# INTEGRATED STUDY OF PHYSICO-CHEMICAL QUALITY PARAMETERS OF WATER AT LUCKNOW

A thesis submitted
in Partial Fulfilment of the Requirements
for the Degree of

## MASTER OF TECHNOLOGY
**In**

**Civil Engineering**

## (ENVIRONMENTAL ENGINEERING)

**SUBMITTED BY:**

**ARCHNA**

**UNDERTHE GUIDANCE OF**

**KAMAL NABH TRIPATHI**

(ASSISTANT PROFESSOR)

to the

**DEPARTMENT OF CIVIL ENGINEERING**

**BABU BANARASI DAS UNIVERSITY**

**LUCKNOW (INDIA)**
**2019**

# CERTIFICATE

This is to certify that Ms. Archna has carried out his research work presented in this thesis entitled " **INTEGRATED STUDY OF PHYSICO-CHEMICAL QUALITY PARAMETERS OF WATER AT LUCKNOW**" for the award of Master of technology in 'Environmental Engineering' from Department of 'Civil Engineering', BabuBanarsi Das University, Lucknow, under my supervision. The thesis embodies results of original work and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University.

**Mr. Kamal Nabh Tripathi**
Department of Civil Engineering
BabuBanarsi Das University,
Faizabad Road, Lucknow
Date:

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

Water is one of the most significant and rich mixes of the environment. Every single living life form on the earth need water for their endurance and development. Starting at now just earth is the planet having around 70 % of water. In any case, because of expanded human populace, industrialization, the utilization of manures in the horticulture and man-made movement, it is profoundly contaminated with various hurtful contaminants. Subsequently, it is important that the nature of drinking water ought to be checked at ordinary time interim, in light of the fact that because of utilization of polluted drinking water, human populace experiences fluctuating of water borne maladies. It is hard to comprehend the organic marvel completely on the grounds that the science of water delights much about the digestion of the environment and clarify the general hydro - natural relationship.Water pollution is a serious problem in India as almost 70 per cent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities, such as irrigation and industrial needs. This shows that degraded water quality can contribute to water scarcity as it limits its availability for both human use and for the ecosystem. Due to growth of population, agriculture, and industries, demand for domestic water has increased many times during the last few years. Improper waste disposal and over exploitation of resources has affected the quality, not only of tap water, but also of ground water, Industrial waste and the municipal solid waste have emerged as one of the leading causes of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems. Generally, most pollutants are introduced into the environment as sewage, agricultural waste, domestic waste, industrial waste, accidental discharge and as compounds used to protect plants and animals. Pollution occurs when a product added to our natural environment adversely affects nature's ability to dispose it off. A pollutant is something which adversely interferes with health, comfort, property or the environment of the people. Generally, most pollutants are introduced into the environment as sewage, agricultural waste, domestic waste, industrial waste, accidental discharge and as compounds used to protect plants and animals. There are many types of pollution such as air pollution, sound pollution, water pollution, oil pollution and soil pollution. Since last few years, continuously growing population, fast pace of industrialization and the simultaneous techniques of waste disposal have been responsible for the discharge of pollutants into the water bodies, resulting in rapid contamination of water. Moreover, the rate of contamination of water is much faster than the processes of its purification2. The analysis of the physicochemical properties of water, assist in analyzing the structure and functions of water bodies3. The physical, chemical and biological characteristics of water are the decisive factor for defining the suitability or non-suitability of water for consumption, irrigation or industrial uses4,5. Considerable number of researches have been made in this direction, which focus on how anthropogenic activities, mainly agricultural and industrial processes, result into the contamination of groundwater6,7. The industrial effluents and disposed sewage water are the main causes of groundwater contamination. Degradation of groundwater quality initiates from a diffuse source and later on covers a larger area. For instance, the percolation of various chemicals from the agricultural fields, septic tanks, dumping areas, etc., can result in contamination of groundwater aquifers of immense size.

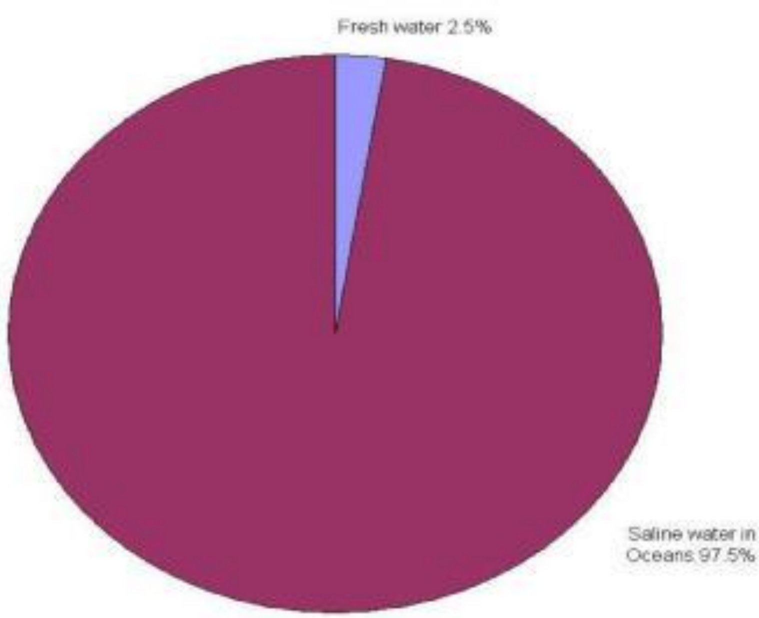


Fig. 1.1

Pollutants such as herbicides, pesticides, fertilizers and chemicals can make their way in to the river through drains of the whole city. This situation is really harmful for those areas where river water is the only source of drinking water; like Lucknow city .In present study we did analysis of different samples of water from different sites

## 1.2 GROUND WATER HYDROLOGY

Natural water is a part of continuing cycle. Atmospheric water condenses and falls to the earth as rain, snow or some other form of precipitation. Once on the earth surface, water flows into the streams, lakes and eventually the oceans or percolates through the soil and into aquifer that eventually discharges into the surface water. Through evaporation from surface water or by evapo-transpiration from plants, water molecule return to the atmosphere to repeat the cycle.

Although the movement through some parts of the cycle may be relatively rapid, complete recycling of ground water must often be measured in geologic time.

Water in nature is most nearly pure in evaporation state. Because the very act of condensation usually requires a surface or nuclei, water may acquire impurities at the very moment of condensation. Additional impurities are added as the liquid water travels through the
remainder of the hydrological cycle and comes into contact with material in the air and on the beneath the surface of the earth. Water is the constant state of motion as depicted in the hydrological cycle shown in fig. 1.1. [39]

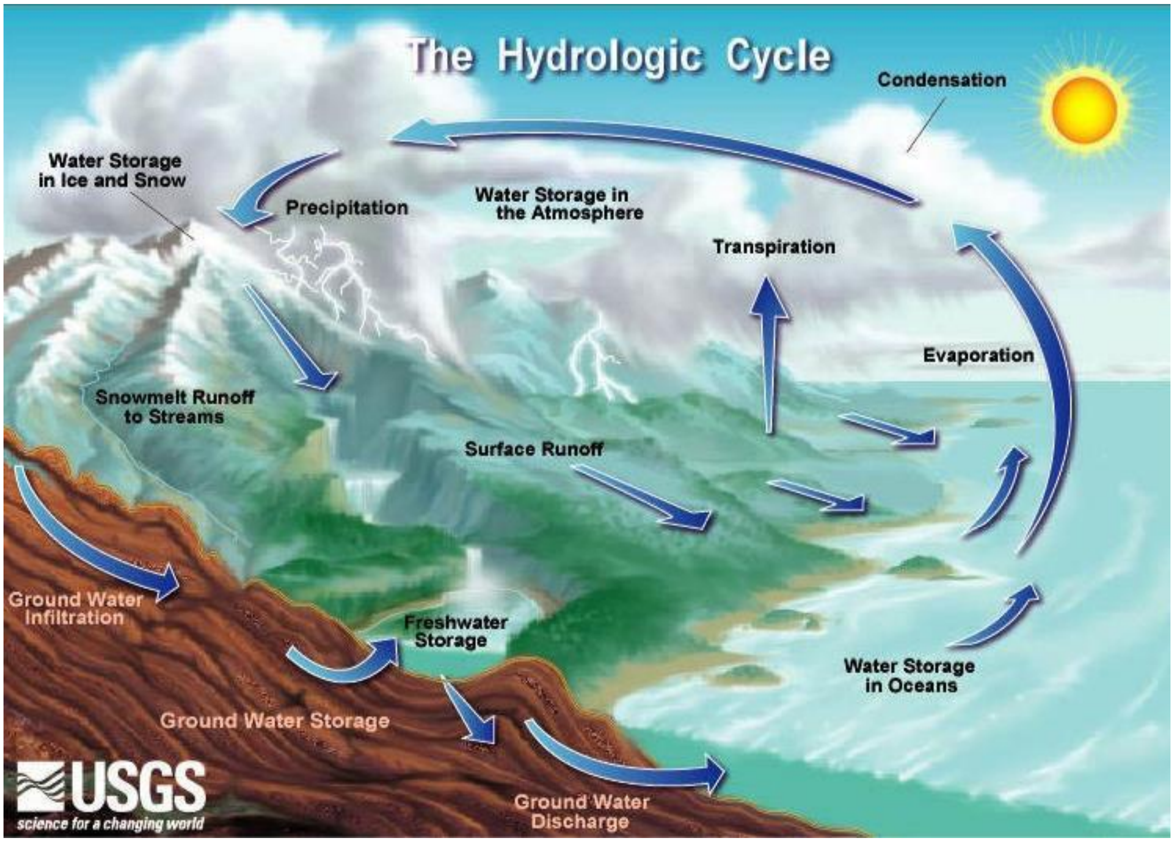


Fig 1.2 Hydrological cycle

## 1.3 WATER POLLUTION AND ITS SOURCE

Water to be utilized for an open inventory must be consumable (drinkable) that isn't containing contamination. Contamination will in general corrupt water quality and establish a peril or weakens the helpfulness of the water.

Because of the expansion of populace and modern development water is getting dirtied at quicker rate. The modern and locally squander with substance get ingested in the dirt and the ground water is dirtied subsequently the individuals were not ready to get unadulterated ground water. Water gets dirtied, inadmissible for use when over weight with any of the accompanying things.

1. **Organic waste:** contributed by domestic sewage and industrial waste of plant and animals origin.
2. **Disease causing agent:** originating in domestic sewage and kind of industrial waste.
3. **Plant nutrients**: this promotes nuisance growth such as algae and water weeds.
4. **Synthetic organic chemical:** such as detergents and pesticides.
5. **Inorganic chemical:** from mining, manufacturing and oil plants operation.

## 1.4 SOURCES OF GROUND WATER CONTAMINATION

As water moves through the hydrological cycle, its quality changes in response to difference in the physical, chemical and biological environments. Therefore the sources of ground water contamination are as follows.

### 1.4.1 Ground water contamination from land/ surface:

#### 1.4.1.1 Land disposal of either solid or liquid waste:

The major causes of ground water pollution is due to the liquid and solid waste material which goes directly onto the land surface e.g. manure sludge , garbage and industrial waste. The waste may occurs as industrial mounds or it may be spread out over the land. If the waste material contains soluble product they will infiltrate the land and lead to ground water pollution.

#### 1.4.1.2 Infiltration of polluted water:

They yield of many wolls tapping standards achieve to sustain by infiltration surface water. As the induced water migrates through ground a few substances are diluted or removed by filtration and absorption. This is especially true when the flows through the materials such as those that occur in carbonate aquifers and many pollutants for example chloride, nitrates and many organic compounds move freely with the water and are removed by filtration.

#### 1.4.1.3 Fertilizer and Pesticides:

Increase amount both fertilizer and pesticides area being used in the whole world each year. Many of these substances are highly toxic and many cases quit mobile in sub surface. Many compounds however become quickly attached to fine grained sediment such as organic matter clay and silt particle. A part of this attached material is removed by surface run off. In many heavily polluted areas the infiltration of nitrate, a decomposition product of ammonia fertilizer has greatly polluted ground water. The consumption of nitrate rich water lead to a serious diseases commonly known as blue babies.

#### 1.4.1.4 Animal feedlots:

Animals feed to cover relatively small areas but provide a large volume of animals waste. These wastes have polluted the land surface and ground water. Even small feedlot etc. has created significantly problems. In a few areas the liquid off from feed is collected in lined basins and pumped onto adjacent grounds as irrigation water. This is providing a growth to the corps grown.

### 1.4.2 Ground water quality problem that originates in the ground above the water table:

Many different types of materials are stored, contracted, or disposed of in the ground above the water table.

#### 1.4.2.1 Septic Tanks, Cesspools, and privies:

The major cause of ground water pollution is effluent from septic tank, cesspools, and privies. These devices are important and occur in every area not served by municipal or privately owned sewage treatment system. The area that each point source affects is generally small, since quantity of effluent is small.

#### 1.4.2.2 Holding Ponds and Lagoons:

The second major source of ground water pollution is holding ponds and lagoons. These ponds and lagoons commonly consist of relative shallow excavation that range in surface area from a few square feet to many acres. These ponds also used to store municipal sewage as well huge quantities of wastes including industrial, chemical, characterized by high solution that may contain toxic compounds.

### 1.4.2.3 Sanitary Landfills:

Sterile landfills by and large are developed by setting waste in unearthings and covering the material day by day with soil. Subsequently the tern 'clean' to show that trash and different materials are not left presented to create scents or smoke or draw in vermine and creepy crawlies. Indeed, even through a landfill is secured, anyway leachate might be created by the invasion of precipitation and surface run off. In this way, numerous substance are expelled from the leachate as it channels the unsaturated zone, however leachate may dirty ground water and even streams in the event that it release at the surface.

### 1.4.2.4 Waste disposal in Excavation:

After the removal of clay, limestone sand, and gravel, or other material, the remaining excavation is traditionally left unattended and often is used as unregulated slumps. The quantity and variety of materials placed in dumps and excavation are almost limitless. Excavation also have been used for the disposal of liquid waste, such a oil-field brines and spent, acids from steel mill operation. Many other excavations serve as disposal sites for snow removal from surrounding streets. Disposal of these and waste may lead to ground water pollution.

