B.Tech Project Report on

Water Quality Analysis of Water Bodies of Kantajhar Basti

For partial fulfillment of the requirements for the degree
of

Bachelor of Technology

In

Chemical Engineering

SUBMITTED BY

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CERTIFICATE

This is to certify that the report on the Project entitled 'Water quality testing of water bodies of Kantajhar basti' is a bonafide record of the work carried out by SRAJAN SHRIVASTAVA (110CH0519) under my supervision and guidance towards the partial fulfillment of requirement for the award of the degree of Bachelor of Technology in Chemical Engineering at National Institute of Technology, Rourkela. To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other university or institute for the award of any degree.

Place: Rourkela, Odisha

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SRAJAN SHRIVASTAVA

ABSTRACT

In this work, samples of water were collected from three different tube-wells at two different times of the year. The first set of samples was collected in the month of September, 2013 & the second set was collected in April, 2014. Over the due course of time various parameters regarding the water quality were analysed & the Indian Standards: 10500 (Drinking water specifications) was referred to in order to check the acceptability of water.

The parameters which were analysed are as follows :

- Total Dissolved Solids
- Total Suspended Solids
- Determination of pH
- Determination of chloride content
- Conductivity
- Determination of sulphate content
- Turbidity
- Iron content
- Manganese content

Most of the parameters were not found to be in the desirable range for drinking water & hence, appropriate measures were suggested to improve the quality of water.

Keywords – Water quality, drinking water, TSS, TDS, Turbidity, Conductivity, chloride, sulphate, iron, manganese.

Contents –

1. Introduction

The project was based on testing the quality of water. Three different samples were collected from 'Kantajhar Basti' situated behind the campus of NIT Rourkela from three different tubewells at two different times of the year. The first set of samples was collected after the rainy season in the month of September, 2013. And the second set was collected in April, 2014.

Water quality

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

Different properties were analysed & compared during the course of the project.

Some of the properties analysed are as follows –

- Total Dissolved Solids
- Total Suspended Solids
- Determination of pH
- Determination of chloride content
- Conductivity
- Determination of sulphate content
- Turbidity
- Iron content
- Manganese content

2. Literature Review

2.1 Total suspended solids

TSS is identified as a conventional pollutant in the U.S. Clean Water Act. TSS was earlier known as non-filterable residue (NFR). TSS is the dry-weight of particles which are trapped by a filter having a specified pore size.

To find TSS of a water sample, measured volume of water should be passed through a pre-weighed filter having a specified pore size, then taking the weight of filter again after drying to evaporate the water in the filter paper. Filters composed of glass fibres are typically used for measuring TSS. The dry weight measure of the particulates present in the water sample is the gain in weight & it is expressed in units derived or calculated from the volume of filtered water.

Turbidity also tends to measure almost the same quality of water property as TSS, TSS is more useful as it gives an actual weight of the undissolved material in the sample provided.

Total Suspended Solids consist of a huge variety of material, for example, decaying plant, silt and animal matter, sewage & industrial wastes. Water having high concentration of suspended solids might cause problems for aquatic life & stream health.

High Total Suspended Solids in a water body might indicate higher amount of metals, pesticides, and bacteria present in the water. Higher amount of TSS can also cause problems for industrial usee, as the solids might clog or scour pipes and machinery.

Few Factors Affecting Total Suspended Solids

- **High Flow Rates**
- **Soil Erosion**
- **Urban Runoff**
- **Wastewater and Septic System Effluent**
- **Decaying Plants and Animals**
- **Bottom-Feeding Fish**

2.2 Total Dissolved Solids

A measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular suspended form is called Total Dissolved Solids (TDS). The solids should be small enough to survive filtration through a filter which has two-micrometer (nominal size or smaller) pores. We generally discuss TDS for freshwater systems only, as salinity consists of some of the ions contributing in the definition of TDS. The Study of water quality for streams, rivers and lakes is the most important application of TDS, although TDS is not a primary pollutant, but TDS is used as an indication of aesthetic characteristics of drinking water and as an indicator of the presence of a broad array of chemical contaminants.

Agricultural and residential runoff are primary sources for TDS in receiving waters, and so are leaching of soil contamination and point source water pollution discharge from industrial plants. Calcium, phosphates, nitrates, sodium, potassium, sulphates and chloride comprise few of the important chemical constituents. The chemicals might be cations, anions, molecules or agglomerations on the order of one thousand or fewer molecules, so long as a soluble micro-granule is formed. Pesticides arising from surface runoff are more exotic and harmful elements of TDS. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils.

Gravimetry and conductivity are the two important methods of measuring total dissolved solids. Gravimetric methods are the more accurate methods and they involve evaporating the liquid solvent and taking the mass of residues left. This is the best method generally, but it is time-consuming. If inorganic salts are there as the great majority of TDS, gravimetric methods are more appropriate.

Concentration of dissolved ionized solids in the water is directly related to the electrical conductivity of water. Ions in the dissolved solids in water generate the ability for that water to conduct electrical current, which is measured by a TDS meter or conventional conductivity meter . Conductivity generally provides an approximate value for the TDS concentration, usually to within ten-percent accuracy.

Hard water has high TDS levels, which might be the reason for scale buildup in filters, pipes, and valves, reducing performance and adding to the cost of system maintenance.

In aquariums, spas, swimming pools, and reverse osmosis water treatment systems, we can see these effects . Total dissolved solids are tested frequently in all these applications, and filtration membranes are also checked just to prevent adverse effects.

TDS is generally monitored in order to create a water quality environment which is favorable for organism productivity in the case of hydroponics and aquaculture. For freshwater oysters, trouts, and other high value seafood, highest productivity and economic returns are achieved by mimicking the pH and TDS levels of native environment of each & every species. Total dissolved solids is considered one of the best indices of nutrient availability for the aquatic plants being grown for hydroponic uses.

