WATER QUALITY MANAGEMENT

An Internship Report

Submitted by

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According to the syllabus of

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY

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ENVIRONMENTAL ENGINEERING LAB

Department of Civil Engineering

JYOTHI ENGINEERING COLLEGE

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ACKNOWLEDGEMENT

First I wish to express my sincere gratitude to **Prof. Joseph Joshy** for providing me an opportunity to do my internship at Jyothi Engineering College. For me, it was a unique experience to study about water quality testing. This internship period was a great chance of learning and professional development.

Next I express my deepest sense of gratitude to **Prof. S. Rathish**, HOD, Department of Civil Engineering, JECC for providing us an opportunity to work in Environmental Engineering Lab which comes under the Civil Department.

I also express my deepest thanks to **Prof. M. G. Cyriac** for giving necessary advice and guidance. He has arranged all facilities to make our internship programme more meaningful. His research papers and PowerPoint Presentations were very useful for me. I thank him for his valuable guidance.

I sincerely thank **Mrs.Vini.P** for her careful and precious guidance which was extremely valuable for my study, both theoretically and practically. I also wish to express my gratitude to the officials and staff members including Rinu Miss, Computer Centre staff and Librarian who rendered their help during my internship period.

Finally, I would like to extend my deep gratitude towards my family and my friends for their support in carrying out this work successfully.

EXECUTIVE SUMMARY

As part of A P J Abdul Kalam Technological University syllabus, I have undergone four weeks internship programme in my college. The topic that I have selected was 'Water Quality Management'. The main reason that I have selected this topic was I wanted to benefit from my experience. In this report I mainly describes the methods of water analysis, its advantages and my own experiences.

I with my friend Rosewin together have done this internship. The internship programme was started with an orientation class. The class was conducted by Prof. Joseph Joshy.Then we registered our names. The first two weeks was for self-study. And in the third and fourth weeks we had our practical lab sections. The water quality testing was held at the 'Environmental Engineering Lab' which comes under Civil Department.Prof. M. G. Cyriac had given necessary advices and guidance for me. The lab work was conducted under the leadership of Mrs.Vini.P, our lab Chemist.

In this report, I describe about the parameters and standards of water quality. Based on these parameters, we have tested water samples from our house and arrived at conclusions. The report also shows the different analysis methods, the importance of water, water pollution, its reasons and water quality measurement parameters.

The internship helped me to acquire both theoretical and practical concepts of water quality. It was a great opportunity for me to have this internship done at my college. The support and hands-on experience during the four weeks has become a value addition towards my curriculum.

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1. INTRODUCTION

This report is a short description of my one month internship programme which is carried out as part of A P J Abdul Kalam Technological University syllabus. Since I was interested in environment related things, I concentrated in 'Water Quality Management'. I have done my internship programme in Environmental Engineering Lab which comes under the Civil Department of Jyothi Engineering College. At the beginning of my internship I have formulated several learning goals. I tried my best to achieve it during this period.

This internship report contains many activities which I have done during this period. In the following pages I have described about the experiences, objectives, methodology and the goals that I achieved. Finally I gave a conclusion on the internship experience according to my goals. The data that I collected during this period was also included in this report.

During this period, I cooperate with my colleagues and faculties to determine the problems. I carried out a detailed study on the importance of water and water quality issues in Kerala. The reason why I am interested in doing this internship is mentioned in the Statement of Purpose (Ref **Annexure A**).Since water pollution is increasing day by day and water crisis becomes a major social issue, it is very good to concentrate in such a field. The Environmental Engineering Lab that I worked is a government approved lab.The lab is fully equipped with all measuring instruments. Our department advisors Prof. S. Rathish and Prof. M. G. Cyriac are well experienced professionals in this field and they had worked for many years in Kerala water authority. It was a great opportunity for me to guide by them. This internship helped me to learn independently, discipline myself, to be patient, self-trust, take initiative and the ability to analyze water.

2. OBJECTIVES

The main objective of this study was to learn about water quality testing. Along with that, I have decided to carry a detailed study on water quality issues in Kerala. I have formulated several learning goals before I started my internship. They are:

- To understand about water quality parameters and standards
- To learn how to test water based on these parameters
- To discuss on water quality related issues in Kerala
- To understand the preventive measures on the water issues
- To get experience in working in a quite different field
- To enhance my communication skills
- To achieve a professional experience
- To build a network

3. METHODOLOGY

3.1 Water Quality analysis

The water can be analyzed based on water quality parameters and standards .These parameters are shown in **Table 1** and **Table 2**.The physical parameters like pH, Turbidity etc. can be measured using the respective instruments like pH meter, Turbidity meter etc. The chemical parameters are analyzed by Colorimetry, and Volumetric titrations etc. (from **Reference 1**) By using these types of analysis methods we have analyzed the water samples from our house and reached a conclusion. Standard plate count, membrane filtration technique, multiple tube method etc. are the methods of bacteriological analysis. The details of water quality parameters are annexed in **Annexure B**.

No	Water quality Parameters
1	Turbidity
2	pH
3	Electrical conductivity
4	Temperature
5	Acidity
6	Alkalinity
7	Total dissolved solids
8	Hardness
9	Chloride
10	Fluoride
11	Iron
12	Nitrate

Table 1 Water Quality Parameters

NO	***Characteristics***	***Unit***	***Acceptable***	***Cause for Rejection***
1	**Turbidity**	NTU	5	10
2	**PH**		6.5 to 8.5	<6.5 & > 8.5
3	**Electrical Conductivity**	Micro mhos/cm		
4	**Temperature (0C)**	mg/litre		
5	**Acidity**	mg/litre		
6	**Alkalinity (Total)**	mg/litre	200	600
7	**Total hardness (as Ca CO3)**	mg/litre	300	600
8	**Calcium(as Ca)**	mg/litre	75	200
9	**Magnesium**	Mg/litre	30	150
10	**Chloride**	Mg/litre	250	1000
11	**Fluoride**	Mg/litre	1	1.5
12	**iron**	Mg/litre	.3	1.0
13	**Nitrate (as NO_3)**	Mg/litre	45	100
14	**Bacteriological analysis**	No of coliforms/100 ml		
15	**Chemical oxygen demand**	Mg/litre		

Table 2 Water Quality Standards

Water quality parameters are the parameters which are used to determine the pollution effects of water. When we apply a limit to it, it becomes a standard. In India, there are several organizations that prescribes water quality standards. They are BIS, CPHEEO, ICMR, WHO, USEPA etc.

i. Physical parameters

The physical parameters are described in Annexure B.

pH

The pH can be calculated using pH meter. The sample to be determined is taken in a small beaker and placed in the pH meter. The value is noted and analyzed.