### 1.4.2.5 Artificial Recharge:

Artificial recharge includes a variety of techniques used in increase the amount of water infiltrating an aquifer. Water used for additional recharge consists of storm runoff, excess irrigation water, stream flow, cooling water and treated sewage effluent, among others. Obviously the quality of water artificially recharge can have deleterious effect on the water in the ground under certain condition.

### 1.4.3.1 Well disposal of Wastes:

For decades, man has disposed of liquid wastes by pumping them into wells. Since Second World War a considerable number of deep well injection proposals have come into the existence, usually at industrial sites. The disposal of highly toxic wastes into these wells leads to several water pollution problems. These problems are caused by the pollution of fresh water due to direct injection in to the aquifer as well as leakage of pollutants from the well head, through the casing or via fractures in confining beds.

### 1.4.3.2 Drainage Wells and Canals:

Where surficial material consists of heavy clay, flat-lying land may be poorly drained and contain an abundance of marshes and ponds. Drainage of this type on land is generally accomplished with fields' tiles and drainage wells. Drainage well is merely a vertical, cased hole in the ground or in the bottom of a pond that allows the water to drain into the pond more permeable material in the pond. Water may be polluted which in turn leads to decrease the water quality in the receiving aquifer.

Depending of stream channels may lower the water table. Where the fresh salt water interface lies at shallow depths, lowering of the water table (whether by channelization, pumping or other causes) may induce up and migrating with saline water. Under these circumstances, reduction of the depth of fresh water and a result in a rise in the level of saline water several times greater than the distance the fresh water level lowered.

**1.4.3.3 Mines:**

Mining has caused a variety of water pollution problems. Pumping of mine waters to the surface, by leaching of the spoil material, by waters naturally, causes these problems. Highly corrosive mineralized water originating from mines and dumps have already polluted a large volume of ground water in eastern regions of India.

**1.4.4.4 Natural controls on ground water contamination**

There are four major natural controls involved in shallow ground water.

The first control includes the physical characteristics of the earth materials through which the liquid wastes flows. A major attenuating effect for many compounds is the unsaturated zone which has been caved the ‘living filter’.Many chemical and biological reactions in the unsaturated zone lead to contaminant degradation, precipitation, absorption and oxidation. The mineral content of the medium probably becomes more important because various clays, hydroxides and organic matters take up some of the contaminants by exchange or absorption.

In second major control includes the natural contaminants flows through the subsurface from the areas of points of recharge to zones or points of discharge. These processes include filtration, absorption, ion exchange, dispersion, oxidation and microbial degradation as well as dilution.

The third natural control is the hydraulics of the flow system through which the waste migrates, beginning with infiltration with discharge. The contaminants may enter an aquifer directly by flowing through the unsaturated zone, by interaquifer leakage, by migration in the of saturation or by flow through open holes.

The final control includes its physical, chemical and biological characteristics and particularly its stability under varying conditions.

### 1.4.4.5 STUDY AREA

River Gomti flows through a vast stretch with numerous small and big tributaries and forms a great river before joining the river Ganga at UdyarGhat near Jaunpur district. The water is mainly used for drinking purpose. Irrigation is also an important aspect of this river water. Five water samples from Five different locations were selected from upstream to downstream and analyzed to access the bacteriological pollution in river Gomti, during three seasons and two years. The sampling location description of river Gomti is given below:

1) Sample 1- Gomti river water Gomti barrage.
2) Sample 2- Gomti river water from Gaughat .
3) Sample 3-Gomti river water from Neemsar.
4) Sample 4-Gomti river water from Mohan Meankin.

**Sample 1- Gomati river water Gomti barrage**

The Gomti, a monsoon- and groundwater-fed river, originates from Gomat Taal (formally known as Fulhaarjheel) near MadhoTanda, Pilibhit, India. It extends 960 kilometres (600 mi) through Uttar Pradesh and meets the Ganges near Saidpur, Kaithi, 27 kilometres (17 mi) from Varanasi district It meets a small river, the Gaihaaee,20 kilometres (12 mi) from its origin. The Gomti is a narrow stream until it reaches MohammadiKheri, a tehsil of Lakhimpur Kheri district (about 100 km from its origin), where it is joined by tributaries such as the Sukheta, Choha and Andhra Choha The river is then well-defined, with the Kathina tributary joining it at Mailani and Sarayan joining it at a village in Sitapur district. A major tributary is the Sai River, which joins the Gomti near Jaunpur. The MarkandeyMahadeo temple is at the confluence of the Gomti and the Ganges. After 240 kilometres (150 mi) the Gomti enters Lucknow, meandering through the city for about 12 kilometres (7 mi) and supplying its water. In the Lucknow area, 25 city drains pour untreated sewage into the river. At the downstream end, the Gomti barrage converts the river into a lake. In addition to Lucknow, Lakhimpurn Kheri, Sultanpur Kerakat and Jaunpur are the most prominent of the 15 towns in the river's catchment basin. The river cuts the district and Jumper in

Half, becoming wider in the city.

**Sample 2- Gomti river water from Gaughat**

This study was aimed to determine the current status of river Gomti along the Lucknow stretch

. Physico-chemical characteristics, level of organic matter, various heavy metals and sewage pollution and their variation has been studied from upstream to downstream of Lucknow

. Gaughat is upstream region and Pipraghat is downstream of Lucknow. The samples are taken

. from upstream to downstream regions of the river. Water samples are subjected to analysis like Total Solids, Total Dissolved Solids, Total Suspended Solid, Conductivity, pH, COD, BOD and DO. Study concluded that large number of drains are responsible for pollution in river Gomti that enter directly into the river carrying untreated industrial and domestic waste. Some othe causes are like removal of solid wastes at pumping stations is still manual, sometimes pumping station does not work ,so the sewage waste is by passed directly to the river Gomti or when most of the branch and trunk sewers do not function properly. Study indicates that the water quality has been deteriorated Gaughat to Pipraghat due to discharge of untreated waste water from about 26 major drains in its entire course. Water of the river Gomti at upstream of Lucknow i.e. Gaughat showed minimum BOD and maximum dissolved oxygen. But due to the presence of 26 drains dissolved oxygen level decreases along its stretch and showed minimum DO at Pipraghat


**Fig.2.1. Map of Gomti River bairaj (Lucknow)**

# CHAPTER 2

## 2.2 LITERATURE REVIEW

The various technical research paper on the assessment of water quality for lake, river, sea and different areas have been presented at research level for the study. These papers are presented below. Bhagat S. Chauhan, S. K. Sagar [03] has studied, in present investigation an attempt was made for assessment of physical chemical parameter and quality of Water at Lucknow (India). The Physico-Chemical parameter were studied and analyzed for the period of one year i.e. July 2017 to June 2018. Various physico-chemical parameters such as water temperature, water colour, Turbidity, free ammonia, Total dissolved solid, pH, Dissolved oxygen, Free CO2, Total hardness, total alkalinity, chlorides, BOD, Nitrates, Phosphates, Sulphates were studied. The results revealed that there was significant seasonal variation in some physicochemical parameters and River water was moderately polluted in Gomti Barrage area. On the basis of primarily study, it was apparent that water was not potable but can be used for propagation of wildlife, fisheries and irrigation. Five samples collected from Five locations along the area. Study area during the months June, August, and October respectively. During present study some physical and chemical properties were determined. The measurement of temperature, pH and TDS were taken in the field. Immediately after the collection of samples, using a portable water quality analyzer, Chlorides, Total hardness, Ca, Total alkalinity. It is believed that continued pollution of the water sources by various human activities may lead to any health problem to human. Mishra and Mishra (2008) carried out physico-chemical studies on the river Gomti and observed that the high concentration of DO

BOD, COD and MPN were noticed in water and concentration of these parameters increased

from 2006 to 2008, while DO was found below the detectable limit. COD and TDS value were also observed to increase day by day due to increase in quantity of dustrial effluents and sewage being discharged in the river, the level of DO also falling rapidly due to increase in BOD and COD Singh et al. (2005) carried out a study on a 630 km stretch of river Gomti, to study the distribution of heavy metals in sediments and the partitioning of their chemical species between five geochemical phases (exchangeable fraction, carbonate fraction, Fe/Mn oxide fraction, and organic fraction) using Tessie's analytical sequential extraction technique most fractions in the sediments associated with the carbonate and the exchangeable fractions were between 11 and 30% except in a few cases where it was more than 50%. According to the Risk Assessment Code (RAC), the sediments having 11–30% carbonate and exchangeable fractions are at medium risk. The concentrations of cadmium and lead at mid Lucknow, Pipraghat, Sultanpur U/S and Sulthanpur D/S are between 31 and 50%. They thus pose a high risk to the environment. Since the concentrations of cadmium and lead at Neemsar (Cd 56.79%; Pb 51%)

are higher than 50%, the RAC as very high. In most cases, the average metal concentrations were Lower than the standard

### 2.2.1 Md. J. B. Alam, [3]M. R. Islam,[1]Z. Muyen , [1]M. Mamun, [2]S. Islam(2007)

Water samples have been collected from a part of Surma River along different points and analyzed for various water quality parameters during dry and monsoon periods. Effects of industrial wastes, municipal sewage**,** and agricultural runoff on river water quality have been investigated. The study was conducted within the Chattak to Sunamganj portion of Surma River, which is significant due to the presence of two major industries- a paper mill and a cement factory. The other significant feature is the conveyors that travel from India to Chattak. This study involves determination of physical, biological and chemical parameters of surface water at different points. The river was found to be highly turbid in the monsoon season. But BOD and fecal coliform concentration was found higher in the dry season. The water was found slightly acidic. The mean values of parameters were Conductivity 84-805µs; DO: dry-

5.52 mg/L, monsoon-5.72 mg/L; BOD: dry-1 mg/L, monsoon-0.878 mg/L; Total Solid: dry-149.4 mg/L, monsoon-

145.7 mg/L. A model study was also conducted and values of different model parameters were estimated.

### 2.2.2 Basavaraja Simpi, S.M. Hiremath, KNS Murthy, K.N. Chandrashekarappa, Anil N Patel, E.T.Puttiah (2010) :

This Paper deals with the Physico - chemical Parameters of Hosahalli Water Tank in Shimoga District, Karnataka. Monthly Changes in Physical and Chemical Parameters Such as Water Temperature, Turbidity, Total Dissolved Solids, pH, Dissolved Oxygen, Free Carbon dioxide and Total Hardness, Chlorides, Alkalinity, Phosphate and Nitrates were analyzed for a periods of one year from 1st January 2007 to 31st December 2007. All Parameters were within the permissible limits. The results indicate that the tank is Non-polluted and can be used for Domestic, Irrigation and Fisheries

### 2.2.3 M. N. Uddin[1], M. S. Alam[2], M. N. Mobin[3] and M. A. Miah[3](2011)

River water quality is a key concern as it is used for drinking and domestic purpose, irrigation and aquatic life including fish and fisheries. The Jamuna River is one of the most prominent central rivers in Bangladesh as well as it represents the tapestries line of our riverine country. The river can play a vital role to contribute social economic structure of development as a developing country like Bangladesh. The study was conducted to assess the physical and chemical water quality parameters of Jamuna River. The water samples were collected in plastic container of 2 liters capacity from five different geographic locations along the river in 2012-2013 during both dry and wet season. And 25 numbers of samples were collected from surface and 2 feet below from the surface of water at different selective sampling points. A number of physiochemical water quality parameters including Temperature, pH, EC, TDS, DO, BOD, COD, Nitrate ($NO^{2-}$ and $NO^{3-}$), Ammonia, Sulphates, Chlorides, and Calcium were measured in laboratory base analysis. The mean value of such respective parameters in both season were compared with the water quality standards as set by the EQS guideline, ADB, and the guideline of Department of Environment (DoE) in Bangladesh.

### 2.2.4 M. Prasad[1]*, B. Muralidhara Reddy[2], M. Ramakrishna Reddy[1] and V. Sunitha[2](2012)

Groundwater constitutes an important source of water for drinking, agriculture and industrial production. The use of groundwater has increased significantly in the last decades due to its widespread occurrence and overall good quality. Physical and chemical constituents are useful in deciding water use strategies for various purposes. The present study deals with the ground water quality in Obulavaripalli Mandal of YSR (Kadapa)

District, Andhra Pradesh, India. The study area lies in the Southeastern part of YSR (Kadapa) District, Andhra Pradesh and is located in the Survey of India Toposheet No s 57 N/4, N/8 O/1 and O/5 lying between e $79^0$ 06 09 - $79^0$22 16 longitudes and N$13^0$ 48 50 - $14^0$ 09 13 latitudes. Geologically the study area consists of shales/phyllites, limestone and quartzite formations. A total of 27 samples was collected from bore wells and surface as well, in the month of September 2014. Deviations were observed by some groundwater samples in the study area. The correlation coefficients were calculated for water quality assessment. Assessment of water samples from various methods indicated that groundwater in the study area is not suitable for drinking purposes, and the TDS, EC TH and fluoride concentrations were exceeding the permissible limits for human consumption, as per the standards of WHO.

### 2.2.5 Devendra Dohare[1], Shriram Deshpande[2] and Atul Kotiya[3](2013)

Due to human and industrial activities the ground water is contaminated. This is the serious problem now a day. Thus the analysis of the water quality is very important to preserve and prefect the natural eco system. The assessment of the ground water quality was carried out in the different wards of Indore City. The present work is aimed at assessing the water quality index (WQI) for the ground water of Indore City and its industrial area .The ground water samples of all the selected stations from the wards were collected for a physiochemical analysis. For calculating present water quality status by statistical evaluation and water quality index, following 27 parameters have been considered Viz. pH, color, total dissolved solids. electrical conductivity, total alkalinity, total hardness, calcium, chromium, zinc, manganese, nickel. The obtained results are compared with Indian Standard Drinking Water specification IS: 10500-2012. The study of physico-chemical and biological characteristics of this ground water sample suggests that the evaluation of water quality parameters as well as water quality management practices should be carried out periodically to protect the water resources.

### 2.2.6 Divya Bhardwaj and Neetu Verma(2014)

Water is a limited natural resource. Therefore, preserving water is very important for protection of our environment [1]. Various water quality monitoring systems have been developed to measure concentration of the constituents in quantity for characterisation of water for different uses [2]. Water quality can be estimated through quality index which in turn is analysed through various parameters such as pH level, Turbidity, Dissolved Oxygen, Conductivity etc. This paper addresses the impact of parameters on water quality index [3]. Moreover, the paper also depicts how water can be utilised based on various values of parameters.