Significance of Total Dissolved Solids in Water

The total dissolved solids concentration of good & palatable drinking water should not be more than 500 mg/L according to general belief. However, higher concentrations might be consumed without harmful physiological effects and might be even more beneficial indeed. This limit was set on the basis of taste thresholds. Wildlife and livestock might get injured by drinking water that contains total dissolved solids exceeding this limit. Continuous use of such water might cause weakness, scouring, reduced production, bone degeneration and death. However, temporarily, animals can drink high saline waters, but that will be harmful if used continuously.

2.3 Conductivity

The measure of the ability of an electrolyte solution to conduct electricity is called its conductivity. Conductivity is also referred to as specific conductance. The SI unit of conductivity is siemens per meter (S/m).

In many industrial and environmental applications, conductivity measurements are used as an inexpensive, reliable and fast way of getting the measure of the ionic content in a solution. For example. A typical way to monitor and continuously trend the performance of water purification systems is the measurement of product conductivity.

Conductivity is directly linked to the the total dissolved solids (T.D.S.) in various cases. Conductivity is found out by measuring the AC resistance of the solution between two electrodes. Dilute solutions follow Kohlrausch's Laws of concentration dependence and

additivity of ionic contributions. A theoretical explanation of Kohlrausch's law by extending the Debye–Hückel theory was given by Lars Onsager.

Units

Siemens per metre id the SI unit of conductivity and it generally refers to 25 °C. Often, the traditional unit of μS/cm is used in industries. 10^6 μS/cm = 10^3 mS/cm = 1 S/cm. Sometimes, a unit of "EC" (electrical conductivity) is seen on the scales of instruments: 1 EC = 1 mS/cm. Occasionally, we also encounter is a so-called mho (reciprocal of ohm): 1 mho/m = 1 S/m. Historically, mhos antedate Siemens by many decades; good vacuum-tube testers, for instance, gave transconductance readings in micromhos.

The standard cell, which is most commonly used has a width of 10 mm, and thus for very pure water in equilibrium with air would have a resistance of about 10^6 ohm, known as a megohm, also sometimes known as "megaohm". Ultra-pure water can get to 18 megohms or more. Thus megohm-cm was used earlier, sometimes spelled as "megohm". Occasionally, a conductivity is given just in "microSiemens" (removing the distance term in the unit). While this can be seen as an error, it can generally be assumed to be equal to the traditional μS/cm. The typical conversion of conductivity to the total dissolved solids is done assuming that the solid is sodium chloride: 1 μS/cm is taken to be an equivalent of about 0.6 mg of NaCl per kg of water.

Molar conductivity's SI unit is S m^2 mol^{-1}. Older publications have the unit Ω^{-1} cm^2 mol^{-1}.

The presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge) affect the value of conductivity in water. Various organic compounds like phenol, oil, sugar and alcohol do not conduct electrical current well and therefore possess a low conductivity in water. Temperature affects the conductivity as well: the warmer the water, the higher the conductivity. For this reason, conductivity is often reported as conductivity at 298.15 K.

Conductivity of water in streams and rivers is affected basically by the geology of the area through which the water is flowing. Streams running through areas with granite bedrock generally have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand,

streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

Discharges to streams have the potential to change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill tends to lower the conductivity.

High quality deionized water has a conductivity of about 5.5 µS/m, typical drinking water in the range of 5-50 mS/m, while sea water about 5 S/m. Distilled water has a conductivity in the range of 0.5 to 3 µmhos/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can range as high as 10,000 µmhos/cm.

2.4 Turbidity

The haziness or cloudiness of a fluid due to various individual particles (TSS or TDS) that can be seen with naked eyes (like smoke in air) is known as turbidity. The determination of value of turbidity might be termed as one of the most important tests of water quality.

Fluids may have suspended solid matter comprising of particles of various different sizes. While some will be big enough settle down quickly at the bottom of the container if a liquid sample is left to stand, the smaller ones might settle very slowly or might not settle at all if the sample is agitated consistently or if the colloidal particles are present. These solid particles, which are smaller in size are the reason for any liquid to look like turbid.

Turbidity (or haze) is considered in the case of transparent solids such as glass as well. In plastic production, the percentage of light that is deflected more than 2.5° from the incoming light direction is known as haze.

Turbidity can also be termed as the measure of a liquid's relative clarity. Turbidity is an optical characteristic of water and is also an expression of the amount of light scattered by material in the water when a light shines through the water sample. The higher the intensity of scattered

light, the higher the turbidity. Material causing water to be turbid include silt, clay, finely divided inorganic and organic matter, soluble colored organic compounds, algae, plankton and various other microscopic organisms.

Turbidity makes water cloudy or opaque. The water collected in the bottle is used to find out the turbidity, which is measured by shining a light through the water and is measured in nephelometric turbidity units (NTU). During periods of low flow (base flow), many rivers are a clear green color, and turbidities are low, usually less than 10 NTU.

Turbidity and water quality

High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality, and cause lakes to fill in faster. In streams, increased sedimentation and siltation can take place, which might result in harming the habitat areas for fish and other aquatic life. Particles also provide attachment places for some other pollutants, especially bacteria and metals. That's why, turbidity readings are used as an indicator of potential pollution in a water body.

Turbidity and human health

Excessive turbidity, or cloudiness, in drinking water is aesthetically unappealing, and may also represent a health concern. Turbidity can provide shelter and food for pathogens. Regrowth of pathogens in the distribution system is promoted if the turbidity is not removed, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis throughout the world. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. The particles of turbidity provide "shelter" for microbes by reducing their exposure to attack by disinfectants. Microbial attachment to particulate material has been considered to aid in microbe survival. Fortunately, traditional water treatment processes have the ability to effectively remove turbidity when operated properly.

2.5 pH Value

pH is basically a measure of the acidity or basicity of an aqueous solution. Solutions having pH less equal to 7.

Primary pH standard values are found out by using a concentration cell with transference, simply by measuring the potential difference between a standard electrode such as the silver chloride electrode & hydrogen electrode. Measurement of pH for aqueous solutions can be done with a pH meter or a glass electrode. We can also find the value of pH by using indicators.

pH measurements have significant importance in the field of biology, environmental science, chemistry, medicine, oceanography, food   science, agriculture, nutrition   ,civil engineering, chemical engineering, forestry, water treatment & water purification and many other applications.

