable layer, the quantity of oxygen can be measured using a DO meter.

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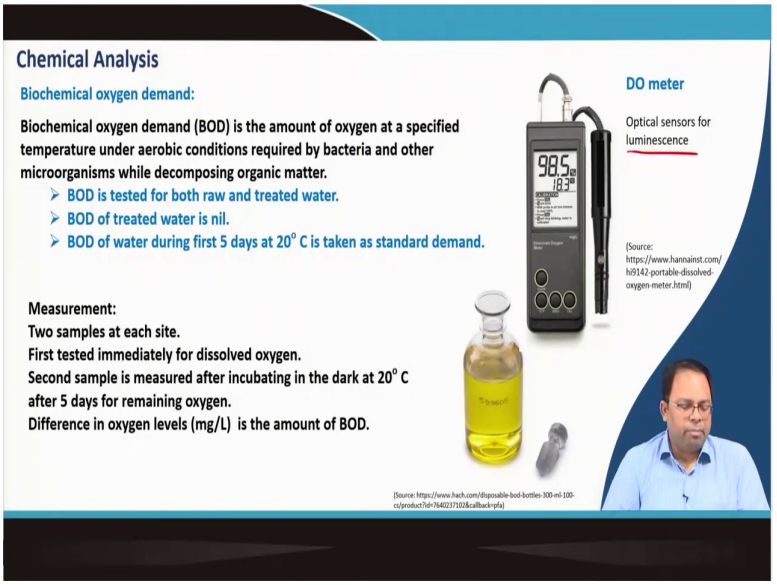

The diagram shows a DO meter where optical sensors are used for determining the luminescence. When this is dipped in water, the DO value can be determined in water.

Biochemical oxygen demand (BOD) is the amount of oxygen at a specified temperature under aerobic conditions required by bacteria and other microorganisms while decomposing organic matter. Organic matter is acted upon by bacteria and they are gradually decomposed. Thus, once the entire decomposition happens, water is safe.

BOD is tested for both raw and treated water. Usually for treated water, BOD would be 0 because all the biological activities are taken care of. But whenever we are taking a sample of water, we measure the dissolved oxygen of that particular water immediately as well as after 5 days at 20 degree centigrade. This testing is done to determine the remaining oxygen or the DO values. The difference in the oxygen level in these two tests provides us the amount of BOD in milligrams per litre.

The value of BOD is actually the standard value or the BOD of water during the first 5 days ot 20 degree centigrade and is considered as the standard demand or biological oxygen demand.

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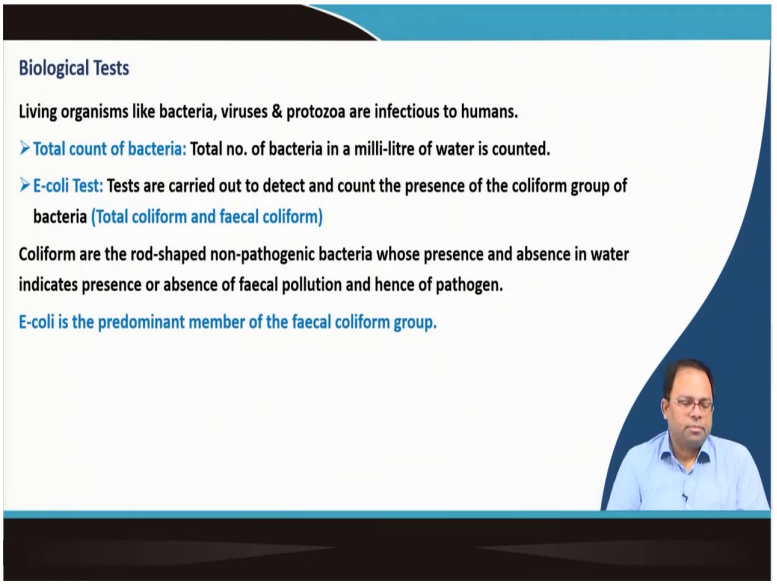

Biological tests

Biological tests are also conducted that involves determining bacteria, viruses, and protozoa which usually infect human beings. Test for total count of bacteria is done at laboratory level. This cannot be done in any field or by using any meters.