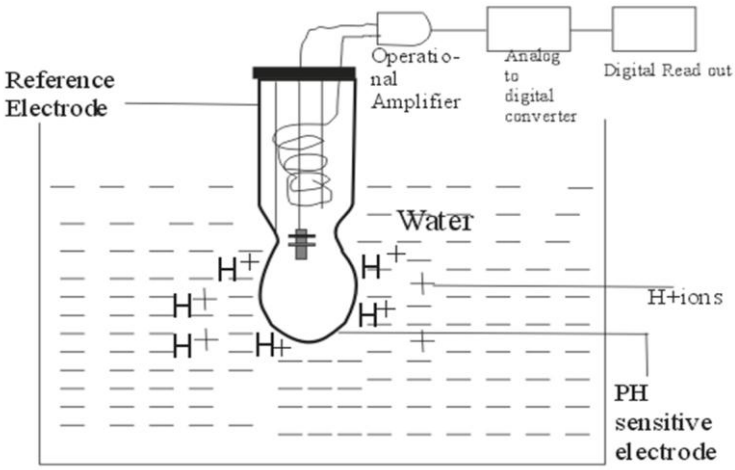

Figure 1 pH meter

Turbidity

The turbidity can be measured using turbidity meter. Here, after the calibration of the instrument, the sample is taken and placed in the meter. Then the value is shown by the meter. Here formazin concentrate is used as the reference.

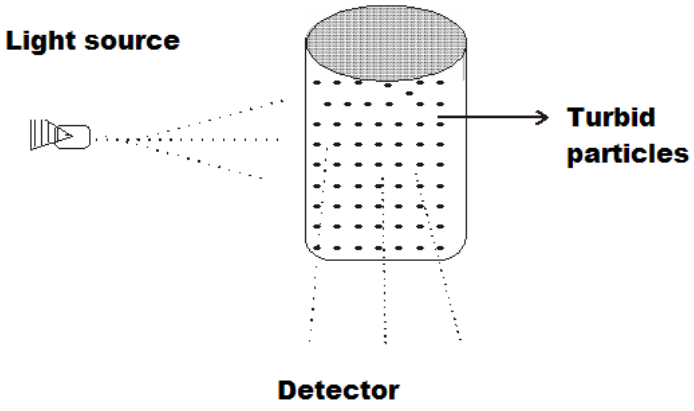

Figure 2 Turbidity meter

Total dissolved solids

Total dissolved solids can be measured by using conductivity method. Here KCl solution having .1N or .01N is used as the reference. After the calibration of the instrument and setting of range, the solution is placed and the value is noted. Conductivity can also be measured by using this instrument by changing the knob to conductivity mode.

ii. Chemical parameters

The list of chemical parameters are annexed in annexure 4.The chemical parameters are analyzed by colorimetry and volumetric analysis.

Colorimetry:

Colorimetry is the formation of colour due to the reaction of chemical in the water with a predetermined chemical in the prescribed mode. Then the formation of colour will take place. The intensity of colour is proportional to the quantity of chemical present in the water. For colorimeter, the incident light is equal to the total sum of reflected light, transmitted light and absorbed light. That is, I=R+A+T.Colorimetry can be measured using spectrophotometer.

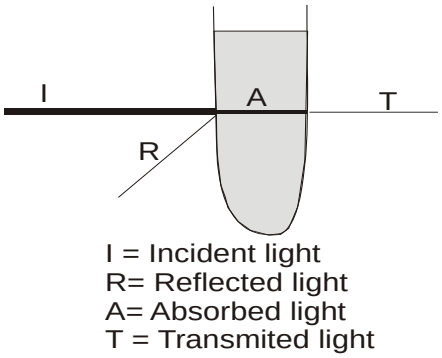

Figure 3 Light rays incident on a coloured medium

Colorimetry is mainly based on the Beer's and Lambert's law. Beer's law states that when monochromatic light passes through a medium, the intensity of light is proportional to the colour intensity of the medium. It is denoted as, $T=I/I_0=10^{-a2C}$ where 'a_2' is the constant of particular medium and 'C' is the colour of concentration of medium.

Lambert's law states that intensity of light is inversely proportional to the thickness of the medium. .The parameters like Iron, manganese, fluoride, Nitrate etc. can be measured by this method. Theoretically, $T=I/I_0=10^{-a1e}$ where 'T' is the transmittance, 'I_0' is the entering light intensity, I is the intensity of transmitted light and 'e' is the thickness of the medium.

The chemical to be added, colour of the medium, its wavelength etc. are shown in the Table 3.

Chemical to be estimated	**Chemical to be added**	**Colour**	**Wavelength**
Iron	1.10 Phenanthroline	Light brown	510
Fluoride	Ammonium acetate and spands reagent	Reduction in colour upon increase in fluoride	570
Manganese	Special Reagent and Ammonium per sulphate		525

Table 3 Colorimetric Analysis

Volumetric Analysis:

It is the reaction between two mutually reactive chemicals. Here a chemical of known strength is used which is termed as reagent and is titrated against titrant which is taken in the burette with the help of an indicator. The endpoint is noted. Then the value is obtained by using the formula $N_1V_1=N_2V_2$.The chemical to be added, reagent, indicator etc. are shown in **Table 4**.The chemical parameters like Alkalinity,Hardness,Chloride etc. can be calculated by volumetric analysis.

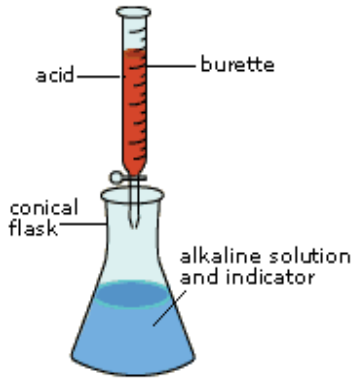

Figure 4 Volumetric titration

Chemical to be evaluated	Reagent	Indicator	End point colour
Acidity	NaOH	Phenolphthalein	Pink
Alkalinity	Sulphuric acid	Methyl orange	Orange
Hardness	EDTA	EBT	Blue
Chloride	Silver nitrate	$K_2Cr_2O_7$	Red deposit