Mathematically,   it   can   be   said   that   pH   is   the   negative logarithm of   the activity of the hydrogen ion.

Importance of pH

The solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.) can be determined by pH of water. For example, in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. Metals are generally more toxic at lower pH as they are more soluble.

Extremely low and high pHs can be significant for the use of water. High pH causes a bitter taste, water pipes and water-using appliances become encrusted with deposits, and it also depresses the effectiveness of the disinfection of chlorine, thereby generating the need for additional chlorine when pH is a bit high. Low-pH water might corrode or dissolve metals and other substances.

Pollution has the potential to change a the pH of water, which might harm animals and plants living in the water.

Effects on Laboratory Animals

If pH is more than 10, skin irritation might be observed in some of the animals. For rabbit, this can be observed at a pH of about 9 as well. And if the pH is more tha 10, it might behave as an irritant for the eyes of rabbit . But for a pH less than 5, no significant effects on eyes were observed.

Effects on Humans

If human beings are exposed to extreme pH values, it might cause irritation to the eyes, skin, and mucous membranes. Eye irritation and exacerbation of skin disorders have been associated with pH values greater than 11. In addition, solutions of pH 10–12.5 are said to cause hair fibres to swell. In sensitive individuals, gastrointestinal irritation may also occur. Exposure to low pH values can also result in similar effects.

2.6 Sulphate Content

Naturally, sulphates are found in various minerals, such as epsomite ($MgSO_4 \cdot 7H_2O$),gypsum ($CaSO_4 \cdot 2H_2O$) & barite ($BaSO_4$). Such dissolved minerals constitute the mineral content in drinking water. Sulfates find their way into water through smelters and mines and also from kraft pulp and paper mills, tanneries & textile mills. Sulphates of potassium, magnesium and sodium are highly soluble in water, while barium and calcium sulfates and various other heavy metal sulfates are little less soluble. Suphur di oxide & Sulphur tri oxide also contribute to the sulphate content of water to some extent.

Effects on Humans

Cathartic effects are commonly reported to be experienced by people consuming drinking-water containing sulfate with higher concentraions. Although it is also reported that humans can adapt to higher concentrations with time .Dehydration is another common side-effect following the ingestion of large amounts of sodium or magnesium sulfate exposed to tap water containing sulfate with a median concentration of 264 mg/litre and a range of up to 2787 mg/litre, compared with the risks for those not using tap water or using low-sulfate tap water, there was no significant association between sulfate ingestion and the incidence of diarrhoea for the range of concentrations studied. Reviews of the literature and a study to experimentally determine a

sulfate dose that would induce effects in adults concluded that it was not possible to set a health-based standard for sulfate in drinking-water and confirmed the conclusions of other workers.

The presence of sulfate in drinking-water can also result in a noticeable mg/litre as the sodium salt. Sulphate may also contribute to the corrosion of distribution systems.

In the light of the above considerations, no health-based guideline value for sulfate in drinking water is proposed. However, there is an increasing likelihood of complaints arising from a noticeable taste as concentrations in water increase above 500 mg/litre.

2.7 Chloride Content

Naturally, chlorides are found as salts such as sodium chloride (NaCl), potassium chloride (KCl), and calcium chloride (CaCl2). Chlorides are leached from different rocks into soil and water due to weathering. The chloride ion is generally mobile and is shifted to oceans or closed basins. It is found that chloride concentration in groundwater and drinking-water is consistently increasing, but there have been a few exceptions. Chloride levels in unpolluted waters are generally below 10 mg/litre and sometimes even below 1 mg/litre. Chloride in water may be significantly increased by treatment processes in which chlorine or chloride is used.

Effects on Humans

Chloride toxicity has not been observed in humans except in the exceptional case of impaired sodium chloride metabolism. Healthy human beings can tolerate the intake of large quantities of chloride if there is a sufficient intake of fresh water. Chloride increases the electrical conductivity of water and also its corrosivity. Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water, but the threshold depends upon the associated cations. Consumers can, however, become accustomed to concentrations in excess of 250 mg/litre. No health-based guideline value is proposed for chloride in drinking-water.

2.8 Iron content in water

Iron accounts for almost 5% in the earth's crust & is consequently the 2nd most abundant metal in the earth's crust. The ions of iron form sulphates, nitrates, carbonates & hydroxides & elemental iron is rarely found in nature. The most common form of iron found in nature is that of oxides. Bacterial growth is generally promoted by iron which is pretty undesirable.

Aeration of iron containing layers in soil can affect the quality of both groundwater & surface water, if the groundwater table is lowered or nitrate leaching takes place. Dissolution of iron might take place as a result of oxidation & decrease in pH.

The concentration of iron is about 0.7 mg/l in rivers. Concentration is in the range of 0.5-10 mg/l in anaerobic groundwater where iron is generally in the form of Fe(II). Conentration of iron in drinking water should be less than 0.3 mg/l.

2.9 Manganese content in water

Manganese can be termed as a metal which is one of the most abundant on earth. Though it is not found in its natural form, it is actually a component of more than 100 minerals. Manganese can exist in 11 oxidative states.

Manganese occurs naturally in many surface water and groundwater sources and in soils that may erode into these waters. However, human activities are also responsible for much of the manganese contamination in water in some areas.

Ambient manganese concentrations in seawater have been reported to range from 0.4 to 10 µg/l , with an average of about 2 µg/l. Levels in fresh water typically range from 1 to 200 µg/l. Manganese has a median level of 16 µg/l in surface waters. Higher levels in aerobic waters are usually associated with industrial pollution.

3. Experimental Procedures

3.1 Total Suspended Solids

Theory

The solids which can't survive the filtration through a filter with 2 micrometer pores are called TSS. And hence, we use that procedure to find TSS.