A Water Quality Index (WQI) is a measure by which water quality can be estimated for various purposes [4]. WOI can be used to predict whether the water is suitable for drinking purpose, industrial purpose or aquatic organisms etc. WQI can be measured on the scale 0 to 100.

**2.2.7 SS Sagar, RP Chavan, CL Patil, DN Shinde, SS Kekane(2015)**

Due to increase population, advanced agricultural practices, industrialization, man- made activity, water is being highly polluted with different contaminants. Water is a vital resource for human survival. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know details about different physico-chemical parameters such as colour, temperature, Total hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity used for testing of water quality.

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. As of now only earth is the planet having about 70 % of water. But due to increased human population, industrialization, the use of fertilizers in the agriculture and man-made activity, it is highly polluted with different harmful contaminants. Therefore, it is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varying of water borne diseases. It is difficult to understand the biological phenomenon fully because the chemistry of water revels much about the metabolism of the ecosystem and explain the general hydro - biological relationship[1].

Water pollution is a serious problem in India as almost 70 per cent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities, such as irrigation and industrial needs. This shows that degraded water quality can contribute to water scarcity as it limits its availability for both human use and for the ecosystem. Due to growth of population, agriculture, and industries, demand for domestic water has increased many times during the last few years. Improper waste disposal and over exploitation of resources has affected the quality, not only of tap water, but also of ground water (V. Nigam 2013)

Industrial waste and the municipal solid waste have emerged as one of the leading causes of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems.(Gupta-2009) Generally, most pollutants are introduced into the environment as sewage, agricultural waste, domestic waste, industrial waste, accidental discharge and as compounds used to protect plants and animals. Pollution occurs when a product added to our natural environment adversely affects nature's ability to dispose it off. A pollutant is something which adversely interferes with health, comfort, property or the environment of the people. Generally, most pollutants are introduced into the environment as sewage, agricultural waste, domestic waste, industrial waste, accidental discharge and as compounds used to protect plants and animals. There are many types of pollution such as air pollution, sound pollution, water pollution, oil pollution and soil pollution

**2.2.8 Arivoli Appavu[1], Sathiamoorthi Thangavelu[2], Satheeshkumar Muthukannan3, Joseph Sahayarayan Jesudoss[4] and Boomi Pandi[5](2016)** The present study is focused on the determination of physico-chemical parameters, such as temperature, pH, EC, hardness, chlorides, alkalinity, DO, BOD5,COD, phosphate and sulphate of water samples from different sampling points. Increase of pollution concentration indicate an increase in the pollution load due to domestic sewage and industrial effluents and anthropogenic activities and discharge of wastes to the discharge into river at Erode district. In the present study water samples were collected from the whole city was divided in four regions for well-organized sampling and interpretation. The results revealed that the average pH value was analyzed as 7.86, Electrical Conductivity was 920 µS/cm$^{-1}$, parameters include Total Solids 1580 mg/l, Total Dissolved Solids 1004 mg/l, total suspended solids was 690 mg/l, total hardness was 340 mg/l, chloride was 380 mg/l, dissolved oxygen was 5.59 mg/l, BOD5 was 38 mg/l, COD was 304 mg/l, phosphate was 6.0 mg/l and sulphate was 60 mg/l of the river water sample. Therefore the study revealed that how the Cauvery river water is contaminated by effluents from small scale industries and dumping of wastages from markets and domestic use wastages.So waterquality management is urgently required to achieve the water quality standards determined by WHO.Correlation coefficient showed highly significant positive and negative relationship.

# CHAPTER 3

# METHODOLOGY

## 3.1 PHYSICAL WATER QUALITY PARAMETERS

The physical characteristics of water are assessed in terms of colour, odour, temperature, solid and taste. Quantative or qualitative measurement of these characteristics is necessary for the determination of water quality.

### 3.1.1 SOLIDS:

The solids found in water typically include silt and clay from riverbanks or lake bottoms and organic matter and microorganism from natural or anthropogenic sources. Solids can be classified by their size, state, chemical characteristics and by their size distribution. On the basis of size, solids can be classified as non-volatile or volatile on the basis of their chemical characteristics.

Solids aesthetically displeasing and provide adsorption sites for chemical and biological agents. The removal of solids is of great concern in the production of clear safe drinking water, in the process industries and wherever a water of high quality is required.

### 3.1.2 TURBIDITY:

Clarity is the first thing that is noticed about water. Turbidity is the measure of the extent to which light is either absorbed or scattered and may be present due to erosion of colloidal material from soil, vegetable fibers, micro organism etc. turbidity measurement is very useful in defining drinking water quality as turbid water apart from giving an unpleasant look, also interferes with various unit operations involved in water treatment.

### 3.1.3 TEMPERATURE

Temperature, one of the most important parameters in natural surface water system affects a number of important water quality parameters. Chemical and biochemical reaction rates increases with increases in temperature. While the solubility of gases decreases with increases in temperature, the temperature of surface water governs to a large extant the biological species present and their rate of activity.

### 3.1.4 ODOUR:

Odours associated with water originate from the presence of decaying organic matter or in case of mineral spring, the reduction of sulphates to H2S gas by bacteria. Odour may also rise due to presence of microorganisms. In general odour wise most commonly be found in surface water as decaying organic matter may accumulates in bottom deposits large enough to provide suitable condition for the anaerobic bacteria that produces gases. Sources of organic include plant debris, dead animals and microorganism and waste water discharges. Consumers find odour aesthetically displeasing and may prefer to use tasteless, odourless water. Odour produced by organic substances may pose more than a problem of simple aesthetics, since some of those substances may be carcinogenic.

### 3.1.5 COLOR:

Pure water is colorless but water may become colored as a result of colloidal suspension. However many of the colors associated with water are not true color. True colors results from dissolved materials most often organics.

Most colour in natural water results from dissolved tannins extracted from decaying plant materials. Many industrial wastes are colored and if not properly treated can impact color to the receiving streams. Colored water is not aesthetically accepted. Moreover highly colorwater is unsuitable for laundering, dying, papermaking, beverage manufacturing, dairy production and other food processing, textiles and plastic production.

## 3.2 CHEMICAL WATER QUALITY PARAMETERS

### 3.2.1 HYDROGEN ION CONCENTRATION (pH):

The pH value of water is measure of its alkalinity or acidity. More accuracy sated the pH is a measure of the hydrogen ion concentration in water. Mathematically this is the logarithm to the base 10 of reciprocal of the hydrogen ion concentration of pure water. Thus a pH value of 7 indicates neutral solution, neither alkaline nor acidic. A pH less than 7 indicates an acidic solution indicates the presence of carbonate of calcium and magnesium and a pH value of 8.5 or above usually indicates appreciable exchargeable solution.

### 3.2.2 ELECTRICAL CONDUCTIVITY

Electrical conductivity is the measure of mineralization of water and thus indicative of the salinity of the ground water. A conductivity measurement is an excellent indicator of the total dissolved solids in water. The unit of conductivity is micro mhos/cm. the factor may be lower than 0.55 for water containing a lot of free acid or higher then 0.70 for highly saline water. The electrical conductivity with 400micro mhos/cm at 25 $^{O}$C is considered suitable for human consumption.

### 3.2.3 TOTAL DISSOLVED SOLIDS

The material remaining in the water after filtration for the suspended solids analysis is considered to be dissolved. Dissolved solids are the term generally associated with fresh water system and consists of inorganic salts, small amount of organic matter and dissolved material. The principle organic anions dissolved in water include the carbonates, chlorides, sulphates and the principle cations are sodium, potassium, calcium and magnesium. Excessive dissolved solids are objectionable in drinking water because of possible physiological effects, unpotablemineral tastes. The water with TDS less then 600mg/l is considered good for drinking purposes and water TDS more than 1200mg/lbis considered un potable, [40].

### 3.2.4 ALKALINITY

Alkalinity is defined as the quantity of ions in water that will react to neutralize hydrogen ions. Alkalinity is most entirely due to bicarbonate and carbonate and hydroxide ions in the water, usually in association with calcium, magnesium, sodium and potassium. Alkalinity can exit in water below the neutral point of PH 7.0. because the relationship between alkalinity, $CO_2$ and PH value.

### 3.2.5 CHLORIDE

The limit of 250 ppm for chlorides in drinking water established (WHO 1904). To some persons this amount is noticeable as imparting a salty or blackish taste to water. On the other hand, some waters with as much as 700 ppm chloride have no noticeable salty taste. There is some indication that these variations depends upon the combination of chlorides with other salts and that chlorides and hardness together may impart a taste when combined content is approximately 400 ppm. Since physiological reaction due to chloride do not occur until much higher concentration, approaching those of sea water, are reached it is obvious that the restriction have been imposed for reasons of portability rather than health.

### 3.2.6 SULPHATE

Sulphates in domestic water contributes the major part of non- carbonate, or permanent hardness, high concentration of sulphate may be because of sodium sulphate and low concentration probably may be because of less oxidation of sulphide to sulphate. Water containing magnesium sulphate at levels 1000 ppm act a purgative in adults while lower concentration may affect new user and children.

### 3.2.7 NITRATE

Nitrate in potable water were not considered of significance except as nitrogenous compounds associated with nitrogen cycle. Use of high nitrates content water in the preparation of food for infants may be responsible for development of cyanosis, or methamoglobinemia, a morbid condition, which involves discoloration of the skin due to changes in the blood. Thus currently, the very high concentration of nitrates in water from wells; apparently due to the nitrification of organic nitrogen in the topsoil have been the object of great concern.

### 3.2.8 FLUORIDE

Fluoride is toxic to humans and other animals in large quantites while small concentration can be beneficial. Concentration of approx. 1.0 mg/l in drinking water helps to prevent dental cavities in children. During formation of permanent teeth, fluoride combines chemically with tooth enamel, resulting in harder, stronger teeth that are more resist to decay excessive dosage of fluoride can also borne fluoris and other skeletal abnormalities.

### 3.2.9 POTASSIUM

Although potassium is one of the abundant elements, potassium salt is of therapeutic value. The treatment of familiar periodic paralysis while no desirable or excessive limits for potassium seems to have been set through 1000-2000 ppm seems to be extreme limits for potassium ion in drinking water.

### 3.2.10 TOTAL HARDNESS

Hardness is defined as the concentration of multivalent metallic cations in solution. At super saturated condition the hardness cations will react with anions in water to form a solid precipitate. Hardness is classified as carbonate hardness and non-carbonate hardness depending upon the anions with which it associates. The hardness that is equivalent to the alkalinity is termed as carbonate hardness, with any remaining hardness being called non-carbonate hardness. Carbonate hardness is sensitive to heat and precipitates readily at high temperature.

### 3.2.11 HEAVY METALS

The term heavy metals refer to any metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations. Living organisms require trace amounts of some heavy metals, including cobalt, copper, manganese, molybdenum, vanadium, strontium and zinc. Excessive levels of essential metals, however, can be detrimental to the organism. Non essential heavy metals of particular concern to surface water systems are cadmium, chromium, mercury, lead and arsenic. Some of these metals are necessary for growth of biological life, and absence sufficient quantities of them could limit growth of algae. The presences of any of these metals in excessive quantities will interfere with many beneficial uses of the water because of their toxicity; therefore it is desirable to measure and control the concentration of these substances. Heavy metals in surface water systems can be from natural and anthropogenic inputs of metals exceed natural inputs. Chemical and physical weathering of igneous and metamorphic rocks and soils often releases heavy metals into the sediment and into the air. Surface runoff from mining operations usually has a low pH and contains high levels of metals such as iron, manganese, zinc, copper, nickel, and cobalt. The combustion of fossil fuels pollutes the atmosphere with metal particulars that eventually settle to land surface. Municipal drains and urban storm water runoff often contains metals from roadways and atmospheric fallout. Currently, anthropogenic inputs of metals exceed natural inputs. Domestic wastewater effluent contains metals from metabolic wastes, corrosion of water pipes, and consumer products, Industrial effluents and waste sludge may substantially contribute to metal loading.

The discharge of electroplating waste, battery waste, the industrial waste involving the washing and finishing of metal sheets and the waste produced in obtaining metals from their ores etc. into the river is responsible for contamination of river water with heavy metals.

Measurement of metals in water is usually made by atomic absorption spectrophotometry. Heavy metal concentration is expressed in mg/L.

### 3.2.12 DISSOLVED OXYGEN

The various gases which may get dissolved in water due to its contact with atmosphere or the ground surface may be nitrogen, methane, hydrogen sulphide, carbon di oxide and oxygen. The concentration of oxygen gas in river water is important. Oxygen gas is generally absorbed by water from the atmosphere; Algae and other tiny plant life of water also give oxygen to the water, but are being consumed by unstable organic matter for their oxidation. Hence, if the oxygen present in water is found to be less than its saturation level, it indicates presence of organic matter and consequently making the water suspicious. Dissolved oxygen is required for the respiration of aerobic microorganisms as well as all other aerobic life forms. However oxygen is slightly soluble in water. The rate of biochemical reactions that uses oxygen levels tends to be more critical in summer because the stream flows are usually lower and thus the total quantity of oxygen available is also lower. The presence of dissolved oxygen in wastewater is desirable because it prevents the formation of noxious odors.The presence of oxygen in water in dissolved form is necessary to keep it fresh and sparkling. Dissolved oxygen is also important to aquatic life because detrimental effect can occur when DO levels drop below 4-5 mg/L, depending upon the aquatic species. Oxygen levels that remain below 1-2 mg/L for few hours can result in fish kills.

### 3.2.13 BIOLOGICAL OXYGEN DEMAND

The extent of oxygen consumed by the organic matter present in water sample is known as Biochemical Oxygen demand (BOD). The BOD of raw water will indicate the extent of organic matter present in the water. If sufficient oxygen is present in water, the useful aerobic bacteria production will flourish and cause the biological decomposition of waste and organic matter, thereby reducing the carbonaceous material from the water. The amount of oxygen required in the process until oxidation gets completed is known as BOD. Polluted waters will continue to absorb oxygen for many months, till the oxidation gets completed and it is not practically possible to determine this ultimate oxygen demand. Hence the BOD of water during the first five days at $20^0$C. The dissolved oxygen is measured after the period of incubation. The difference between the original oxygen content and the residual oxygen content will indicate the oxygen consumed by the water sample in five days. If BOD of water is zero it means that no oxygen is required and thus no organic matter is present. The extent of pollution of sewage and other industrial wastewater is also measured by determining the values of their BOD.