Table 4 Volumetric Analysis

Chemical Oxygen Demand

COD is the quantity of oxygen required to oxidise the organic matter in water using chemical compounds. It is the indication of chemical pollution. COD requires 3 hours and that of BOD is 3 days. Here the sample along with mercurric sulphate, potassium dichromate and conc.H_2SO_4 is taken in a round bottom flask. Then it is placed in Sauhlet's extraction mantle. It is then connected with Graham's condenser tube. It is then boiled for two hours and keep it for reflexing. After making up, it is then titrated against ferrous ammonium sulphate using ferroine as indicator

iii. Bacteriological analysis

Here in this method, we are analyzing the indicator organisms such as coliform and E- coli. For this we are growing the bacteria in a favorable condition by providing food and other environment and counting its growth by a suitable method. If the indicator organism is present, it denotes that there is chemical pollution. The common methods used for analyzing the bacteria are ***Standard plate count method, membrane filtration technique, multiple tube method*** etc. (from **Reference 2 & 1**)

Commonly, faecal coliform is detected in laboratories. It is because, we are actually strengthen the bacteria by providing its food. So if we culture the bacteria, there is a chance for it to escape into our bodies. And this will cause many diseases to our bodies. We know that 10% of the bacteria in the human excreta consists of coliforms. Per day, human being discharges 100 to 400 billion coliforms. Compared to other bacteria in the human excreta, life period of coliform is maximum after coming out of the intestine. This is the major advantage of coliform. And also its analysis is simple. This also makes it different from other bacterias.Colliform is also present in the excreta of all cold blooded animals.

Multiple tube method

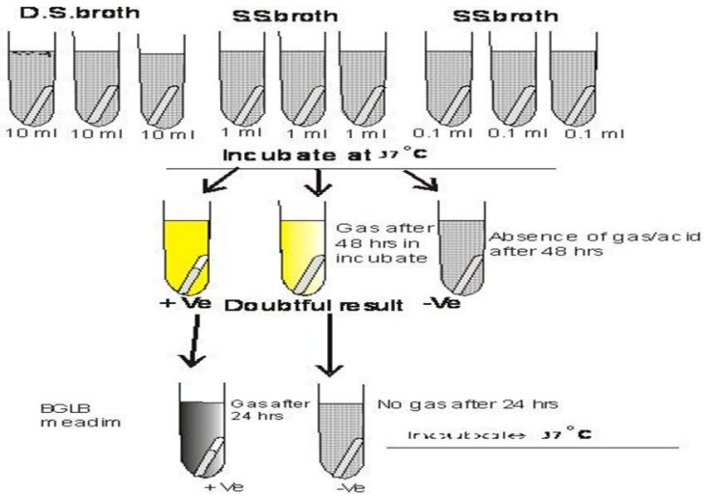

Figure 5 MPN method of analysis

This is one of the oldest method. In this method, instead of culturing bacteria, we are preparing food for the bacteria in incubator under specified conditions. Here, a Macconkey broth is prepared and the water samples are diluted with 100 ml of sterile growth medium and an aliquot of 10 ml is then decanted into ten tubes. The remaining 10 tubes is diluted again and the process is repeated. Thus we are preparing double strength and single strength broths. The tubes are then incubated at 37 ^{0}C for 24 hours. After incubation we determine the gas production in each of the tubes. If there is gas production, it denotes the presence of coliform. By assigning certain values for the tubes and by looking on the MPN chart, we can count the no of coliforms per 100 ml of our water sample. If there is no gas production, it denotes that there is no coliform in the water sample. The two types of tubes used in this method are fermentation tube and Durham's tube. The fermentation tube is used for preparing broth and Durham's tube is used for detecting the presence of gas production.

Standard plate count method

Incubate the water in a petridish with the specified ingredients at a specified temperature. It relies on bacteria growing a colony on a nutrient medium so that colony becomes visible to the naked eye and the no of colonies on a plate can be counted.

Membrane filtration Technique

In this method, membrane filters are used and they are laid on the nutrient medium within sealed plates. The membranes have a printed millimeter grid printed and can be used to count the no of Colonies under microscope.

3.2 Water quality related issues in Kerala and its remedial measures

There are many water quality issues in our state. These mainly includes

- Presence of coliform bacteria
- Variation in pH value– High pH and Low pH
- Excess iron
- Excess turbidity
- Excess fluoride
- Salinity
- Excess hardness
- Growth of algae
- Pollution due to organic matter
- Deposition of carbonate.

For solving these issues we must take the following preventive measures

- Presence of bacteria in water can be avoided by disinfection methods. The disinfection methods mainly includes chlorination, boiling etc.
- The decrease in pH or the increase in acidity is a major problem affected to our water resources the reason behind this is that CO_2 (present in the topsoil) which is formed due to bacterial action will dissolve in water when it percolates. We can avoid acidity of water by adding lime to the water.
- Almost all our water resources have normal alkalinity. It has not been reported about the excess of alkalinity issues. If there is so, we can remove it by adding certain chemicals.
- Excess of iron in water is a major problem in all countries including India. The water containing iron will show turbidity when it is exposed to air, it will cause stains on the walls and the vessels, Oily appearance on the surface of water etc. So the iron content in water is harmful for human beings. Iron constitutes 6% of the earth crust .Of these, 3% is soluble i.e. in Fe^{2+} form and 3% is insoluble i.e. in Fe^{3+} form. While rain water is percolated through the earth, Fe^{2+} dissolves in the water. For the removal of iron we have to increase the pH of water by adding suitable alkaline materials such as lime, Soda ash, bleaching powder etc. We must have to aerate the water for oxidation to take place. Then it is allowed to settle and thereafter for filtering.