Apparatus Required

1. Funnel
2. Conical Flask
3. Filter paper
4. Oven
5. Weighing Machine
6. Measuring Cylinder
7. Beaker

Procedure

- 10 ml of water sample is measured using the measuring cylinder.
- Water sample is transferred into a beaker.
- Weight of the filter paper is recorded.
- Filter paper is adjusted in the funnel.
- Water is transferred to the conical flask through the filter paper.
- Filter paper is kept in the oven in order to get it dried.
- Once the filter paper gets dried, it is taken out.
- The weight of filter paper is then recorded.
- The initial weight of the filter paper is then subtracted from the final weight.
- The result which we get is the amount of suspended solids in 10 ml of water.
- It is divided by 10 in order to get the amount of TSS per ml of water.

3.2 Total Dissolved Solids

Theory

The definition of TDS says that the dissolved solids which are small enough to survive filtration through a filter with two micrometer pores are TDS. And that is the procedure used here. The water is evaporated after the filtration & TDS is measured.

Apparatus Required

1. Conical flask
2. Petridish
3. Oven
4. Weighing machine

Procedure

- TDS is measured in continuation to the procedure of finding TSS.
- A petridish is taken.
- Weight of the petridish is recorded.
- Filtered water from the TSS process is transferred into the petridish.
- Petridish is then kept in the oven.
- The temperature of the oven is set at over 100° C.
- After sometime, water is evaporated.
- The petridish is then taken out.
- The weight of petridish is then recorded.
- The initial weight of the petridish is then subtracted from the final weight.
- The result which we get is the amount of dissolved solids in 10 ml of water.
- It is divided by 10 in order to get the amount of TDS per ml of water.

3.3 pH value

Apparatus Required

1. pH meter
2. Beaker

Procedure

- All the samples are taken in the beaker one by one.

- The pH value is recorded for all the sample using the pH meter.

3.4 Conductivity

Apparatus Required

1. Conductivity meter
2. Potassium Chloride (KCl)
3. Small Beaker
4. Distilled Water

Procedure

- First, some amount of Potassium Chloride is taken.

- Then, KCl is dissolved in distilled water & the potassium chloride solution is prepared.

- Conductivity of KCl is checked using conductivity meter.

- If there is some error in the conductivity of KCl, then the settings of the conductivity meter is adjusted accrordingly.

- Then, the sample is taken in the beaker.

- The conductivity of the sample is measured.

- The same procedure is repeated for all the samples.

- Hence, the conductivity of all the samples are recorded.

Conductivity meter

3.5 Turbidity

Apparatus Required

1. Turbidity meter
2. Distilled Water
3. Beaker

Procedure

- First, the beaker is taken & is washed properly.
- Then, distilled water is poured into the beaker.
- Turbidity of distilled water is measured by the turbidity meter.
- If the turbidity is not zero, then the settings are adjusted as to make it zero.
- Then, the beaker is again washed properly.
- Then, the sample is poured into the beaker.
- The turbidity of the beaker is measured using the turbidity meter.
- The same procedure is repeated for all the samples.

Turbidity meter

3.6 Chloride content in water

Theory

The amount of chloride present in water can be easily determined by titrating the given water sample with silver nitrate solution. The silver nitrate reacts with chloride ion according to1 mole of AgNO3 reacts with 1 mole of chloride. The titrant concentration is generally 0.02 M. Silver chloride is precipitated quantitatively, before red silver chromate is formed. The end of titration is indicated by formation of red silver chromate from excess silver nitrate.

Chemicals Required

1. Potassium Chromate
2. Phenolphthalein Indicator
3. Sodium Chloride
4. Silver Nitrate

Apparatus Required

1. Conical Flask
2. Standard Flask

3. Beaker
4. Burette
5. Pipette
6. Wash Bottle

Procedure

First, a standard NaCl solution is prepared.

➢ 1.648 g of NaCl is measured.

➢ NaCl is dissolved in distilled water.

➢ Volume is made upto 100 ml.

➢ Solution is transferred to a 100 ml standard flask.

Then, a standard silver nitrate solution is prepared.

➢ 4.791 g of Silver Nitrate is dissolved in distilled water & the volume is made upto 100 ml.

➢ This solution is standardized against the NaCl Solution.

Then, the potassium chromate indicator is prepared.

➢ 25 g of Potassium Chromate is taken & is transferred to the beaker containing distilled water.

➢ Few drops of silver nitrate solution is added until slight red precipitate is formed.

➢ It is allowed to stand for 12 hrs & then, it is filtered.

➢ The filtrate is diluted to 1000 ml

- 20 ml of sample is taken in a 250 ml flask.
- 1 ml of the indicator is added to get a slight yellow colour.
- The sample is titrated against the silver nitrate solution until a brick red colour is observed.

3.7 Sulphate content in water

Theory

The turbidimetric method of measuring sulphates is based upon the fact that barium sulphate tends to precipitate in a colloidal form of uniform size and that this tendency is enhanced in presence of sodium chloride, hydrochloric acid and glycerol. The absorbance of the barium sulphate formed is measured by a spectrophotometer at 420 nm and the sulphate ion concentration is determined by comparison of the reading with a standard curve.

Chemicals Required

1. Con. HCl
2. Sodium Chloride
3. Ethyl Alcohol
4. Sodium Sulphate
5. Barium Chloride
6. Glycerol
7. Distilled Water

Apparatus Required

1. Sample Tubes
2. Standard Flask
3. Beaker
4. Measuring Cylinder
5. Tissue Paper
6. UV-visible Sprectrophotometer

Procedure

First, a conditional reagent is prepared in the following way.-

- 25 ml of glycerol is taken & is poured into a beaker.
- 15 ml of con. HCl is added to the same beaker.

- Then, 50 ml of ethanol is added to the same beaker.

- Then, 37.5 g of NaCl is dissolved in distilled water & is added to the beaker.

- The total volume is made to 250 ml.

After preparing the conditional reagent, the sodium sulphate solutions of different concentrations of 50 ml volume are prepared-

- Blank Solution
- 0.2 g/l
- 0.4 g/l
- 0.6 g/l
- 0.8 g/l

50 ml of all the the three samples are also taken.