### 3.2.14 CHEMICAL OXYGEN DEMAND

Chemical oxygen demand (COD) is a measure of the oxygen consumed when organic matter is broken down chemically rather biologically. It is measure of non-biodegradable organics present in the waste water. It is a measurement of pollutants in natural and wastewaters to assess the strength of discharged water such as industrial effluent waters and sewage. It is normally measured in both municipal and industrial wastewater treatment plants and gives an indication of the efficiency of the treatment process.

## 3.3 BIOLOGICAL WATER QUALITY PARAMETERS

All natural water support biological communities' .including many organisms that are harmful to humans. The biological characteristics of water, related to the aquatic population of microorganism directly affect the water quality. The most important impacts are the transmission of disease by pathogenic organism in water. Other important water quality impacts include the development of tastes and odours in surface water and ground water and corrosion and biofouling of heat transfer surface in cooling.

### 3.3.1 PATHOGENS

Pathogens are the most important biological organism in water from the view point of human use and consumption of water. Pathogens are the organism capable of infecting and transmitting diseases to humans. Many species of pathogens are able to survive in water and maintain their infections capabilities for a significant period of time. The water borne pathogens include species of bacteria, viruses, protozoa and helminthes.

### 3.3.2 TOTAL COLIFORM AND FECAL COLIFORM

Total coli form and fecal coli form are defined as all grams negative, nonspore-forming bacteria capable of developing red colonies. This heterogeneous group of bacteria has been used as standard indicators of water quality impacted by fecal pollution sources. This was because they were found to be quite numerous in feces of human and animals and survived similarly too many pathogens in the environment. Most of the water borne pathogens is introduced through fecal contamination of water. Thus, any organism native to the intestinal tract of humans and meeting the above criteria would be good indicator organism. The organism most nearly meeting these requirements belong to the fecal coliform group, composed of several strains of bacteria, principle of which is Escherichia cote these organism are found exclusively in the intestinal tract of warm blooded animals and are excreted in large numbers with feces. Fecal coliform organism are non pathogenic and are believed to have longer survival time outside the animal body then do most pathogens. There are other coliform groups, which flourish outside the intestinal tract of animals. These organisms are native to the soil and decaying vegetation and are often found in water that was in recent contact with these materials. Because the life cycles of some pathogens may include period in the soil, this group of coliform also serve as an indicator of pathogens.

## 3.4EFFECTS OF WATER QUALITY PARAMETER ON HUMAN HEALTH

It is essential to ensure that various constituents are within the prescribed limits in drinking water supplies to avoid impact on human health. The main life forms and the domestic animals are affected by alteration in water quality due to natural reasons or anthropogenic reasons.

Table 3.1 Effect of water quality on human health

| **S.No.** | **Parameter** | **Permissible limits** | **Probable effects** |
|---|---|---|---|
| 1 | pH | 7.0-8.5 | Indicative of acidic or alkaline waters, affects taste, corrosivity and the water supply system |
| 2 | TDS in mg/l | 500 | It may cause gastro-intestinal irritation in humans. May have laxative effects particularly upon transits and corrosion, and may damage water system. |
| 3 | Chloride in mg/l | 200 | May be injurious to some people suffering from disease of heart or kidneys. Taste, indigestion, corrosion are affected. |
| 4 | Sulphate in mg/l | 200 | Excess of sulphate in drinking water give rise to gastrointestinal irritation when combined with magnesium or sodium. |
| 5 | Nitrate in mg/l | 4.5 | High levels of nitrate in the drinking water may cause premomethoglobnacmia blue baby syndrome |
| 6 | Fluoride in mg/l | 1 | Excess dosage of fluoride can lead to bone fluorosis and other skeletal abnormalities |
| 7 | calcium in mg/l | 75 | Causes encrustation in water supply system. While insufficiency causes a severe type of rickets, excess causes concentration in the body such as kidney |
| | Magnesium | | High concentration may have laxative effect particularly on new users. Its deficiency is |

| | | | |
|---|---|---|---|
| 8 | mg/l | 30 | associated with structural and functional changes. It is essential as an activator of many enzyme systems. |
| 9 | Hardness as $CaCo_3$ | 200 | Affects water supply system (Scaling) excessive soap consumption, calcification of arteries. |
| 10 | Alkalinity | 200 | In large quantities it imparts a batter taste to water. |

## 3.6 MATERIAL AND METHODS

### 3.6.1 GENERAL

The present study is under taken the residents of the town depend on ground water for their drinking and other domestic and industrial requirements depending upon the water table of the locality. Only those installations are collected for sampling whose water is used for drinking and other household's purposes.

Samples are collected in pre cleaned sterilizes plastic bottles preserved after flushing for about 10 minutes. The samples are brought to the laboratory as soon as possible and analysis is completed within 48 hours to avoid any change in phsyco - chemical characteristics of the water. All the salts used for the preparation of regents and standards are dried at $110^{o}$c for 24 hours before use. Distilled water is used to prepare the reagents, dilution standards and as dilution water and borosil glassware are used throughout this study. Physico - chemical analysis is conducted following the Standard methods. The analyzed parameter are color, odour, Turbidity, TDS, Conductivity, pH, Nitrate, Sulphate, Total hardness, Calcium Hardness, Magnesium hardness, Alkalinity, Fluoride, DO, BOD, COD, Arsenic, Potassium. The parameters are compared with WHO and BIS drinking and household water standards.

## 3.7 REAGENTS USED

### 3.7.1 Ferrous Ammonia Sulphate (FAS)

It was prepared according to the standard method by adding to about 9.80 gram FAS and 5 ml $H_2SO_4$ in 250 ml distilled water.

### 3.7.2 Sulphuric Acid

It was prepared by adding 2.75 gram of and 272 ml of $H_2SO_4$ in 500 ml distilled water. Then it was allowed to stand for one day to dissolve $AgSO_4$.

### 3.7.3 Potassium Dichromate ($K_2CR_2O_7$)

It was prepared by dissolving16.65 gram of $HgSO_4$, 83.5 ml $H_2SO_4$ and 2.45 gram $K_2CR_2O_7$ in 500 ml distilled water.

### 3.7.4 Phosphate Buffer

It was prepared by adding 8.5 gram pot. Hydrogen phosphate, 21.75 gram Di Pot. Hydrogen phosphate, 33.4 gram di sodium hydrogen phosphate and 1.7 gram Ammonium chlorides dissolved in 500 ml distilled water and then dilute with 1litre distilled water.

### 3.7.5 Magnesium Sulphate

It was prepared by adding 22.5 gram Magnesium sulfate in 1 liter distilled water.

### 3.7.6 Ferric Chloride (FeCl)

It was prepared by adding 2 gram FeCl 1 liter distilled water.

### 3.7.7 Calcium Chloride

It was prepared by adding 27.5 gram calcium chloride in 1 liter distilled water.

### 3.7.8 MagnousSulphate ($MnSO_4$)

It was prepared by adding 364 gram $MnSO_4$ in 1 liter distilled water.

### 3.7.9 Alkali Azide

It was prepared by adding 125 gram NAOH Sodium hydrogen pallets, 37.5 gram potassium Iodide and 2.5 gram Sodium Azaid ($NAH_3$) in 250 ml distilled water.

### 3.7.10 Sodium Thiosulphate of 0.025 Normality

It was prepared by adding 6.205 gram in 1 liter distilled water.

### 3.7.11 Starch Indicator

It was prepared by adding 2 gram starch powder and 0.2 gram salicylic acid in 100 ml distilled water.

### 3.7.12 Potassium Chromate

It was prepared by adding 12.5 gram Potassium Chromate in 100 ml distilled water and then after 12 hours filter the solution and add 250 ml distilled water.

## 3.8 METHODS

### 3.8.1 Chemical Oxygen Demand (COD)

i) Take 2.5 ml sample

ii) Add 1.5 ml $K_2Cr_2O_7$ to the sample

iii) Add 3.5 ml Sulphuric acid to the sample

iv) Now put the sample in the oven for at least 1 hour at 150oc

v) Now add 1 drop ferroin indicator to the sample the color of sample change from yellow to light green.

vi) Finally titrate the sample with Ferrous Ammonia Sulphate (FAS)**,** the color changes from light green to blue and finally to brown.

vii) Note down the reading.

### 3.8.2 Biological Oxygen Demand (BOD)

i) Take 5 liter tap water in a bucket and add 5 ml Nutrients viz Ferric Chloride, Calcium Chloride, Phosphate Buffer, Magnesium sulphate and aerated it for about 1 hour.

ii) Take 100 ml sample and add 200 ml diluted water.

iii) Now add 2 ml mangnoussulphate to the solution.

iv) Add 2 ml Alkali Azide in the solution and shake it until the yellow color appears.

v) When the solution is half settle then add 2 ml $H_2SO_4$ and shake it until the clear yellow color appears.

vi) Now take 203 ml sample from the solution and add 2-3 drops starch indicator.

vii) Finally titrate the sample with Sodium Thiosulphate up to the colorless.

vii) Note down the readings.

### 3.8.3 Alkalinity

i) Take 50 ml sample.

ii) Add 2-3 drops Methyl orange indicator the yellow color will appear.

iii) Now Titrate the sample with 0.02 Normality H2SO4. The color changes from yellow to orange.

iv) Finally note down the readings.

### 3.8.4 Hardness

i) Take 50 ml sample.

ii) Add 1ml Ammonia Buffer solution to the sample.

iii) Now add Aero chrome black T to the sample purple color appear.

iv) Finally titrate the solution with E.D.T.A the color changes from purple to blue color.

v) Now note down the readings.

## 3.9 REAGENTS, CHEMICALS & INSTRUMENTS USED

### 3.9.1 Reagents


Fig 3.1 Reagents & Chemicals


**Fig. 3.2 Electrical Conductivity**

**3.9.2 Determination of Electrical Conductivity of the given water samples.**

**Procedure:**

1. Switch on the conductivity meter for 15 minutes.

2. Take out the conductivity cell dipped in distilled water, wash it with distilled water and wipe it dry with a tissue paper.

3. Calibrate the cell with standard 0.1N KCl solution of conductivity 14.12 mhos at 30°C.

4. Take out the conductivity cell, wash it thoroughly with distilled water and wipe it dry.

5. Dip the cell into the sample solution, swirl the solution and wait up to 1 minute for a steady reading.

6. Note down the instrument reading and also temperature by a thermometer. Dissolved minerals, gases and organics may produce aesthetically displeasing colours, taste and odours to water.

2. EC measurements are the basis to evaluate the performance of the processes of desalination, demineralization, distillation and many process plants.

3. Salinity and total dissolved solids can be estimated very quickly from conductivity.

4. If conductivity of a water sample is more than 2000μmhos/cm i.e. if TDS exceeds 2100mg/1, it cannot be disposed off without treatment.

5. If TDS is more, water cannot be used for drinking as well as construction purposes. TDS affects strength and solidity of concrete and palatability of food cooked. It also causes gastro intestinal irritation.

**3.9.3 Determination of pH of the given water samples.**

**Procedure:**

pH ranges: 2 to 4.5; 4 to 6.5; 6 to 9.5; 8.5 to 10.5; 10 to 12.

**Using pH-meter:**

**(i)** Switch on the pH meter for 15 minutes.

**(ii)** After washing and wiping the pH electrode and the temperature probe dip it in a solution of pH 4.0buffer. Change knob from standby to pH.

**(iii)** With the CAL knob set the pH value to 4.0

**(iv)**With a pH 9.2buffer, set the pH value to 9.2 using the SLOPE knob.

**(v)** Repeat steps 2-3 till the pH meter is standardized with respect to both pH 4.0 and 9.2

**(vi)** Take the pH values of the different water samples with the pH meter.


**Fig. 3.3 pH Meter ( Normal Water)**


**3.4 pH Meter ( Sample Of Water)**

**Significance:**

**1.** Knowing pH value is very important parameter for analysis of water/wastewater and its treatment, its suitability for domestic use and for irrigation. Certain chemical and biological processes work only at a particular pH. pH of 6.5 to 8.5 has no direct adverse effect on health. However a lower value below will produce sour taste and higher value above 8.5 a bitter taste. Higher value of pH encourages the scale formation in water heating systems and also reduces the germicidal potential of chlorine. High pH induces the formation of tri-halo-methane which are causing cancer in human beings. According to BIS, water for domestic consumption should have a pH between 6.5- 8.5.

**2.** Corrosion of water mains is the main the main problem associated with acidic waters. Acidic/alkaline waters cannot be used for construction purposes also. If pH is less, algae die, fish cannot reproduce and it causes acidity, corrosion, irritation of mucous membranes, tuberculosis and other health problems in humans.

**3.9.4 Determination of chloride of the given water samples.**

**Procedure:**

1. Take 100 ml of sample in conical flask.

2. Adjust the pH between 7.0 and 8.0 either with sulphuric acid or sodium hydroxide solution.

3. Add 1 ml of potassium chromate indicator to get light yellow colour.

4. Titrate with standard silver nitrate solution till the colour changes from yellow to brick-red.

5. Note the volume of silver nitrate added (A).

6. For better accuracy, titrate 100 ml of distilled water in the same way after adding 1 ml of potassium chromate indicator to establish reagent blank.

7. Note the volume of silver nitrate added for distilled water (B).

**Significance:**

1. Analysis of a water sample is necessary to know whether the sample may be considered as suitable for drinking, construction, hydro-testing and some industrial process or not.

2. Water containing chloride in excess of 250 mg/l is considered to be undesirable for drinking purposes.

3. Chlorides are also corrosive and impart permanent hardness to water. Waters with chloride in excess of 2000 mg/l are not recommended for many construction purposes also.

**3.9.5 To determine the total solids of the given water samples.**

**Procedure:**

1. A clean porcelain dish is ignited in a muffle furnace and after partial cooling in the air; it is cooled in a desiccators and weighed.

2. A 100 ml of well mixed sample (graduated cylinder is rinsed to ensure transfer of all\ suspended matter) is placed in the dish and evaporated at 1000°C on water bath, followed by drying in oven at 1030°C for 1 hour.