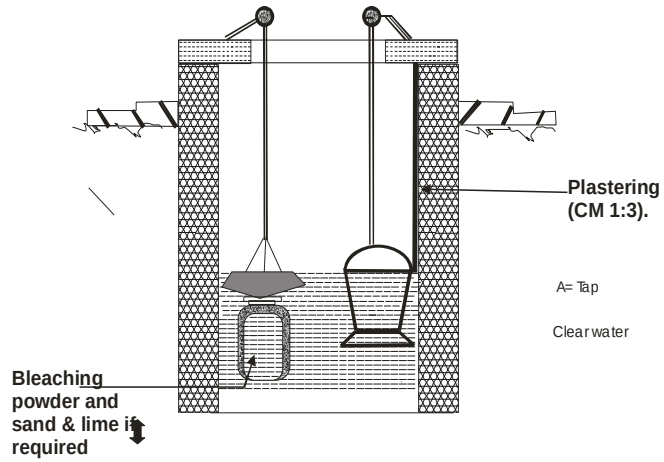

Figure 6 Removal of iron in open well

- The calcium and magnesium ions present in the water in the form of bicarbonates is the root cause of hardness in water. By boiling or by using softeners we can remove the hardness of water.
- Alappuzha and Palakkad district have high content of Flouride.Flouride dissolves from the crust of the earth. Domestic kit using activated alumina can be used for the removal of fluoride.
- The major problem that we can see in coastal areas and in filter point wells is the presence of chloride. It is mainly due to seawater intrusion. The excessive withdrawal of seawater results into intrusion of sea water manifested as presence of excess Chloride, Hardness etc. For the removal of chloride, the large treatment plants which follows the principle of reverse osmosis is commonly used. These types of plants are common in Saudi Arabia. Now a days small treatment units (following the reverse osmosis principle) are widely available in the market.
- The pollution in open wells due to the growth of algae is now common. The water in these wells will be clear in the morning. But when it is exposed to sunlight, it turns green. This will surely affects the water quality. Algae is an aquatic plant. It attains strength when exposed to sunlight and it is not active during night. The algae growth in our water tanks when it is not covered by nets is an example for this. The solution for this problem is to avoid the direct fall of sunlight in waterbodies.Addition of bleaching powder and lime is also a solution.
- The deposition of carbonate is another issue that we have to face. This deposition is in the form of white powder. It can be seen in our bathroom floors. It mainly affects the water in borewells.The water which percolates through the earth will undergo certain chemical reactions. That is,

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

$$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2$$

This is shown in the figure below.

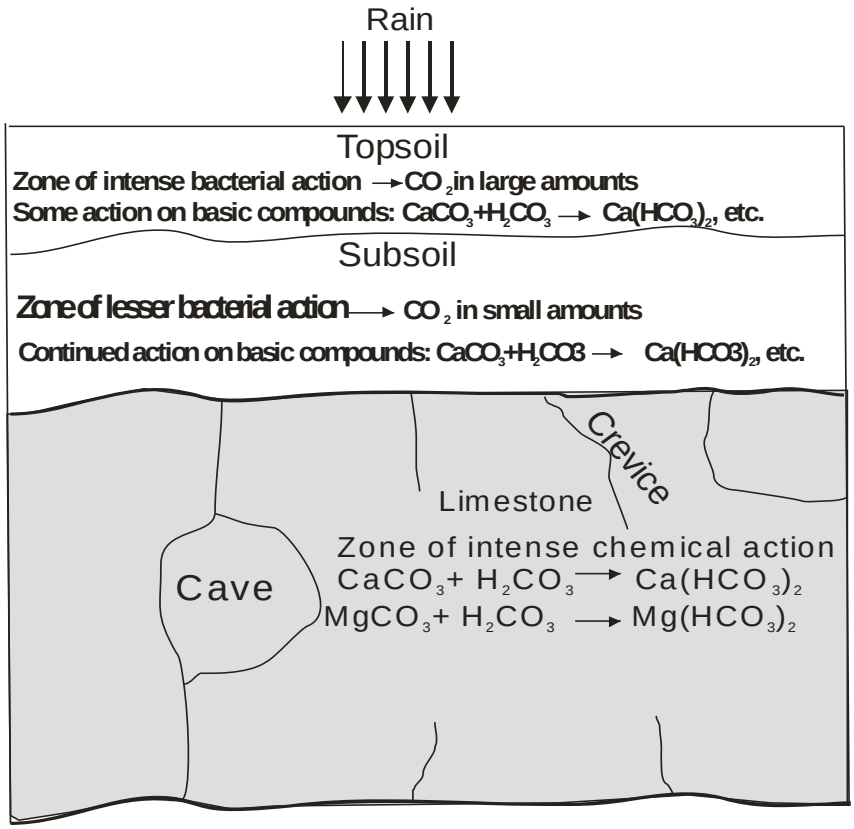

Figure 6 Chemical Reactions occurring when water percolates through earth

Due to these actions, water reaching the bottom of earth's crust contains a large amount of calcium bicarbonate. When this water is pumped to the top, the carbon dioxide present in the water will start to escape. As a result, reverse reaction occurs. Then calcium bicarbonate decomposes into calcium carbonate and carbonic acid. This calcium carbonate is deposited as white powder. Sufficient filtration is the solution for this problem. (**Reference 3**)

Water quality problems are always increasing day by day. There are many reasons behind these water pollution. Presence of heavy metals, chemicals, pesticides etc. are few of them.(from **Reference 4**)These are mentioned in **Annexure C.**We should realize the importance of water **(**Refe**r Annexure D)** and take necessary measures to solve the water quality issues in our area.

4. INTERNSHIP ACTIVITIES

4.1 Week 1 (June 06-June 10)

The internship programme was started with an orientation class which was held on 03 June at 11.00 am in the seminar hall at Jyothi Engineering College. The class was conducted by Prof.Joseph Joshy. The role of engineers and the need of internship etc. were discussed in the class. Those who attended the class has registered for their one month internship programme.I, with my friend Rosewin has selected 'Water Quality Management' as our internship topic. On the first day, I have been asked to submit Statement of Purpose (SOP) which describes why I had selected this topic. The first two weeks was for self-study. In the first week, I referred many books, and magazines to study about water quality issues, its parameters and standards. The reference books include '***Jalam***' published by Kerala water authority, '***Water pollution: Causes and effects***', '***Global Water Pollution***' etc. Based on my studies, I have asked to prepare a report discussing the importance of water, Water quality testing, Water pollution, Water quality parameters and standards etc. I had submitted the report on June 10.

4.2 Week 2 (June 13- June 17)

In this week, I had asked to watch some videos and PowerPoint presentation which are helpful for my studies.Cyriac sir had sent me a lot of presentations which mention about the '***Water Quality issues in Kerala'***, '***Well maintenance and sanitation'***, '***Water Quality parameters and Standards'***, and '***Bacteriological analysis of water'.*** I had gone through all these presentations. It was very informative. Here in this week I also visited the digital library section in our college with the help of librarian .I went through many research papers, and international journals which helped in my studies. Based on my studies, I prepared a presentation which described about all that I had studied. I also watched videos such as '***An introduction to water quality'***, '***How do we test water quality?***' and ***'Water quality: sampling and analysis'*** which gave a detailed description on water quality.

4.3 Week 3 (June 20- June 25)

This week was for presentation. I met Prof. Cyriac sir and had a detailed discussion on water quality. I discussed about the presentations he had prepared. He introduced about the scientists related to this field. The discussion was in the form of usual talk. I asked my doubts and Cyriac sir cleared it well. He

shared with me his experiences from the Kerala water authority. The practical class was started on Wednesday afternoon itself. I was guided by Mrs.Vini, the Lab Chemist and her class was very interesting. During this week, I brought the water sample from my house and tested its physical and chemical parameters. (The methods are described in the annexure).I had tested acidity, alkalinity, turbidity, COD, Hardness, and Chloride etc. The testing of water samples was very interesting. I understood the problems in my water and decided to take remedial measures.