- Then, 5 ml of reagent is added to all the solutions.
- A pinch of barium chloride is added to all the solutions.
- Then, the absorbance of all the samples is taken using the spectrophotometer at 420 nm.
- A graph is plotted between the absorbance & the concentration of the solution.
- The sulphate content of the samples are found out using the graph.

3.8 Iron content in water

Apparatus required

1. Beaker
2. Spectrophotometer
3. Weighing machine
4. Measuring cylinder

Chemicals required

1. Phenanthroline
2. Hydroxylamine hydrochloride
3. Distilled water

4. Iron solution

Procedure

- An iron solution having a concentration of 0.125 g/l was taken.
- Using the solution 6 solutions of different concentration (20 ml each) were prepared. –
    1. Blank solution
    2. 0.025 g/l
    3. 0.05 g/l
    4. 0.075 g/l
    5. 0.1 g/l
    6. 0.125 g/l
- Apart from these six solutions, 20 ml of each sample was taken.
- Phenanthroline & Hydroxylamine hydrochloride were added to all the solutions.
- Absorbances of all the solutions were measured using spectrophotometer at 510 nm.
- A graph was plotted & the concentration of all the samples were determined.

3.9 Manganese content in water

Apparatus required

1. Beaker
2. Volumetric flask
3. Measuring cylinder
4. Spectrophotometer

Chemicals required

1. Potassium permanganate
2. Distilled water
3. Conc. Hcl
4. Nitric Acid
5. Sodium Bismuthate

Procedure

- 1 mg of pure Mn was dissolved in 2 ml conc. HCl & then diluted to 100 ml using distilled water.

- From this solution, different solutions of 0.2, 0.4, 0.6 & 0.8 mg/l were prepared & 5 drops of Nitric acid were added to all of them.

- 0.01 mg of sodium bismuthate was added to all the solutions.

- Same was done to the samples as well.

- The solutions were bolied for 45 minutes until effervescence was ceased.

- The spectrophotometer was turned on at 510 nm & the absorbances were recorded for all the samples.

- A graph was plotted & the concentrations of the samples were determined.

4. Results & Discussion

4.1 TSS

1st set of samples (September)

Sample	Initial weight of filter paper	Final weight of filter paper	Weight of suspended solids in 10 ml	TSS
A	1.03 grams	1.05 grams	0.02 grams	2 grams/litre
B	1.01 grams	1.04 grams	0.03 grams	3 grams/litre
C	1.04 grams	1.06 grams	0.02 grams	2 grams/litre

2nd set of samples (April)

Sample	Initial weight of filter paper	Final weight of filter paper	Weight of suspended solids in 10 ml	TSS
A	1.051 g	1.062 g	0.011 g	1.1 g/l
B	1.06 g	1.082 g	0.022 g	2.2 g/l
C	1.06 g	1.074 g	0.014 g	1.4 g/l

It can be clearly seen that the value of TSS is decreasing from September to April. In September, due to the rainy season more dirt particles are there in the water which account for TSS. While their amount decreases significantly in April, the values are still more than the desirable limit. Generally the value of TSS should not be more than 150 mg/l, if we are using water for drinking purposes. But here it can be clearly seen that the values are much more than that.

Few of the methods to reduce TSS in such case are as follows:

- **Membrane filtration**

Membrane filtration is a technique for the separation of suspended or dissolved materials by molecular weight and size. Application of a pressure differential causes the membrane to act like a sieve. Substances which are smaller than the pore size of the membrane pass with the solvent as permeate while larger solutes or particles are retained as concentrate.

- **Low Pressure DAF**

Dense, homogeneous micro-bubbles generate extremely high interphases and enable in most cases, a separation of almost 99% of the settleable matters or oil. At the same time, the systems attain extremely high dry mass contents or pure oil sludge.The Low Pressure Dissolved Air Flotation (DAF) system's simple and innovative design increases the flow by removing effluent from the same end of the tank as the influent is introduced, resulting in a higher hydraulic loading rate.

Advantages of using Low pressure DAF

- Low energy required.

- Low maintenance efforts.

- High quality industrial components.

- High operational reliability due to self-monitoring systems.

4.2 TDS

1st set of samples (September)

Sample	Initial weight of petridish	Final weight of petridish	Weight of dissolved solids in 10 ml	TDS
A	29.37 g	29.44 g	0.07 g	7 g/l
B	30.11g	30.2 g	0.09 g	9 g/l
C	29.37 g	29.43 g	0.06 g	6 g/l

2nd set of samples (April)

Sample	Initial weight of petridish	Final weight of petridish	Weight of dissolved solids in 10 ml	TDS
A	29.355 g	29.443 g	0.088 g	8.8 g/l
B	27.717 g	27.838 g	0.121 g	12.1 g/l
C	30.752 g	30.829 g	0.077 g	7.7 g/l

According to Indian Standards : 10500 (Drinking water specifications), the value for TDS should not be more than 2 g/l. If it exceeds this value, it might cause gastro intestinal irritation.

However it can also be seen that the value of TDS increases in the month of April as compared to the values in September. Evaporation & lower flow volume might be the reason for that. But, the values are much more than the desirable limits.

So, to bring down the value of TDS & to bring the water within the limits of drinking water specifications, the following measures can be taken.-

- **Carbon Filters**

A method of filtration which uses a bed of activated carbon to remove the impurities & also the contaminants, using chemical adsorption is called carbon filtering.
We get to see very slight reduction if we use carbon filters.

- **Reverse osmosis**

Reverse osmosis uses semi-permeable membrane for water purification. This is not a proper filtration method.
Yet, it can be used as it gives high reduction & great tasting water.

- **Distillation**

Distillation provides total reduction & flat taste of water.
So, it can be used if we want total reduction.