In this test, the total number of bacteria in a millilitre of water is counted under microscope. For E coli test, the presence of coliform group of bacteria are detected where both total coliform and faecal coliform bacteria is measured. As coliforms are non-pathogenic bacteria, these are rod shaped but these are the predominant member of the faecal coliform group, thus the presence and absence of this bacteria actually indicates the faecal pollution and faecal pollution again indicates other pathogens.

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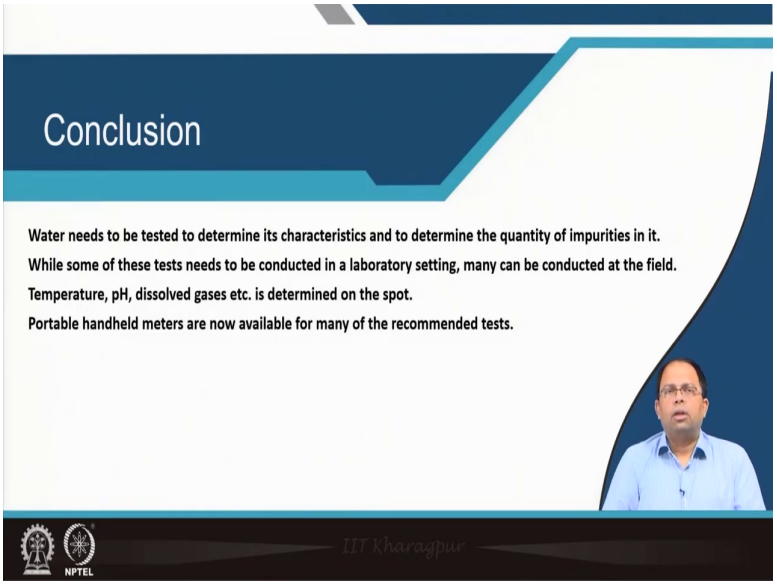

Conclusion

To conclude, water needs to be tested to determine its characteristics and to determine the quantity of impurities in it. While some of this test needs to be conducted in a laboratory setting, many can be conducted at the field. Then, temperature, pH, dissolved gases etc., is determined on the spot during sample collection. Portable handheld meters are now available for many of the recommended tests.

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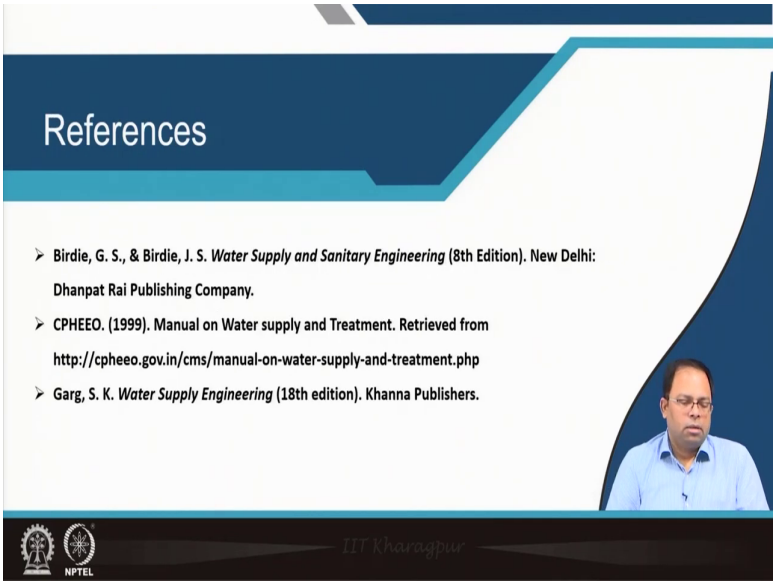

References

These are the references.