3. Dry to a constant weight at 1030°C, cool in a desiccator and weigh.

**Significance:**

1. Total solids determination is used to assess the suitability of potential supply of water for various uses.

2. The pH at stabilization depends on total solids also.

**3.9.6 To determine the total dissolved solids of the given water samples**

**Procedure:**

1. A clean porcelain dish is ignited in a muffle furnace and after partial cooling in the air; it is cooled in a desiccator and weighed.

2. A 100 ml of filtered sample is placed in the dish and evaporated at 1000C on water bath, followed by drying in oven at 1030°C for 1 hour.

3. Dry to a constant weight at 1030°C, cool in a desiccator and weight.

**Significance:**

1. Many dissolved substances are undesirable in water. Dissolved minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odour.

2. Estimation of total dissolved solids is useful to determine whether the water is suitable for drinking purposes, agriculture and industrial processes or not.

3. High concentration of dissolved solids about 3000 mg/I may also produce distress in live stock. In industries, the use of water with high amount to dissolved solids may lead to scaling in boilers, corrosion and degraded quality of the product.

4. Water with higher solids content often has a laxative effect.

5. Refer to experiment on electrical conductivity (EC) also.

Calculation:

$$DO\ (mg/L) = \frac{V_1\ N \times 8 \times 1000}{V_2 - V_3}$$

$$= \frac{3 \times 0.025 \times 8 \times 1000}{400 - 1.43}$$

$$= 1.02 mg/l$$

Where,

DO = Dissolved oxygen

$V_1$ = Volume of titrant ($Na_2S_2O_3$) (ml) N =

Normality of titrant (0.025 N)

$V_2$ = Volume of sample after placing the stopper

$V_3$=Volume of manganous sulphate + alkaline KI solutions added (ml.) 8 = Equivalent weight of oxygen

* To obtain the value of DO in ml/L divide the DO in mg/l by 1.43

**Result:** The dissolved oxygen in sample is ---------1.02.mg/L (Gomti)

2. Calculation:

$$DO\ (mg/L) = \frac{V_1\ N\ X\ 8X\ 1000}{V_2 - V_3}$$

$$= \frac{2X0.025X8X1000}{400 - 1.43}$$

$$=0.6mg/l$$

Where,

DO = Dissolved oxygen

$V_1$ = Volume of titrant ($Na_2S_2O_3$) (ml) N = Normality of titrant (0.025 N)

$V_2$ = Volume of sample after placing the stopper

$V_3$=Volume of manganous sulphate + alkaline KI solutions added (ml.) 8 = Equivalent weight of oxygen

* To obtain the value of DO in ml/L divide the DO in mg/l by 1.43

**Result:** The dissolved oxygen in sample is----------0.6.mg/L **(Gaughat**)

Calculation:

$$DO\ (mg/L) = \frac{V_1\ N\ X\ 8\ X1000}{V_2 - V_3}$$

$$= \frac{3.5 X 0.025 X 8 X 1000}{400 - 1.43}$$

=1.23mg/l

Where,

DO = Dissolved oxygen

$V_1$ = Volume of titrant ($Na_2S_2O_3$) (ml) N =

Normality of titrant (0.025 N)

$V_2$ = Volume of sample after placing the stopper

$V_3$=Volume of manganous sulphate + alkaline KI solutions added (ml.) 8 =

Equivalent weight of oxygen

* To obtain the value of DO in ml/L divide the DO in mg/l by 1.43

**Result:** The dissolved oxygen in sample is--------------1.23.mg/L (**Neemsar**)

Calculation:

$$DO\ (mg/L) = \frac{V_1\ N\ X\ 8\ X\ 1000}{V_2 - V_3}$$

$$= \frac{2.5 X 0.025 X 8 X 1000}{400 - 1.43}$$

=0.8mg/l

Where,

DO = Dissolved oxygen

$V_1$ = Volume of titrant ($Na_2S_2O_3$) (ml) N

=Normality of titrant (0.025 N)

$V_2$ = Volume of sample after placing the stopper

$V_3$=Volume of manganous sulphate + alkaline KI solutions added (ml.) 8 =

Equivalent weight of oxygen

* To obtain the value of DO in ml/L divide the DO in mg/l by 1.43

**Result:** The dissolved oxygen in sample is -------------0.8.mg/L (**mohan)**

### 3.9.7 To determine the total suspended solids of the given water samples.

**Procedure :**

1. A clean gooch crucible is ignited in a muffle furnace and after partial cooling in the air, cool in a desiccator and weigh ($W_1$).

2. Pour 100 ml of well mix sample on gooch crucible or glass fiber filter which is kept on filter flask and apply suction.

3. Wash the gooch crucible with 100 ml of distilled water to remove all soluble salts.

4. Carefully remove the glass fiber filter paper or gooch crucible and dry in an oven at105°C for one hour.

5. Cool in a desiccator and weigh ($W_2$).

6. Ignite gooch crucible in a muffle furnace at 600°C for 15-20 minutes.

7. Cool the crucible partially in air until most of heat has been dissipated and then in adessicator and record final weight ($W_3$).

**Significance:**

1. Suspended solids may be objectionable in water for several reasons. It is aesthetically displeasing and provides adsorption sites for chemical and biological agents.

4. Suspended organic solids which are degraded anaerobically may release obnoxious odours.

5. Biologically active (live) suspended solids may include disease causing organisms.

6. The suspended solids parameter is used to measure the quality of wastewater Influent and effluent and is useful in the analysis of polluted water.

Calculation:

Weight of dry solid + dish – weight of dish
TDS (g/L) =100
Volume of sample taken (ml)

150-45
TDS (g/L) =1000
250

= 420

For determination of total solids, instead of total dissolved solids do not filter

the sample.

**Result:** The total dissolved solids in effluent sample is 420 g/L (**Gomt**i)

Calculation:

Weight of dry solid + dish – weight of dish
TDS (g/L) =100
Volume of sample taken (ml)

170-57
TDS (g/L) =1000
250

= 450

For determination of total solids, instead of total dissolved solids do not filter the sample.

**Result:** The total dissolved solids in effluent sample is 450 g/L (**Gaughat)**

Calculation:

Weight of dry solid + dish – weight of dish
TDS (g/L) =100
Volume of sample taken (ml)

180-25
TDS (g/L) =1000
250

= 623

For determination of total solids, instead of total dissolved solids do not filter the sample.

**Result:** The total dissolved solids in effluent sample is 623 g/L (**Neemser)**

Calculation:

Weight of dry solid + dish – weight of dish
TDS (g/L) =100
Volume of sample taken (ml)

120-25
TDS (g/L) =1000
250

= 385

For determination of total solids, instead of total dissolved solids do not filter

the sample.

**Result:** The total dissolved solids in effluent sample is 385 g/L (**Mohan**)

### 3.9.8 Determination of BOD of the given water samples.

**Procedure:**

**1.** Place the desired volume of distilled water in a 5 liter flask. Aeration is done by bubbling compressed air through water.

**2.** Add 1 ml of phosphate buffer, 1 ml of magnesium sulphate solution, 1 ml of calcium chloride solution and 1 ml of ferric chloride solution for every liter of distilled water (dilution water)

**3.** In the case of the waste waters which are not expected to have sufficient bacterial population, add seed to the dilution water. Generally 2 ml of settled sewage is sufficient for 1000 ml of dilution water.

**4.** Highly acidic or alkaline samples are to be neutralized to a pH of 7.

**5.** Add 2 or 3 ml of sodium thiosulphite solution to destroy residual chlorine if any.

**6.** Take the sample as follows:

Strong wastes: 0.1, 0.5, or 1 %

Settle domestic sewage: 1, 2.5 or 5%

Treated effluents: 5, 12.5 or 25%

River water 25 % to 100%

**7.** Dilute the sample with the distilled water and mix the contents well.

**8.** Take diluted sample into 2 BOD bottles.

**9.** Fill another two bottles with diluted (distilled) water alone.

**10.** Immediately find D.O. of a diluted waste water and diluted water (distilled water).

**11.** Incubate the other two BOD bottles at 200C for 5 days. They are to be tightly stoppered to prevent any air entry into the bottles.

**12.** Determine D.O. content in the incubated bottles at the end of 5 days (120 hours).

**Significance:**

1. BOD test gives an idea of the biodegradability of any sample and strength of the waste.

2. Drinking water usually has a BOD of less than 1 mg/l and water is considered fairly up to

3 mg/l of BOD. When BOD value reaches 5 mg/l, the water is doubtful in purity.

**CALCULATIONS**

1 To determine the value of the BOD in mg/L, use the following formula:

Initial DO = 1.02mg/L

Final DO = 0.69mg/L

Sample size = 100 mL

BOD, mg/L = [(Initial DO - Final DO) x 100]/mL sample

=(1.02-0.69)x100
=33ml ------------------------------1**(Gomati)**

2 To determine the value of the BOD in mg/L, use the following formula:

Initial DO = 0.69mg/L

Final DO = 0.30mg/L

Sample size = 100 mL

BOD, mg/L = [(Initial DO - Final DO) x 100]/mL sample

=(0.69-0.30)x100
=31ml ------------------------------2.**(Gaughat)**

3. To determine the value of the BOD in mg/L, use the following formula:

Initial DO = 1.22mg/L

Final DO = 1.03mg/L

Sample size = 100 mL

BOD, mg/L = [(Initial DO - Final DO) x 100]/mL sample

=(1.22-1.03.)x100
=19ml ------------------------------3**(Neemsar)**

4. To determine the value of the BOD in mg/L, use the following formula:

Initial DO = 0.8mg/L

Final DO = 0.52mg/L

Sample size = 100 mL

BOD, mg/L = [(Initial DO - Final DO) x 100]/mL sample

=(0.8-0.52)x100
=28ml -----------------------------------1**(Mohan)**


Fig. 3.4  BOD Incubator

# CHAPTER 4

## RESULTS AND DISCUSSION

### 3. RESULTS AND DISCUSSIONS

**Table No.3.2**

| **Sampling station/parameter** | **Gomti Barrage** | **Gaughat** | **Neemsar** | **Mohan meakin** |
|---|---|---|---|---|
| Temp. | 18 | 19 | 18 | 18.6 |
| Odour | Odourless | Odourless | odourless | Odourless |
| pH | 7.8 | 8 | 7 | 6.5 |
| Turbidity | 23 | 20 | 19.8 | 20 |
| TDS | 420 | 450 | 623 | 385 |
| Hardness | 160 | 155 | 123 | 161 |
| Chloride | 129 | 135 | 175 | 170 |
| DO | 1.02 | 0.6 | 1.23 | 0.8 |
| BOD | 33 | 31 | 19 | 28 |
| COD | 180 | 155 | 319 | 218 |
| MPN | 4900 | 3900 | 3500 | 4100 |

### 4.1. TEMPERATURE

It is found that the temperature of the water supplied to the hostels, canteens and the institute building are within the permissible limit as per IS:10500. As the result in figure 4.1 shows the temperature of the tap water collected from hall 2, hall 5, HomiBhabha hall of residence, hexagon canteen and institute building during winter.

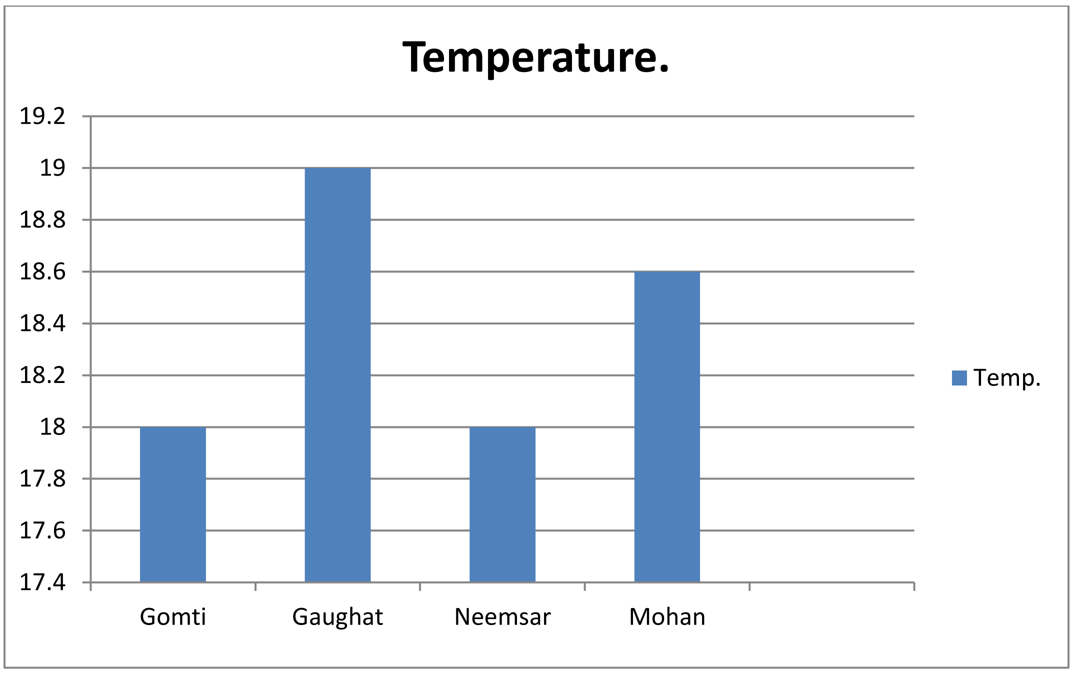


Fig.4.1. Average Temperature of tap water from different areas during winter

### 4.2. pH VALUE

The pH is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It has no direct adverse affect on health, however, a low value, below 4.0 will produce sour taste and higher value above 8.5 shows alkaline taste. A pH range of 6.5 – 8.5 is normally acceptable as per guidelines suggested by ISI. In the present study, the fluctuation of pH in the samples is from 7.32 to 7.53.