4.3 pH Value

1st Set of Samples (September)

Sample	pH observed	Nature (Acidic/Neutral/Basic)
A	7.1	Slightly basic
B	6.7	Acidic
C	7.6	Basic

2nd Set of Samples (April)

Sample	pH observed	Nature (Acidic/Neutral/Basic)
A	7	Neutral
B	6.6	Acidic
C	7.2	Slightly basic

According to Indian Standards:10500, pH of drinking water should be between 6.5 & 8.5. So, here it can be seen that the pH of all the sample fall within the required specifications.

However it can be seen that the pH slightly decreases in the second set of samples.

4.4 Turbidity

First set of Samples (September)

Sample	Turbidity observed
A	15 NTU
B	26 NTU
C	19 NTU

Second set of Samples (April)

Sample	Turbidity observed
A	11 NTU
B	21 NTU
C	15 NTU

According to Indian Standards: 10500 (Drinking water specifications), maximum value of turbidity should be 5 NTU. But here, it is much more than that.

It can also be seen that the value of turbidity is less in April than the value in September. The reduction in value of TSS might be the reason for that.

The water is certainly not fit for drinking. Few of the steps which might be taken to reduce the value of turbidity are as follows :

- **Cloth filtration**

A simple option to pre-treat turbid water is to filter through a locally available cloth. Users pour water from the transport container through the cloth into the storage container. The benefits of this option include its simplicity & the wide availability of cloth.

- **Sand filtration**

Filtration through clean sand is a fast and simple pre-treatment option. Users pour water from a transport container through a container of sand with gravel and a spigot at the bottom. The water then flows into a storage container. The benefits of sand filtration are that it is effective at removing some bacteria, it is simple and fast for the user, and, if sand is available locally, it is inexpensive. The drawback of sand filtration is that it requires three containers and a spigot. In laboratory studies, the use of sand filtration significantly reduced both the turbidity and the chlorine demand of turbid water.

- **Settling & decanting**

Settling and decanting is a method to reduce turbidity by letting the water sit for 2-24 hours so that the particulates settle to the bottom of the container. The clear water is then decanted off the top into a second container. The benefit of settling and decanting is that it requires no equipment besides the containers. The drawbacks of settling and decanting are the need for multiple containers, the time it takes the water to settle, and, if the containers are opaque, the difficulty in observing the effect of settling. In laboratory studies, the use of settling and decanting significantly reduced both the turbidity and the chlorine demand of turbid waters.

4.5 Conductivity

First set of samples (September)

Sample	Conductivity
A	0.306 mS/cm
B	0.308 mS/cm
C	0.282 mS/cm

Second set of samples (April)

Sample	Conductivity
A	0.385 mS/cm
B	0.414 mS/cm
C	0.363 mS/cm

Conductivity is directly related to the total dissolved solids. Therefore, it can be seen that the value of conductivity is more in the samples collected in the month of April as compared to September.

If we reduce TDS, the value of conductivity will automatically be reduced.

4.6 Chloride content

Volume of Silver Nitrate solution titrated for various samples :

Sample	Volume
Blank	0.25 ml
A-1	2.1 ml
B-1	3.5 ml
C-1	3.1 ml
A-2	2.2 ml
B-2	3.7 ml
C-2	3.2 ml

Normality = 0.0282 N

Volume of Sample = 20 ml

Equivalent weight of chlorine = 35.45

Hence, we get the chloride content as follows :

| Sample	Chloride Content
A-1	92.47 mg/l
B-1	162.45 mg/l
C-1	142.46 mg/l
A-2	97.47 mg/l
B-2	172.45 mg/l
C-2	147.45 mg/l

According to Indian Standards: 10500 (Drinking water specifications), the chloride content should not be more than 250 mg/l. Hence, it can be seen that the chloride content is fine with respect to the drinking water specifications.

However, the chloride content slightly increases in the second set of samples as the TDS increases due to evaporation.

4.7 Sulphate content

Absorbance recorded for different samples:

Sample	Absorbance
Blank Solution	0.04
0.2 g/l	0.817
0.4 g/l	1.574
0.6 g/l	1.632
0.8 g/l	1.756
A-1 (September)	0.05
B-1 (September)	0.175
C-1 (September)	0.072
A-2 (April)	0.055
B-2 (April)	0.208
C-2 (April)	0.105
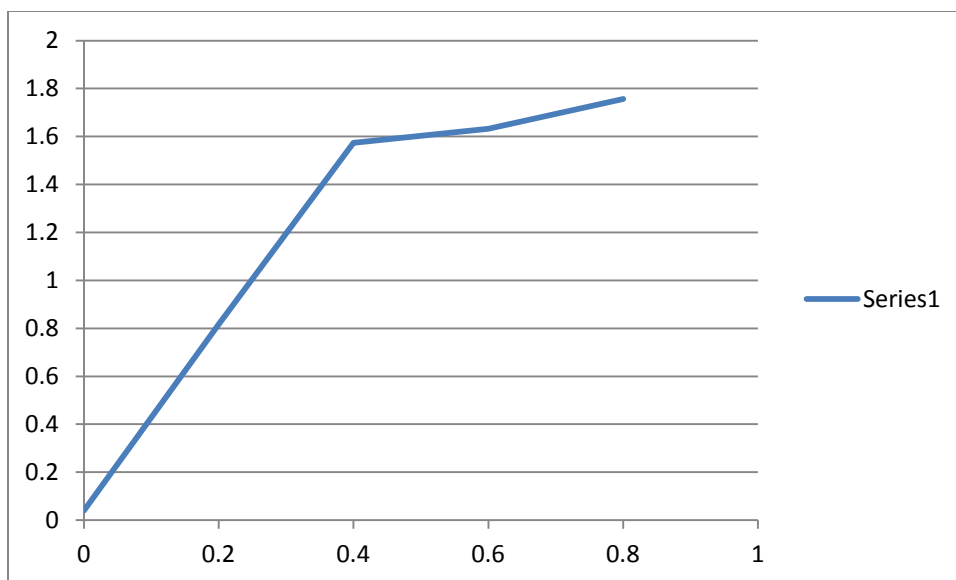
Absorbance(y-axis) v/s Concentration (g/l) (x-axis)

This graph is obtained from the values. Hence we get the concentration of the samples as follows-

Sample	Concentration
A-1	2.57 mg/l
B-1	34.75 mg/l
C-1	8.24 mg/l
A-2	2.83 mg/l
B-2	41.3 mg/l
C-2	12.02 mg/l

According to Indian Standards: 10500 (Drinking water specifications), the maximum value for sulphate content in water should be 200 mg/l. Hence, the sulphate content in these samples are acceptable.