Figure 7 Analysis performance in Environmental Engineering Lab at Jyothi Engineering College

<u>Week 4</u> (June 27- July 2)

This was my last week. In this week I studied about the spectrophotometer, colorimetry etc. and analyzed the parameters including iron and manganese. I have asked to submit my report on Saturday. The report mainly describes the activities that I have done in my lab sections.

5. RESULTS AND DISCUSSION

	BIS Standard	Bhavya (open well)	Rosewin (Bore well)
pH value	**6.5 to 8.5**	**5.35**	**6.20**
Turbidity,NTU	**5**	**3.3**	**.4**
TDS ,mg/L	**500**	**45**	**159.5**
COD		**7**	**9**
Total Hardness	**300**	**96**	**114**
Chloride	**250**	**9**	**25**
Alkalinity, mg/L	**200**	**10**	**70**
Iron	**.3**	**.15**	**.18**
Manganese	**.1**	**0.000**	**.002**
MPN		**150**	**30**

Table 5 Readings of tested water samples

We have tested two types of samples. The samples were brought from our house. The two samples represent two types of well: an open well and a bore well. We analyzed the water quality parameters of each water. By comparing these readings with the BIS standards we have reached our conclusion. When compared with the BIS standard, I understood that my water is little acidic and there is presence of bacteria. The acidity can be reduced by adding lime and pollution can be removed by adding bleaching powder. I also understood that since it is rainy, the water in open well would always be turbid. By analyzing the bore well water, I understood that the presence of minerals and chemicals are more in the bore well.

So from this analysis section, I have studied to assess whether the water is good for drinking, to determine the chemicals present in water, to identify whether there is organic pollution present in water etc.

6. CONCLUSION

This internship was a great experience for me .I have gained new knowledge, skills and met many people. I achieved several of my goals. Books that I have referred, videos and presentations that I have watched, research papers I have gone through etc. helped me a lot.

I studied about the major water quality issues in Kerala and carried out a detailed discussion with Prof.M.G.Cyriac. He gave me vast information on water quality parameters and standards. The moment I spent with him provided me a lot of benefits. The experiences shared by him was great and his each and every word was lessons for us. It helped me to improve our knowledge.

During this internship period I have learned that 'Water Quality Management' is not a mere subject, but it has a major role in our daily life. I tested the water sample from my house. I understood that my water is little acidic and there is presence of bacteria. This helped me to study about the preventive measures.

The main benefit of the internship was that I have gained an extensive amount of knowledge on water quality, its parameters and standards. The internship also provided me a chance to visit our digital library in the college. It was a very wonderful experience. I have gone through many research journals and international libraries which helped me to understand related topics on water.

I tried to improve my communication skills and to build a network. Now I am sure that I can give necessary directions to people who face water quality issues. From this one month internship programme, I understood about the importance of water, its testing methods, well maintenance and proper sanitation and sure that it will benefit me in my future.

LIST OF ANNEXURES

ANNEXURE A

Statement of Purpose

Why I am interested to do internship in 'Water Quality Management'?

I had selected the topic 'Water Quality Management' for my one month internship programme.The reason to choose to this subject is was that I wanted to benefit from my experience. I came to know that 'Water Quality Management' is a subject of my higher study. So I was sure that doing this internship will provide me a great benefit. I also thought that, this rainy period is the most apt time for the studying of water quality .During this season, outbreaks of diseases which spread through contaminated water are common in our areas where there is poor sanitation and lack of proper sewage system. We read these types of news in newspapers daily. So I thought that, the internship during this period will be a different experience for me to study about waterborne diseases in detail. These all are the main reasons that I chose to do my internship on this topic.

On practical thinking, we know that there are large amount of water resources in our area. But one in two persons has no access to safe drinking water .Usage of waste water, poor water treatment practices causes a major environmental and social challenge to the country. Every week, 42000 deaths of mostly children under five-occur from preventable diseases like diarrhea and dysentery caused by unsafe drinking water .The major reason behind is the use of impure water. So to solve these problems I wanted to know more about water quality. I will extend my studies to other areas also. My intention is to collect water sample from my nearby houses, college premises etc., to analyze it and to find whether it is suitable for drinking .My friends in hostels had told that their drinking water has bad taste and odour.So I am interested in analyzing water samples there. I have a little knowledge on water quality, its purification methods, parameter etc. I wanted to go deeply on these subjects. So I think this internship will provide me a professional experience, new insights and motivation to pursue a career. To prepare myself for my future career, I can work on my communication skills, to build a network etc. during this period.

ANNEXURE B

Water quality measurement parameters

The parameters are of two types: physical and chemical.

I. Physical parameters

The parameters which can be detected directly or by using certain instruments (ex: Color, taste, odour, turbidity, electrical conductivity, pH value) are known as physical parameters.

- **Colour**

Normal Method of Analysis: *Colorimetric*

Natural colour reflects the presence of complex organic molecules derived from vegetable matter such as peat, leaves, branches and soon. Its effect can be enhanced by the presence of suspended matter but this is normally eliminated in the analysis by filtration. Obviously, the more vegetable matter in the water the greater is the colour. Exceptionally, natural colour may arise from the presence of colloidal iron/manganese in water but organic matter is almost always the cause. Objections to high colour are generally on aesthetic grounds rather than on the basis of a health hazard. Consumers are reluctant to drink water, however safe, which has a yellowish-brown colour not unlike that of urine, and because of this revulsion any marked colour is very undesirable. So strong may be the objection to colour in water that occasional cases have been noted of people turning from coloured but otherwise safe waters to alternative supplies without coloration, and of a much lower bacteriological quality. However, the1998 EU Drinking Water Directive - in contrast to its 1980 predecessor - does not set a quantitative standard for colour, effectively leaving the matter to the reactions of consumers. Nonetheless, it must be noted that the presence of colour on a persistent basis (i.e. with short-term seasonal peak values discounted) in a water which is then disinfected by chlorination is highly undesirable. This because of the readiness with which the colour-causing substances reacted with the added chlorine giving rise to the presence of trihalomethanes .The latter compounds is a potential hazard to public health. The degree of colour in water will vary very widely in space and in time. Colors are of two types: True colour (no change when filtered) and apparent colour (change when filtered).