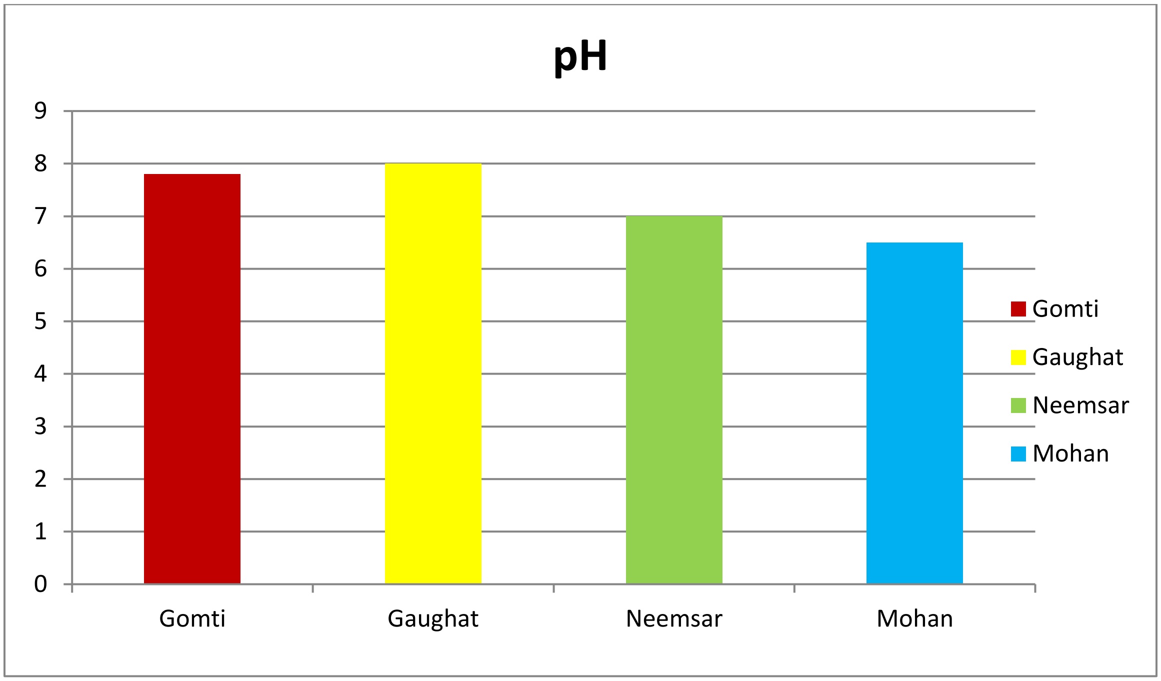


Fig.4.2. Average pH of the water samples from different areas.

## 4.3. TURBIDITY

Measurement of Turbidity reflects the transparency in water. It is caused by the substances present in water in suspension. In natural water, it is caused by clay, silt, organic matter and other microscopic organisms. It ranged from 2.31 to 2.56 NTU. However the prescribed limit of Turbidity for drinking water is 5 NTU (IS: 10500). Turbidity was found within the permissible limit in all the water samples.

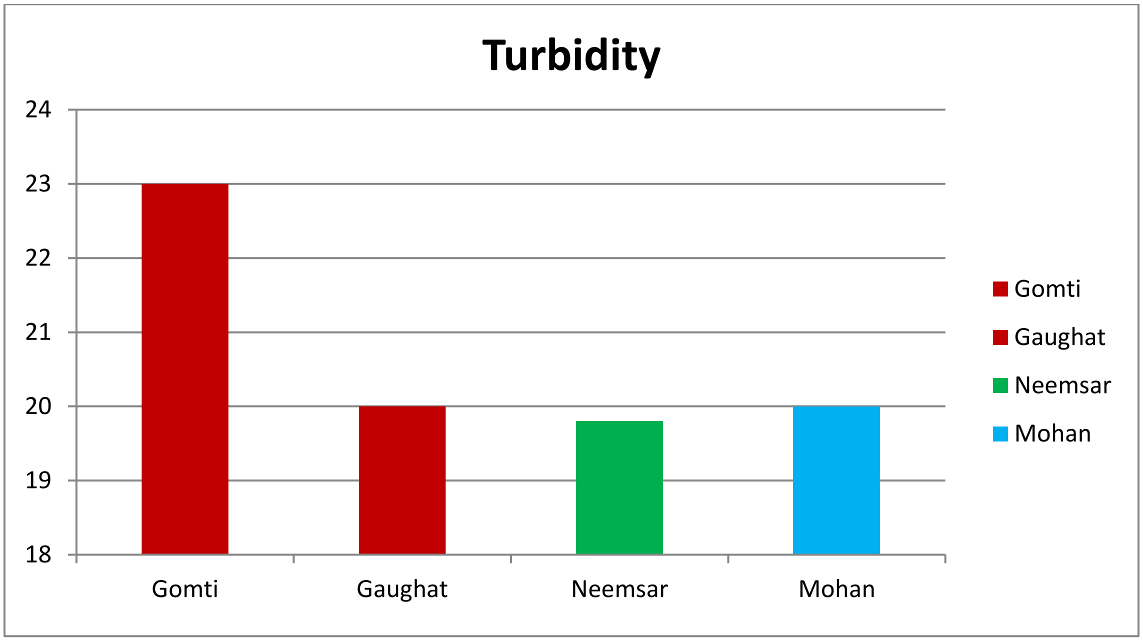


Fig.4.3. Average Turbidity of the water samples from different areas

## 4.4. TOTAL SOLIDS AND TOTALSUSPENDED SOLIDS

Total Dissolved Solids may be considered as salinity indicator for classification of groundwater. The TDS in groundwater is due to the presence of Calcium, Magnesium, Sodium, Potassium Bicarbonate, Chloride and Sulphate ions. In the study area TDS varied from 145 to 175 mg/l. As prescribed limit of TDS for drinking water is 500 mg/l, all the water samples have TDS concentration well below the prescribed limit. Total Suspended Solids in the study area varied from 2.419 to 2.863 mg/l.

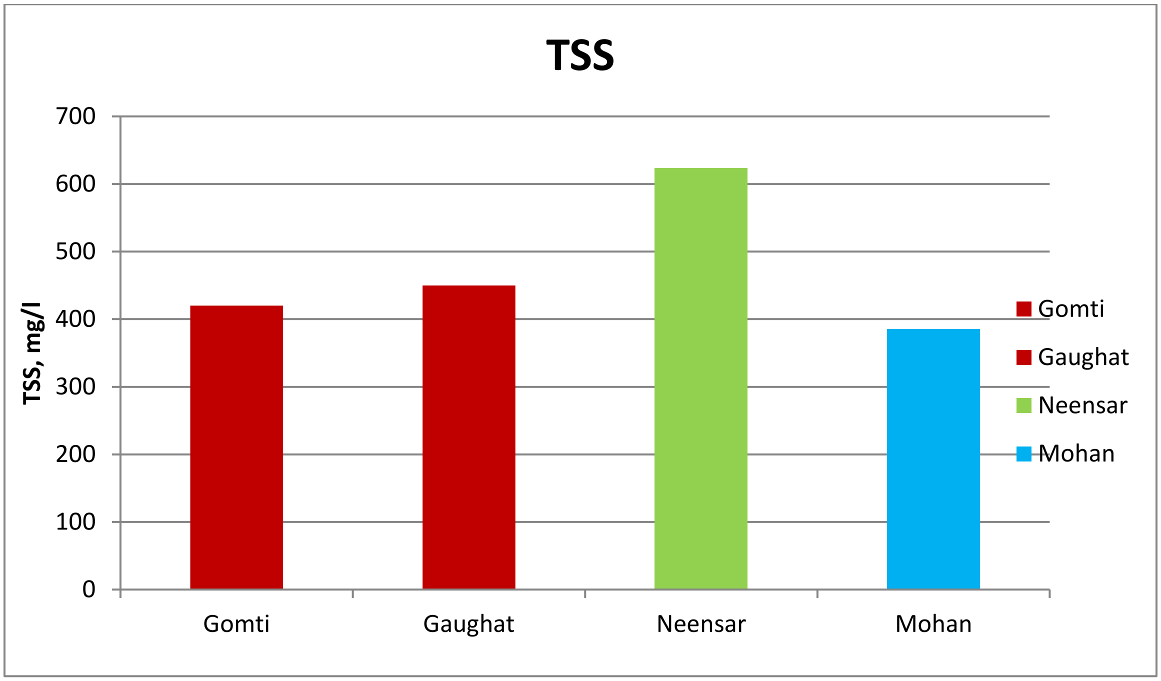


Fig.4.4. (b) Average Total suspended solids of the samples from the different area

## 4.5. TOTAL HARDNESS

Hardness of water is objectionable from the view point of water use for laundry and purposes since it consumes a large quantity of soap. Based on present investigation, hardness varied from 40.2 to 45.2mg/l. However the permissible limit of Hardness for drinking water is 300 mg/l (IS 10500). According to Hardness classification (Durfor and Backer, 1964), the no of water samples of the study area can be classified as given in table 4.1. It is found that the water supplied to the hostels, canteens and institute building is soft

**Table 4.1.Classification of the water according to hardness.**

| TDS Range | Description |
|---|---|
| 0-60 | Soft |
| 61-120 | Moderately hard |
| 121-180 | Hard |
| >180 | Very hard |

**DRINKING WATER STANDARDS (IS: 10500)**

| Sl. No. | Parameters | Permissible value | Standard |
|---|---|---|---|
| 1. | Colour | Unobjectionable | IS: 10500 |
| 2. | Taste | Agreeable | IS: 10500 |
| 3. | pH | 6.5-7.5 | IS: 10500 |
| 4. | Turbidity (Max NTU) | 5 | IS: 10500 |
| 5. | TDS | 500 | IS: 10500 |
| 6. | TSS | 5 | USPHS |
| 7. | BOD | Nil to 5 | USPHS |
| 8. | DO | 4.0 to 6.0 | USPHS |
| 9. | Total hardness | 300 | IS: 10500 |
| 10. | Chloride | 250 | IS: 10500 |
| 11. | Alkalinity | 120 | USPHS |
| 12. | Residual chlorine | 0.2 | IS: 10500 |

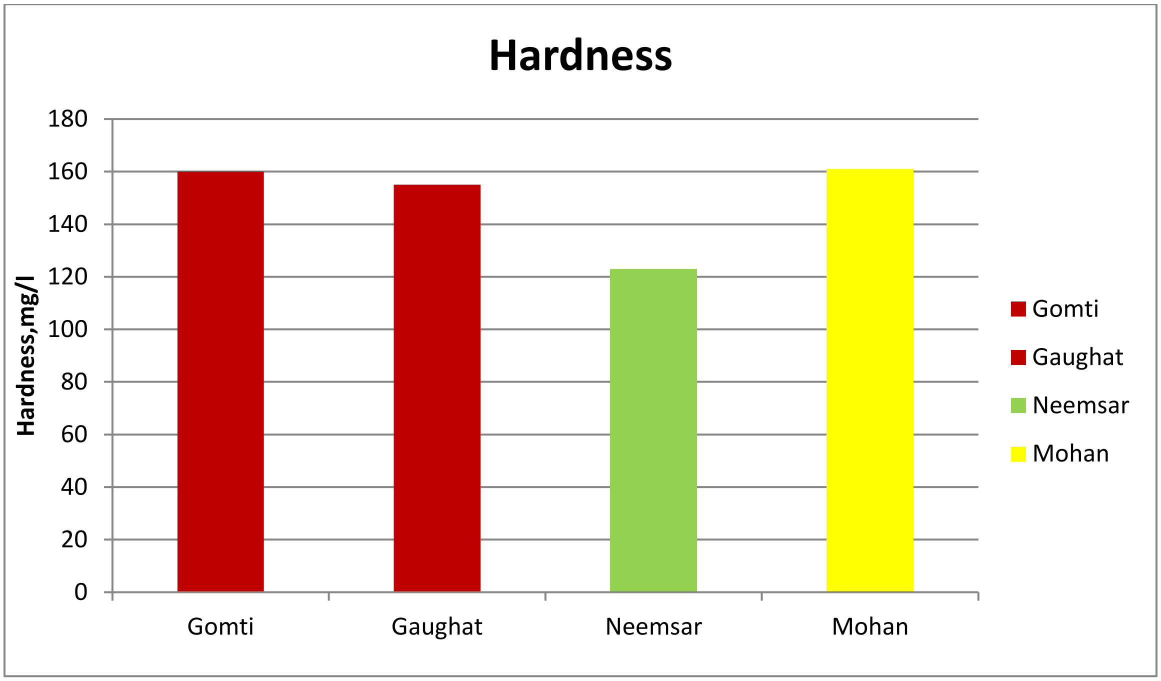


Fig.4.5Average hardness of the water samples from different areas.

### 4.6. BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD gives a quantitative index of the degradable organic substances in water and is used as a measure of waste strength. The low BOD value in all samples showed good sanitary condition of the water. It is found that all the water supplied to the institute is within the permissible limit.(ie;3 to 4 mg/l) .

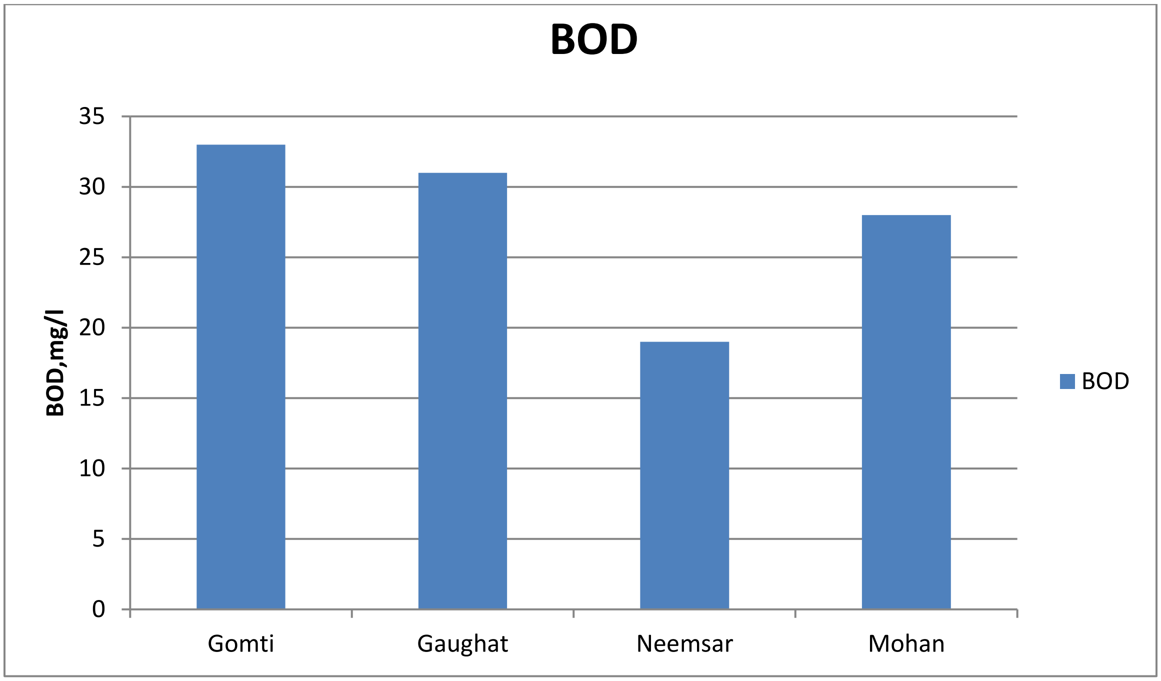


Fig.4.6. Average BOD of the water samples from different areas.