4.8 Iron content in water

Absorbance recorded for different samples

Sample	Absorbance
Blank Solution	0.035
0.025 g/l	0.074
0.05 g/l	0.138
0.075 g/l	0.169
0.1 g/l	0.209
0.125 g/l	0.261
A-1 (September)	0.037
B-1 (September)	0.041
C-1 (September)	0.036
A-2 (April)	0.036
B-2 (April)	0.039
C-2 (April)	0.036

Absorbance(y-axis) v/s Concentration (mg/l) (x-axis)

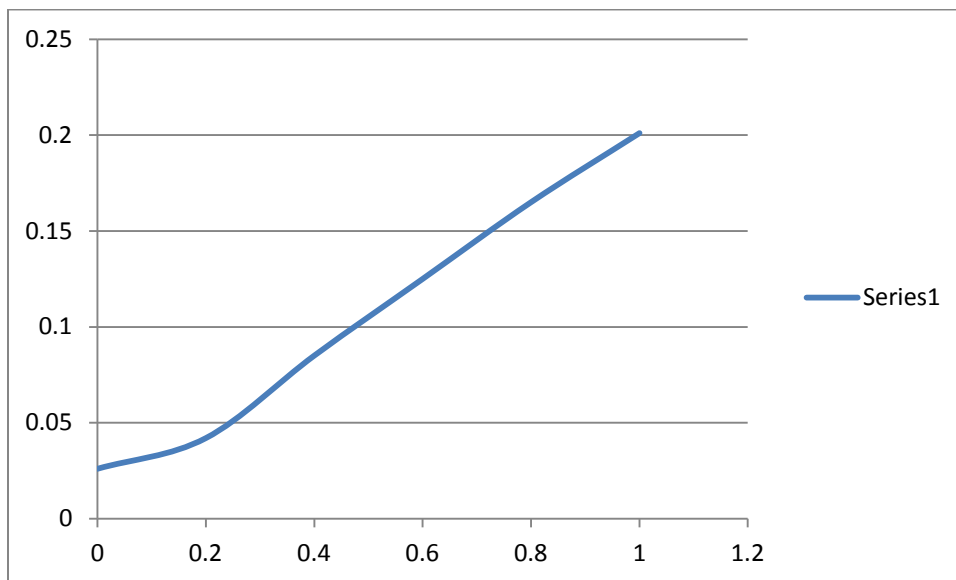This graph is obtained from the values. Hence we get the concentration of the samples as follows

Sample	Concentration
A-1	1.1 mg/l
B-1	2.76 mg/l
C-1	0.55 mg/l
A-2	0.6 mg/l
B-2	1.66 mg/l
C-2	0.5 mg/l

According to Indian Standards: 10500 (Drinking water specifications), value of iron content should not exceed 0.3 mg/l in drinking water. But here it can be seen that the value is much higher than that.

4.9 Manganese content in water

Absorbance recorded for different samples

Sample	Absorbance
Blank Solution	0.026
0.2 mg/l	0.042
0.4 mg/l	0.086
0.6 mg/l	0.125
0.8 mg/l	0.165
1 mg/l	0.201
A-1 (September)	0.055
B-1 (September)	0.095
C-1 (September)	0.062
A-2 (April)	0.049
B-2 (April)	0.078
C-2 (April)	0.059

Absorbance(y-axis) v/s Concentration (mg/l) (x-axis)

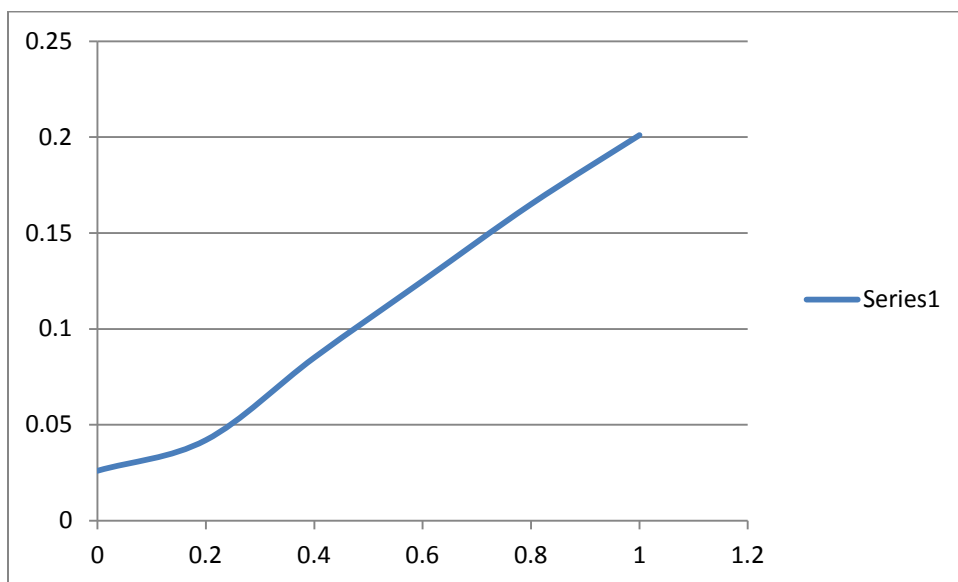This graph is obtained from the values. Hence we get the concentration of the samples as follows

Sample	Concentration
A-1	0.266 mg/l
B-1	0.467 mg/l
C-1	0.301 mg/l
A-2	0.235 mg/l
B-2	0.381 mg/l
C-2	0.286 mg/l

According to Indian Standards: 10500 (Drinking water specifications), value of manganese content should not exceed 0.1 mg/l in drinking water. But here it can be seen that the value is much higher than that.