- **Taste and odour**

Units Used for Analytical Results: *Dilution Factor /Qualitative Description.*

Normal Method of Analysis: *Subjective personal assessment; Odour Panel; Taste Panel in Controlled Conditions*

Taste and odour are the parameters which can lead to severe consumer reaction which may necessitate the condemnation of a water supply. These are due to the presence of dissolved minerals, chemical substances, oils, and other organic matter etc. While astringent tastes can be caused by the presence of excessive amounts of metals or dissolved salts, there are often other more serious problems which arise in such cases (e.g. physiological effects). Purely organoleptic taste problems arise most commonly from algae and from phenols after chlorination. Decaying algal masses can release to the water trace organic compounds (including phenolic types) which produce offensive tastes after chlorination during treatment. Taste is assessed by an individual analyst and is described subjectively. Dilution factor at stated temperature (D) is the unit used for analytical results.

- **Turbidity**

Units Used for Analytical Results: *Formazin Turbidity Units [FTU]; Jackson Turbidity Unit [JTU]; Nephelometric Turbidity Units [NTU]; Silica Units [SiO2].*

Normal Method(s) of Analysis: *Turbidimeter or Nephelometer*

Turbidity is the measure of the ability of light to pass through water, that is, a measure of water's murkiness. Measuring murkiness gives an estimate of suspended solids in the water. Turbidity is measured in Nephelometric Turbidity Units NTU's).Suspended solids usually enter the water as a result of soil erosion from a disturbed land or can be traced to the inflow of effluents from sewage plants or industry. Suspended solids also occur naturally in the water from bank and channel erosion; however this process has been accelerated by human use of waterways. Turbidity measurements also take into account algae and plankton present in the water. High turbidity affects submerged plants by preventing sufficient light from reaching them for photosynthesis. High turbidity also has the capacity to significantly increase water temperature. Water temperature needs to remain fairly constant so aquatic fauna can survive. High turbidity is assign of poor water quality and land management.

- **Electrical conductivity**

Units Used for Analytical Results: μS/cm.6

Normal Method of Analysis: *Electrometric*

Conductivity is a measure of how well water can pass an electrical current. It is an indirect measure

of the inorganic dissolved solids such as chloride, nitrate, Sulphates phosphate, sodium, magnesium, calcium, iron and aluminium.The presence of these substances increases the conductivity of a body of water. Organic substances like oil, alcohol and sugar have low conductivity in water. Inorganic dissolved solids re essential ingredients for aquatic life. They regulate the flow of water in and out of organisms' cell and are the building blocks of the molecules necessary for life. A high concentration of dissolved solids however can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels.

- **pH value**

Units Used for Analytical Results: *pH units.*

Normal Method of Analysis: *Electrometry [pH electrode]*

pH is an important limiting chemical factor for aquatic life. If the water in a stream is too acidic or basic, the H+ or OH- ion activity may disrupt aquatic organism's biochemical reactions by either harming or killing the stream organisms. Streams generally have a pH values ranging between 6 and 9, depending upon the presence of dissolved substances that come from bedrock, soils and other materials in the watershed. Changes in pH can change the aspects of water chemistry. For example, as pH increases smaller amounts of ammonia are needed to reach a level that is toxic to fish. As pH decreases, the concentration of metal may increase because higher acidity increases their ability to be dissolved from sediments into water.

- **Temperature**

Water temperature is a controlling factor for aquatic life. It controls the rate of metabolic activities, reproductive activities and therefore, life cycles. If temperature increase, decrease or fluctuate too widely, metabolic activities may speed up, slow down, mal function, or stop altogether. Temperature is significant because it affects the amount of dissolved oxygen in the water. The amount of oxygen dissolves in water increases, as temperature decreases.

II. Chemical parameters

The chemical substances present in the water can be measured using chemical parameters. Acidity, alkalinity, iron, fluoride; Chloride, Nitrate, Sulphates, Manganese, arsenic etc. are few of them. To measure these quantities, different methods are adopted. Volumetric analysis and colorimetric are the techniques which are usually adopted (from **Reference 5**).

- **Acidity**

Units Used for Analytical Results: *mg/l CaCO3.*

Normal method of analysis: *Titration with sodium hydroxide*

Acidity of water is its quantitative capacity to react with a strong base to a designated pH. Acidity is a measure of an aggregative property of water and can be interpreted in terms of specific substances only when the chemical composition of the sample is known.

- **Alkalinity**

Units Used for Analytical Results: *mg/l CaCO3.*

Normal method of analysis: *Titration with sulphuric acid*

The alkalinity or buffering capacity of a stream refers to how well it can neutralize acidic pollution and resist changes in pH. Alkalinity measures the amount of alkaline compounds in the water, such as carbonates, bicarbonates and hydroxides. These compounds are natural buffers that can remove excess hydrogen or H+ ions.

- **Iron**

Units Used for Analytical Results: mg/l Fe.

Normal method of analysis: *Colorimetric (o-PhenanthroIine); Atomic Absorption Spectrometry*

Iron is present in significant amounts in soils and rocks, principally in insoluble forms. However, many complex reactions which occur naturally in ground formations can give rise to more soluble forms of iron which will therefore be present in water passing through such formations. Appreciable amounts of iron may therefore be present in ground waters. Severe problems can be caused in drinking water supplies by the presence of iron although there is normally no harmful effect on persons consuming waters with significant amounts of iron. Rather, the problems are primarily aesthetic, as the soluble (reduced) ferrous (Fe2+) iron is oxidised in air to the insoluble ferric (Fe3+) form, resulting in colour or turbidity (or, in severe cases, precipitate formation). Laundry becomes stained if washed in water with excessive iron, and vegetables likewise become discoloured on cooking. Taste problems may also occur. When waters rich in iron are used to make tea (in which tannins are present) there may be a reaction giving rise to off-color which may in severe cases resemble that of ink. Relatively high concentrations where it is relatively nontoxic to aquatic organisms. When nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can become a problem. Iron is quite harmful to aquatic life, as evidenced by laboratory studies, but in nature the degree of toxicity may be lessened by the interaction of the iron

with other constituents of water

• Fluoride

Units Used for Analytical Results: *mg/I F.*

Normal method of analysis: *Colorimetric (after distillation); Specific Ion Electrode*

Fluorides occur naturally in quite rare instances. It arises from fluoridation of public water supplies and from industrial discharges. Health studies have shown that the addition of fluoride to water supplies in levels above 0.6 mg/l F leads to a reduction in tooth decay in growing children and that the optimum beneficial effect occurs around 1.0 mg/l.At levels markedly over 1.5 mg/l an inverse effect occurs and mottling of teeth (or severe damage at gross levels) will arise. For this reason there is a constraint on fluoride levels, the effects of which vary with temperature.