## 4.7. DISSOLVED OXYGEN (DO)

Dissolved oxygen content in water reflects the physical and biological processes prevailing in water and is influenced by aquatic vegetation. Low oxygen content in water is usually associated with organic pollution. DO is ranged from 8.61 to 8.96 mg/l in the study area, where as the prescribed limit for DO is 5.0 mg/l.

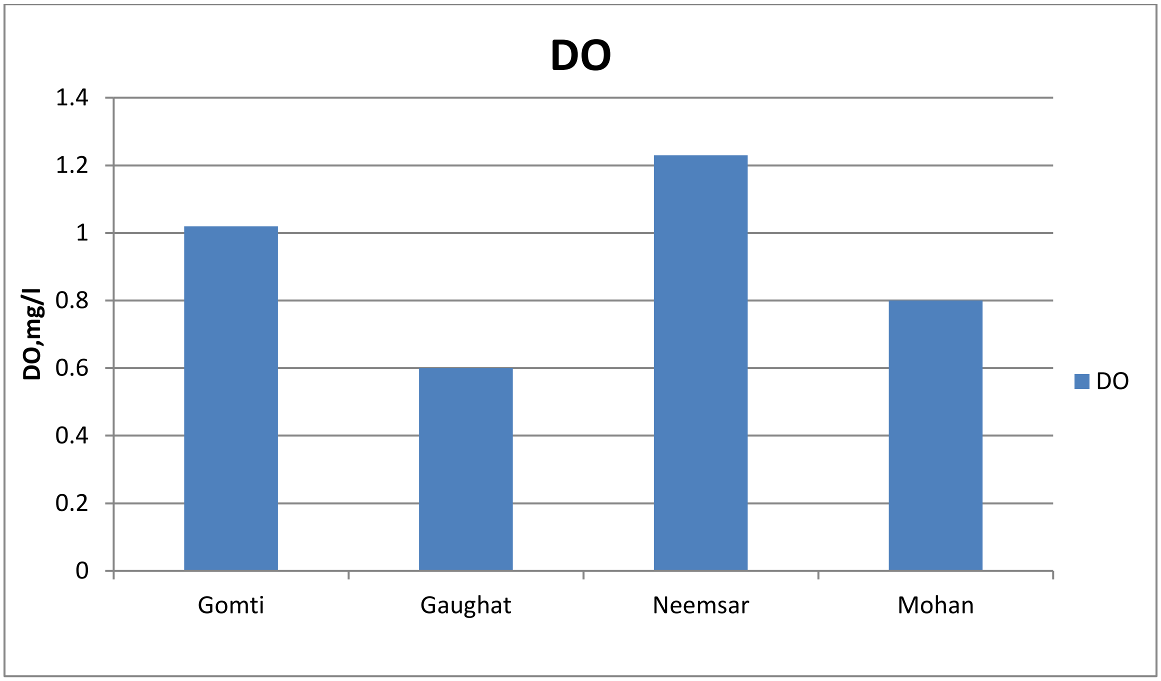


Fig.4.7. Average DO of the samples from different areas.

## 4.8. ALKALINITY

In the present study Phenolphthalein Alkalinity was absent in all samples and Methyl Orange Alkalinity was ranged from 98 mg/l to 106.3 mg/l, this indicates the absence of Hydroxyl and Carbonate and presence of Bicarbonate. However the prescribed limit for Total Alkalinity is 120 mg/l.

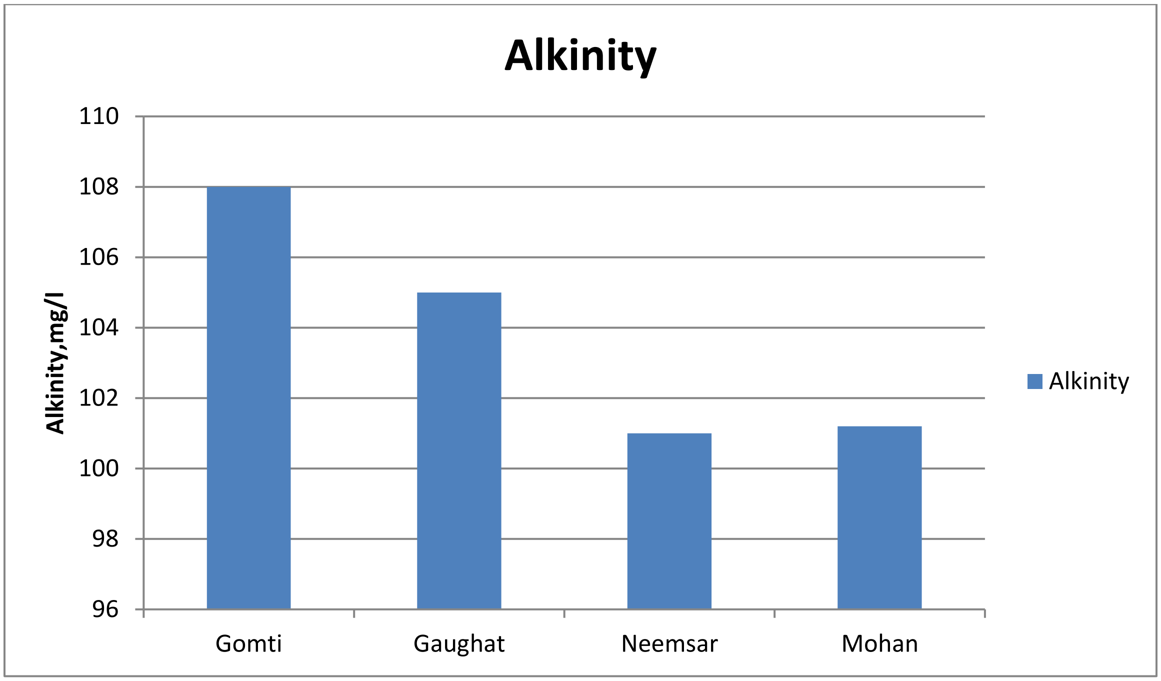


Fig.4.8. Average Alkalinity of the water samples from different areas

### 4.9. CHLORIDE

In the study area there is no significant change in chloride concentration and it ranged from 21.0 to 21.4 mg/l. Chloride which have been associated with pollution as an index are found below the permissible value set at 250 mg/l in most of the study area. Chloride in excess (> 250 mg/l) imparts a salty taste to water and people who are not accustomed to high Chlorides can be subjected to laxative effects.

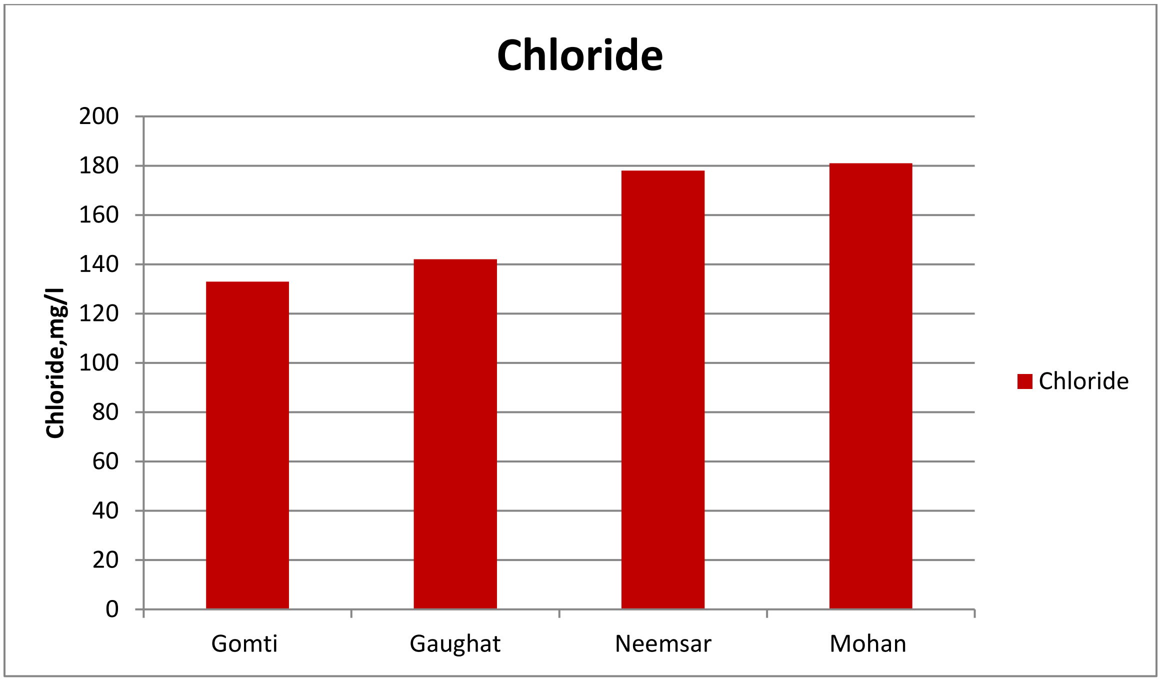


Fig.4.9. Average chloride present in the samples from different areas.