Methods used for removal of Iron & Manganese :

Ion exchange

- Conventional water softeners are sometimes effective for removing iron and small amounts of manganese.
- Softeners are generally only recommended when the water pH is greater than 6.7, the water hardness is between 3 and 20 grains per gallon (50 to 350 mg/L) and the dissolved iron concentration is less than 5 mg /L. Oxidized forms of iron and manganese will foul the softener resin.
- If oxidized iron and/or manganese are present in the raw water, filtration should be used for removal.

Birm filters

- Birm filters are similar to manganese greensand but they do not require regen.eration because they utilize oxygen present in the raw water to oxidize the metals.
- As a result, the raw water must contain a certain amount of dissolved oxygen and the pH should be at least 6.8 for iron removal and 7.5 for manganese removal.
- Even under ideal conditions, manganese removal efficiency is highly variable with birm filters. Birm filters do require backwashing to remove accumulated oxidized metal particles.

Oxidation followed by filtration

- When combined levels of iron and manganese exceed 10 mg/L, the most effective treatment involves oxidation followed by filtration.
- In this process, a chemical is added to convert any dissolved iron and manganese into the solid, oxidized forms that can then be easily filtered from the water. Chlorine is most commonly used as the oxidant although potassium permanganate and hydrogen peroxide can also be used.
- A small chemical feed pump is used to feed the chlorine (usually sodium hypochlorite) solution into the water upstream from a mixing tank or coil of plastic pipe. The mixing tank or pipe coil is necessary to provide contact time for the iron and manganese precipitates to form.
- Significant system maintenance is required with these units. Solution tanks must be routinely refilled and mechanical filters need to be backwashed to remove accumulated iron and manganese particles.

Sample A

Property	Sample collected in September, 2013	Sample Collected in April, 2014	Desirable Limit
Total Suspended Solids	**2 grams/litre**	**1.1 grams/litre**	**Not more than 150 mg/l**
Total Dissolved Solids	**7 grams/litre**	**8.8 grams/litre**	**Not more than 2 g/l**
pH	**7 (Neutral)**	**7 (Neutral)**	**6.5 – 8.5**
Conductivity	**0.306 mS/cm**	**0.385 mS/cm**	**0.05 – 0.5 mS/cm**
Turbidity	**1.5 NTU**	**1.1 NTU**	**Not more than 5 NTU**
Sulphate content	**2.57 mg/l**	**2.83 mg/l**	**Not more than 200 mg/l**
Chloride content	**92.47 mg/l**	**97.47 mg/l**	**Not more than 250 mg/l**
Iron content	**1.1 mg/l**	**0.6 mg/l**	**Not more than 0.3 mg/l**
Manganese content	**0.266 mg/l**	**0.235 mg/l**	**Not more than 0.1 mg/l**

Sample B

Property	Sample collected in September, 2013	Sample Collected in April, 2014	Desirable Limit
Total Suspended Solids	3 grams/litre	2.2 grams/litre	Not more than 150 mg/l
Total Dissolved Solids	9 grams/litre	12.1 grams/litre	Not more than 2 g/l
pH	Slightly less than 7 (Acidic)	Between 5 & 6 (Acidic)	6.5 – 8.5
Conductivity	0.308 mS/cm	0.414 mS/cm	0.05 – 0.5 mS/cm
Turbidity	2.6 NTU	2.1 NTU	Not more than 5 NTU
Sulphate content	34.75 mg/l	41.3 mg/l	Not more than 200 mg/l
Chloride content	162.45 mg/l	172.45 mg/l	Not more than 250 mg/l
Iron Content	2.76 mg/l	1.66 mg/l	Not more than 0.3 mg/l
Manganese Content	0.467 mg/l	0.381 mg/l	Not more than 0.1 mg/l

Sample C

Property	Sample collected in September, 2013	Sample Collected in April, 2014	Desirable Limit
Total Suspended Solids	**2 grams/litre**	**1.4 grams/litre**	**Not more than 150 mg/l**
Total Dissolved Solids	**6 grams/litre**	**7.7 grams/litre**	**Not more than 2 g/l**
pH	**Between 7&8 (Basic)**	**7 (Neutral)**	**6.5 – 8.5**
Conductivity	**0.282 mS/cm**	**0.363 mS/cm**	**0.05 – 0.5 mS/cm**
Turbidity	**1.9 NTU**	**1.5 NTU**	**Not more than 5 NTU**
Sulphate content	**8.24 mg/l**	**12.02 mg/l**	**Not more than 200 mg/l**
Chloride content	**142.46 mg/l**	**147.45 mg/l**	**Not more than 250 mg/l**
Iron content	**0.55 mg/l**	**0.5 mg/l**	**Not more than 0.3 mg/l**
Manganese content	**0.301 mg/l**	**0.286 mg/**	**Not more than 0.1 mg/l**

5. Conclusion

It can be seen that the amount of total suspended solids has decreased from September, 2013 to April, 2014 in all the three tubewells. The reason might be the dirt particles which are more significant in the rainy season than in the summer.

As far as the TDS (total dissolved solids) is concerned, the value of TDS increases across the three samples. Lower flow volume & evaporation might be the reason.

If we take a look at the pH value, it decreases a bit in samples B & C, but is pretty much constant in sample A.

Conductivity increases in the second set of samples and so is TDS along with that. The reason being evaporation and lower flow volume again.

Turbidity decreases in the second set of samples. The reason might be the lower TSS.

There is a significant increase in both the sulphate content & chloride content in the second set of samples. TDS increases and so is the amount of salts dissolved in water.

If we compare the three tubewells, then the water from A seems to be the purest as it is colourless on both the occasions, is neutral & has the least TSS.

Sample B might be termed as the most impure among the three.

Hence, the required properties of all the three samples collected at two different times of the year were analysed and compared & appropriate measures were suggested wherever required.

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