• Chloride

Units Used for Analytical Results: *mg/l Cl.*

Normal method of analysis: Titration (Mohr Method: Silver Nitrate)

Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l Cl). In fresh waters the sources include soil and rock formations, sea spray and waste discharges. Sewage contains large amounts of chloride, as do some industrial effluents. Chloride does not pose a health hazard to humans. At levels above 250 mg/l Cl water will begin to taste salty and will become increasingly objectionable as the concentration rises further. However, external circumstances govern acceptability and in some arid areas waters containing up to 2,000 mg/l Cl are consumed, though not by people unfamiliar with such concentrations. High chloride levels may similarly render freshwater unsuitable for agricultural irrigation. Sewage is a rich source of chloride; a high result may indicate pollution of water by a sewage effluent. The level of chloride in rivers and other fresh waters are usually in the range 15-35 mg/l Cl - much below drinking water standards. In coastal areas, however, elevated chloride values may be due to sea spray, or sea water infiltration, and not necessarily to discharges. Normal raw water treatment processes do not remove chloride (**Ref 7**).

• Nitrate

Generally occurs in trace quantities in surface water. It is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient. It is only found in small amounts in fresh domestic water, but in effluent of nitrifying biological treatment plants, nitrate may be found in concentrations up to 30 mg nitrate as nitrogen/L.Nitrate is a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms. When

nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can become a problem.

- **Hardness**

Units Used for Analytical Results: mg/l CaCO3.

Normal Method(s) of Analysis: *Titration with EDTA*

The hardness of water is governed by the content of calcium and magnesium salts (temporary hardness), largely combined with bicarbonate and carbonate and with Sulphates, chlorides, and other anions of mineral acids (permanent hardness).

- **BOD**

Units Used for Analytical Results: mg/l O2

Normal Method of Analysis: *Incubation technique with oxygen determinations by Winkler Method or by Oxygen Meter*

The Biochemical Oxygen Demand is the amount of oxygen consumed by the bacteria in the decomposition of organic material.BOD is determined by measuring the dissolved oxygen level in a freshly collected sample and comparing it to the dissolved oxygen level in a sample that was collected at the same time but incubated under specific conditions for a certain number of days. The difference in the oxygen readings between the two samples in the BOD is recorded in units of mg/L. Unpolluted, natural waters should have a BOD of 5mg/L or less. Raw sewage may have BOD levels ranging from 150-300 mg/L.

- **COD**

Units Used for Analytical Results: mg/l O2

Normal Method of Analysis: *Micro digestion and Colorimetry; Titrimetric following Reflux Distillation with Acid Potassium Dichromate*

The chemical oxygen demand is used as a measure of the oxygen equivalent of the organic matter content of the sample that is susceptible to oxidation by a strong chemical oxidant. For samples from a specific source, COD can be related empirically to BOD, organic carbon, or organic matter. The test is used for monitoring and control after correlation has been established.

ANNEXURE C

Water Pollution and its reasons

Water pollution is the contamination of water bodies (for example, lakes, rivers, oceans, aquifers and groundwater).This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. The pollution can be defined in many ways. Usually it means one or more substances have built up in water to such an extent that they cause problems for animals or people. Oceans, lakes, rivers, and other inland waters can naturally clean up a certain amount of pollution by dispersing it harmlessly. Water pollution is all about quantities: how much of a polluting substance is released and how big a volume of water it is released into. A small quantity of a toxic chemical may have little impact if it is spilled into the ocean from a ship. But the same amount of the same chemical can have a much bigger impact pumped into a lake or river, where there is less clean water to disperse it.Water pollution is the leading worldwide cause of deaths and diseases, as it accounts for deaths more than 14000 people daily. It is estimated that about one-sixth of the world's people still don't have easy access to safe drinking water and proper sanitation. Over the last century, human population has increased 3 times, global water withdrawal has increased 7 times, and per capita water withdrawal has increased 4 times. With human population increasing rapidly it has resulted in polluting all the water resources of our planet, so much so, precious and unique organisms and ecosystems are being harmed and are even dying at an alarming rate. Thus, water pollution can be defined as the presence of some foreign substances or impurities in water in such a quantity so as to constitute a health hazard by lowering the water quality and making it unfit for use. Offensive odors from rivers, streams etc. ; oily and greasy material floating on the water bodies; Unchecked growth of aquatic weeds in waterbodies;bad taste of drinking water; Decrease of aquatic life in fresh water bodies etc. are some of the noticeable signs of water pollution.

Sources of water pollution

i. Point source

Sources which can be readily identified at a single location (direct discharges from a single point).Some of the examples are industrial discharges, municipal sewage, combined sewer discharges etc. This type of discharges can be controlled easily. (Water pollution caused by these sources can be minimized if the effluents from these sources are controlled, treated up to acceptable levels and disposed off).

ii. Non-point source or diffused sources

Non-point sources are diffused across a broad area and their contamination cannot be traced to a single discharge point(whose location cannot be easily identified).Here the pollutants scattered on the ground ultimately reach the water sources and cause pollution, like run off from agriculture lands, mining area etc. However water pollution caused by diffused sources like agriculture can be controlled by changing the crop patterns and advanced farm management practices (from **Reference 8**).

iii. Natural sources of water pollution

- Rain water
- Atmosphere
- Surrounding vegetation
- Underground rocks and volcanoes
- Natural run-off etc.

are the natural sources of water pollution.

iv. Anthropogenic sources of water pollution

These sources include oil spills, atmospheric deposition, marine dumping, radioactive waste, global warming and eutrophication. Among these, the following are the most important sources that contribute to water pollution.

- **Domestic waste water**

Domestic sewage is the waste water generated from the household activities (residential community) that originates from residential areas, commercial places, institutions and other public places. Generally domestic sewage consists of 99.9% of water and 0.1% of solids. These solids are mostly organic with a small fraction of inorganic matter. Its decomposition produces large quantities of malodorous gases and contains a number of pathogens (harmful micro-organisms).

- **Agricultural waste water**

This is the run-off from the agricultural fields and animal farms and this wastewater is considerably rich in nitrogen, phosphate, organic matter, pesticides. Water bodies enriched with nutrients (nitrogen and phosphate) induce rapid growth of microscopic plant life(algae) in surface waters which lead to algal boom thus reducing the oxygen content in the aquatic environment popularly known as Eutrophication (which is most common in stagnant water bodies such as ponds and lakes).

- **Industrial waste water**

Industrial wastes are the one which results from industrial operations. Each year, the world generates around 400 hundred billion tons of industrial waste, much of which is pumped untreated into rivers, oceans and other water ways. Industrial waste water may have pollutants of almost all kinds ranging from simple nutrients and organic matter to complex toxic substances. The nature and composition of the industrial waste water vary widely from industry to industry, and even for the same industry depending upon raw material, processes, and operational factors

Reasons for water pollution

- **Inorganic salts**

These include Nitrates, Phosphates, Carbonates, Chlorides, Sulphates of Calcium, Magnesium, Iron etc. These salts make water "hard". Hard water increases soap consumption and deposits scales on pipe lines. Iron causes spots and stains on white fabrics. Water bodies enriched with nitrates and phosphates induce rapid growth of microscopic plant life which can lead to algal bloom popularly known as Eutrophication.

- **Acids / Alkalis**

Most fresh water bodies have a natural pH in the range of 6-8. Acids and alkalis are discharged into streams by chemical industry and other industrial plants .High concentrations of acid , sufficient to lower the pH to below 7 causes eye irritation to swimmers , rapid corrosion of ship's hull, and deterioration of fishermen's nets. When the pH of water goes below 5, the fish populations begin to disappear. Also the efficiency of water-treatment plants is affected by acidity. Alkalis appear in wastewater from soap manufacturing, textile dyeing, rubber reclamation, leather tanning etc. High pH is also detrimental to aquatic life.

- **Organic matter**

Organic pollution occurs when large quantities of organic compounds such which act as substrates for microorganisms, are released into water sources. During the decomposition of organic pollutants, the dissolved oxygen in the receiving water may be used up at a greater rate than it can be replenished, causing oxygen depletion. The critical range of dissolved oxygen in water for sustenance of fish life is 3 to 4 mg/L.

- **Suspended solids**

Suspended solids either settle to the bottom or remains suspended in the waterbody.These solids increase the turbidity of the waterbody.Solids that get deposited on the banks decompose and causes odors.

- **Floating matter**

These include oils, greases and other materials which float on the surface, and not only make the river unsightly, but also obstruct passage of light through water. Presence of floating matter hinders the self-purification process of water bodies as well.

- **Thermal discharges**

Increase in the normal temperatures of natural waters is caused binuclear power plant/boiler/industrial discharges. Since warm water is lighter than cold, stratification occurs in the water body, and this causes most of the aquatic life to retreat to stream bottom.Also,bacterial action increases which in turn results in accelerated depletion of the stream's dissolved oxygen content.

- **Coloring materials**

Color in water is an indicator of pollution. Colour interferes with the transmission of sunlight into the stream, thus reducing its natural disinfection action. Colour in water is contributed by the effluents discharged from textile industries, paper mills, tanneries, slaughter houses etc.

- **Toxic chemicals**

Highly complex both organic and inorganic toxic compounds produced by various chemical industries have proved extremely toxic to aquatic life. These include cyanides, sulphides, acetylene, alcohol etc. Many of these have a cumulative effect on the flora and fauna. For example, hexavalent chromium found in wet cement is water soluble and can soak into skin and produce an allergic reaction.

- **Foam producing matter**

Presence of foam producing matter leads to an undesirable appearance of the receiving streams or water bodies which is usually discharged by textile mills, pulp and paper mills, and some chemical plants.

ANNEXURE D

The importance of water

Water is the lifeblood of our planet. It is fundamental to the biochemistry of all living organisms. The planet's ecosystem are linked and maintained by water, and it drives plant growth, provides a permanent habitat for many species (such as 8500 species of fish) and is a breeding ground or temporary home for others, including most of the 4200 species of amphibians and reptiles described so far .Water is always a universal solvent and provides a major pathway for the flow of sediment, nutrients and pollutants. Through erosion, transportation and deposition by rivers, glaciers and ice sheets, water shapes the landscape and through evaporation, it drives the energy exchange between land and the atmosphere, thus controlling the earth's climate. Water covers more than 70 % of earth's surface. It is one of the most precious natural resources. The reason being that 97% of it is salty and therefore undrinkable and further 2% is locked in glaciers and polar icecaps, thus leaving just about 1% of it useful for direct consumption. So water is very important to us. The importance of water in different aspects is as follows:

- **Water in human life**

Water is essential to our life.70% of our body and 90% of blood is water. Similarly, the presence of water in our brain is 95% and in liver is 90%.Water is involved in all bodily functions such as digestion, assimilation, elimination ,respiration, maintaining temperature (homeostasis) integrity and the strength of all bodily structures. An average adult body contains 42 litres of water and with just a small loss of 2.7 litres he or she can suffer from dehydration, displaying symptoms of irritability, fatigue, nervousness, dizziness, weakness, headaches and consequently reach a state of pathology. We cannot live without water.

- **Water in agriculture**

Water plays the most important role in agriculture. Agriculture is impossible without irrigation throughout the crop season. Irrigation ensures proper plant growth.

- **Water for municipal use**

Lifestyle of the inhabitants and their economic conditions affect the water use within the home in different parts of the country.Muncipal demand includes water for domestic purposes, commercial uses

, street washing, lawn and garden irrigation, fire protection. Water in the domestic sector is generally used for drinking, washing toilets, lawn sprinkling and food preparation.

- **Water for industries**

Water is used in huge quantities in the industries like steel industry, chemicals, fertilizers, textiles, cement, electricity, petrochemicals and paper industry etc. These industries require a large amount of water for purposes such as cooling, generation of power, cleaning purposes, fire protection, air conditioning etc.

- **Balancing the ecosystem**

Water is not only important for human beings but also plays an important role to balance the entire ecosystem by various ways:

- By its presence in the atmosphere it absorbs the sun's heat.
- The rainwater scours the hills and carries the sediments into rivers, valleys etc.
- Percolating water into rock crusts takes part in the formation of mineral deposits.
- In Polar Regions, water in the form of the caps influences climatic and geographical changes.
- Through hydro geologic cycle, water from sea and other water sources evaporates into the atmosphere and condenses back into rain.

- **Water for power**

Thermal power plants require large volume of water for the purpose of cooling and the disposal of flyash.Water is used in thermal power generation.

- **Water for fish, wildlife and recreation**

Fish, wildlife and recreation facilities play an important role in nation's life and adequate water supplies for their continued development. Swimming, boating, fishing etc. which are the important outdoor recreational activities are impossible without water.

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