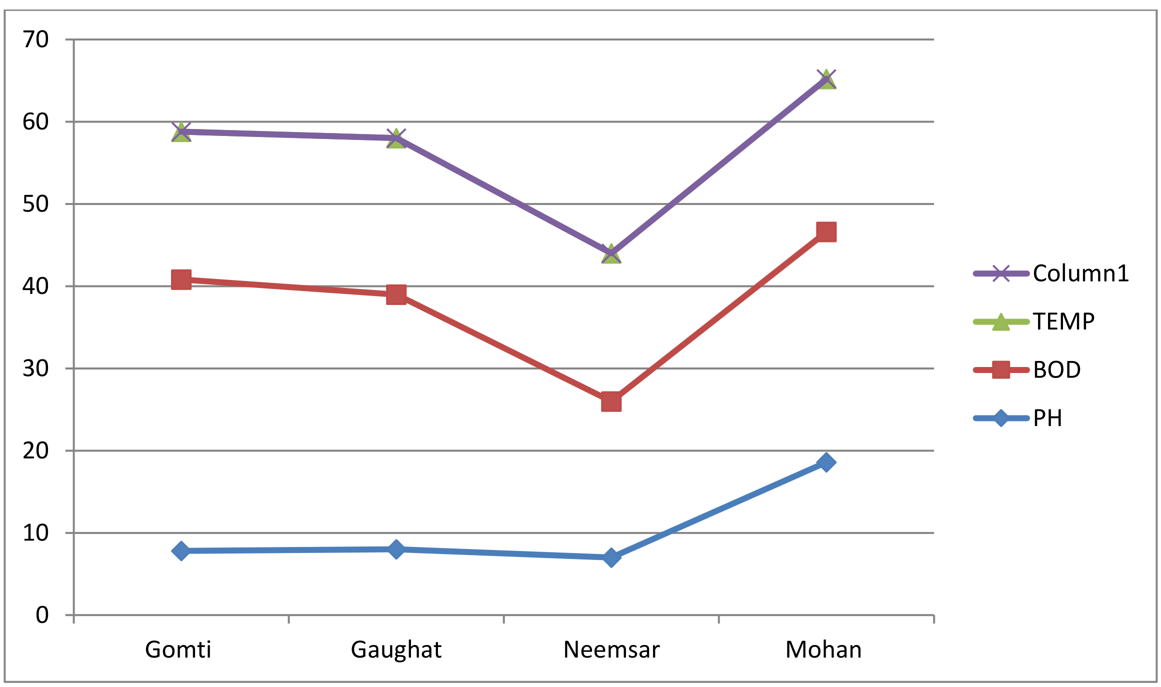


Fig. 4.10 Temp., BOD , pH value

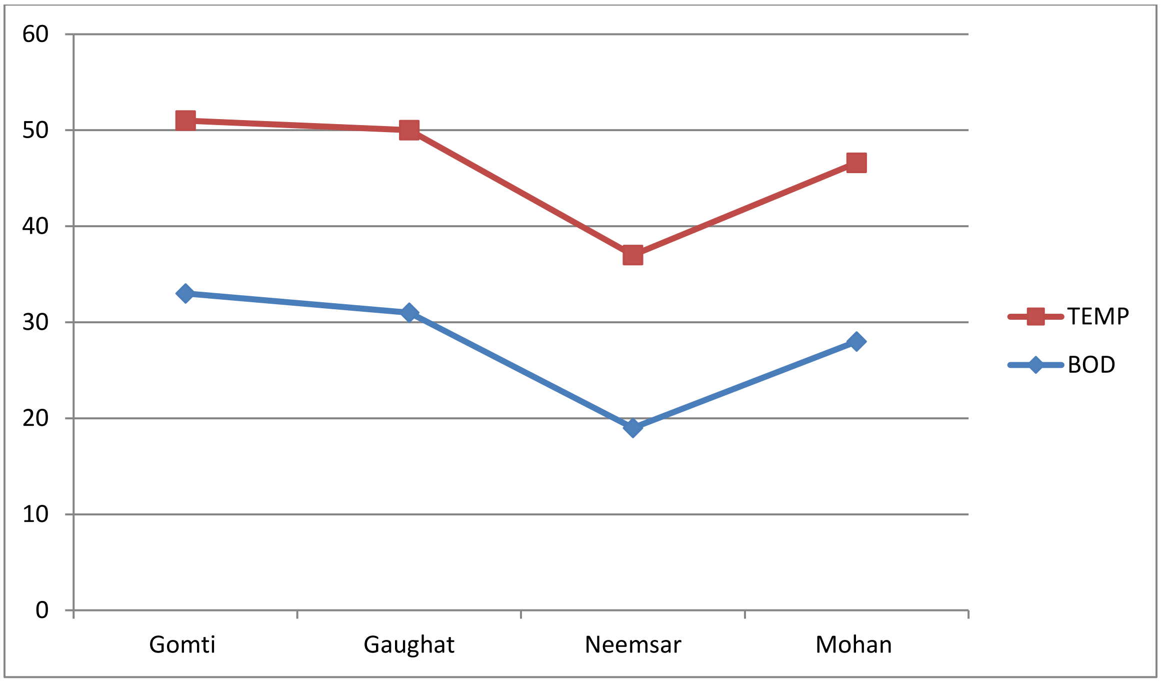


Fig. 4.11 Temp., BOD

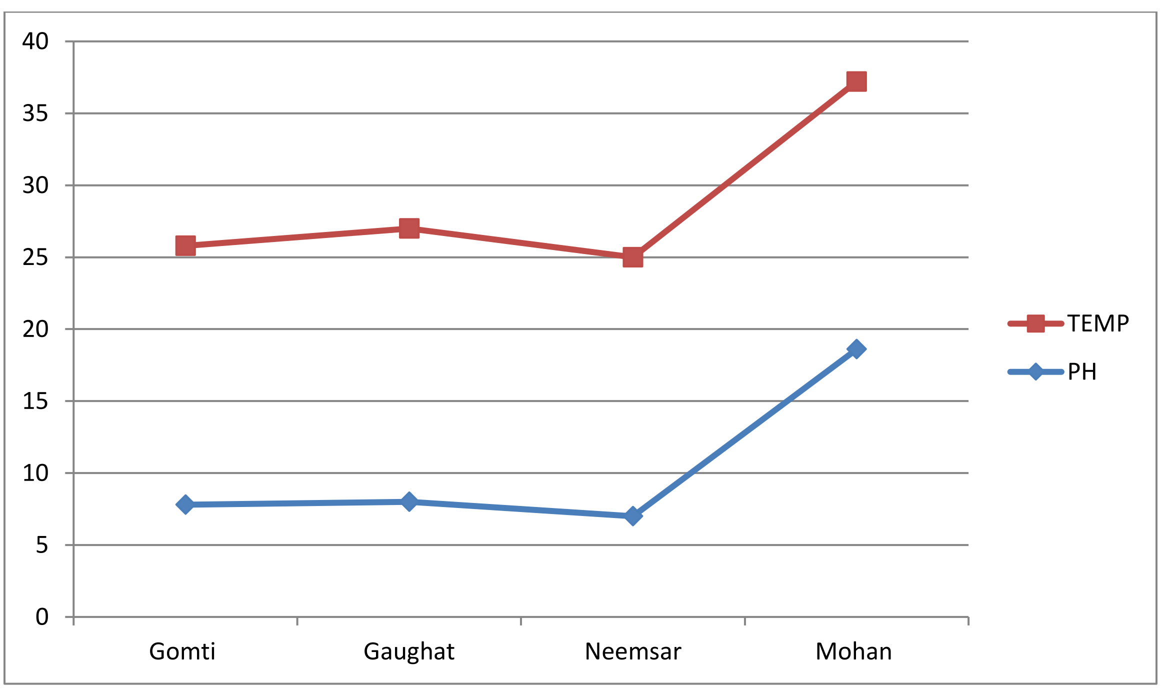

Fig.4.12 Temp., pH

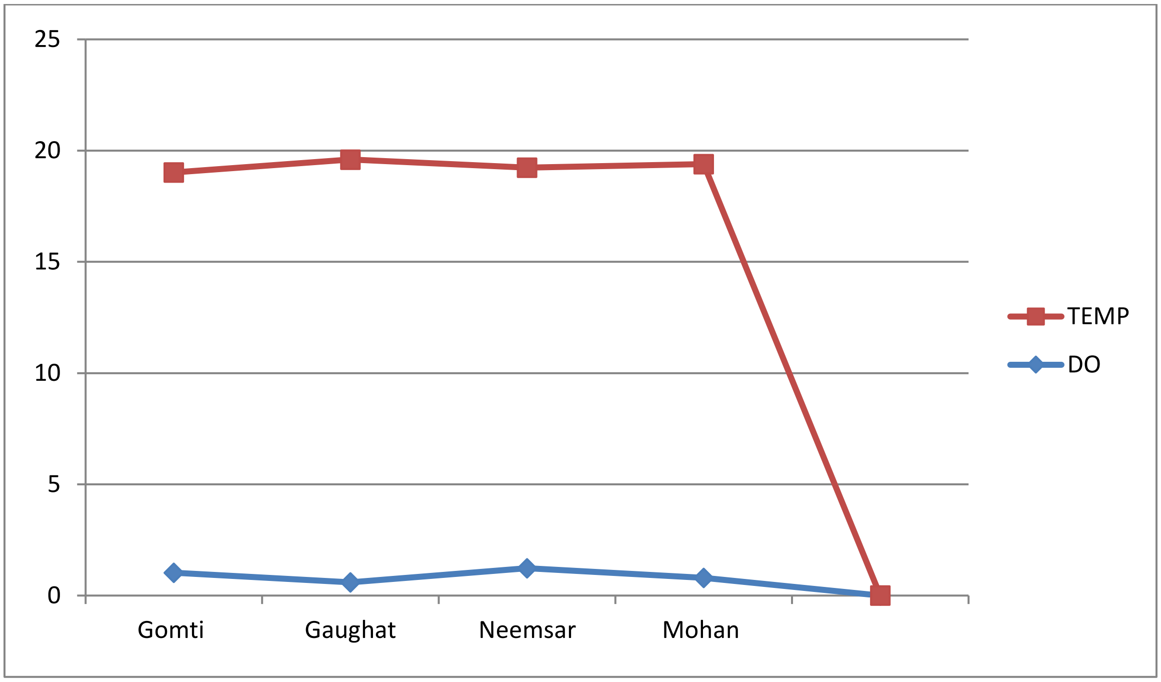


Fig.4.13 DO, Temp.

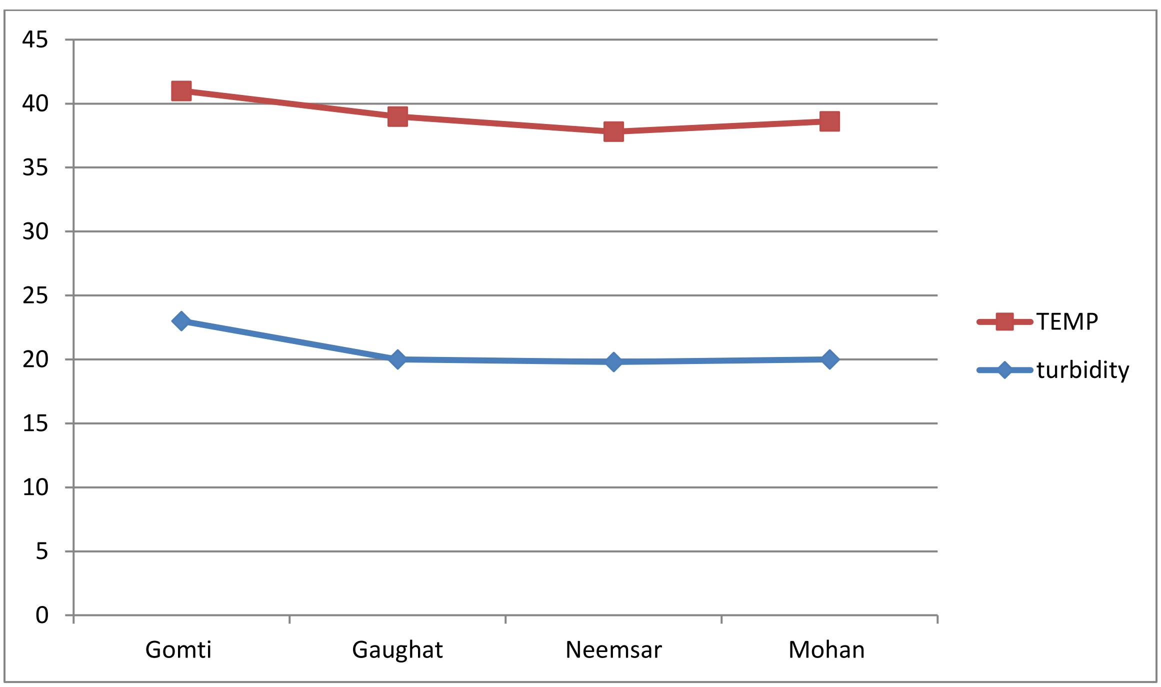

Fig.4.14 Temp., Turbidity

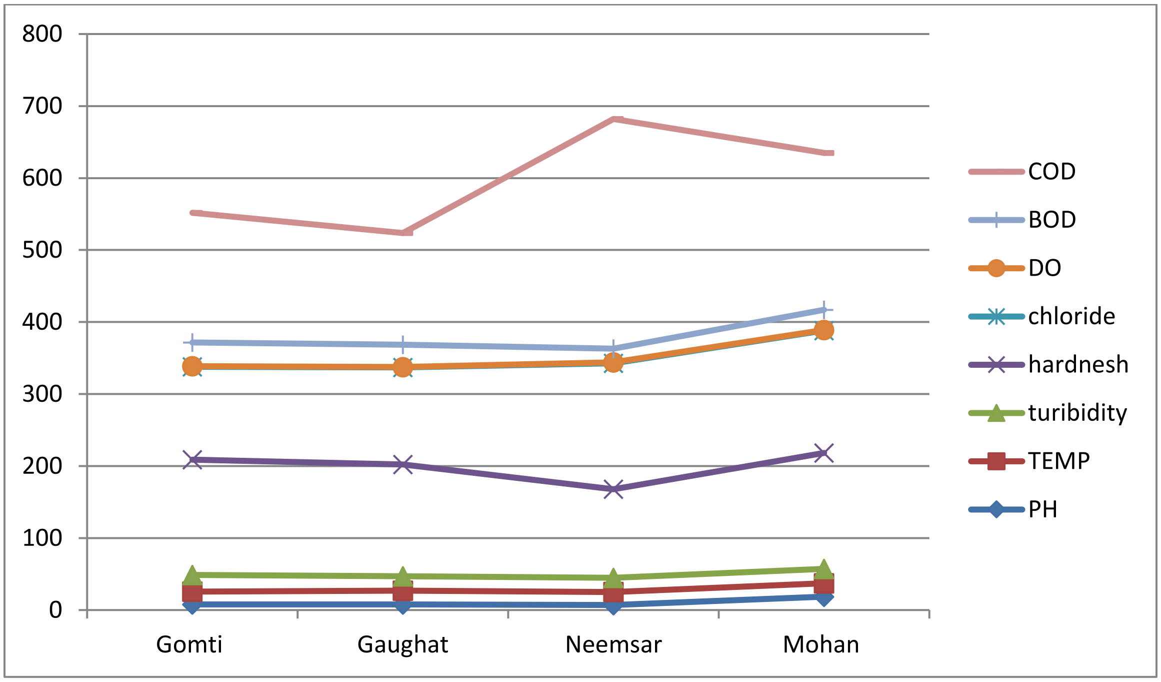


Fig.4.15 COD, BOD, DO, Chloride, Hardness, Turbidity, Temp., pH

# CHAPTER 5

# CONCLUSION

## 5. CONCLUSIONS

1. The average ranges of physical, chemical and biological characteristics of water quality are as per the ground water quality. The pH ranges from 7.32 to 7.53.

2. The Turbidity, TDS and TSS ranged from 2.31 to 2.56 NTU, 145 to 175 mg/l and 2.419 to 2.863mg/respectively

3. The DO and BOD were in the range of 8.68 to 8.96 mg/l and 3 to 4 mg/l. The Chloride and Alkalinity were in the range of 21 to 21.4 mg/l and 98 to 106.3 mg/l respectively. The parameters studied resemble the drinking water quality.

4. The present study revealed that water quality of river Gomati form upstream to downstream was found to be more polluted with reference to bacteriological parameters rather than all physic-chemical parameters.

5. The high values of sewage pollution indicator bacteria detected, revealed that the microbiological quality of water of river Gomati was very poor ,unsafe and not acceptable for any purpose especially in Lucknow and Barabanki districts.

6. Prevention of pollution in rivers and other water bodies is a high priority cost in the country. The indiscriminate discharge of treated or untreated industrial waste water in to rivers as rendered degradation of water quality of many major rivers and the efforts are being made for the last three decades to restore them as clean rivers. Over the year, many industrial clusters have cropped up on the bank of medium and small rivers too. This result in additional pollution load in joining rivers, which are already facing the menace of pollution.

7. It is realize that urgent steps are needed to restore the water quality and regenerate the aquatic ecosystem in the river. This necessitates, on one hand, adequate treatment and disposal of industrial effluents, drains and regular monitoring of the river water to ensure that the ‘River remains a River’ throughout its length.

# CHAPTER 6

# REFERENCES

**6 .REFERENCE**

1. Abida B. and Harikrishna, (1999). "Study on the Quality of Water in Some Streams of Cauvery River," Journal of Chemistry, ISSN:0973-4945, 5(2), 377-384.

2. Ahipathi M.V., and Puttaiah, E.T (1998). "Ecological Characteristics of Vrishabhavathi River in Bangalore (India)", Environmental Geology, 49,pp 12171222

3. Faith Ngwenya, (2000). "Water Quality Trends in the Eerste River, Western Cape, 1990-2005. A mini thesis submitted in partial fulfillment of the requirements for the degree of Magister Scientiae, Integrated Water Resources Management in the Faculty of Natural Science , University of the Western Cape". pp. 41.

4. Harwood, V.J., Brownell, M., Perusek, W., Whitelock, J.E (2000). "Vancomycinresistant Enterococcus sp. Isolated from waste water and chicken feces in the United States." Applied and Environmental Microbiology, 67 (10) 4930-4933

5. H.B.Mahananda, M.R. Mahananda, and B.P. Mohanty, (2001) "Studies on the Physico-chemical and Biological Parameters of a Fresh Water Pond Ecosystem as an Indicator of Water Pollution". Ecology Environment & Conservation.11 (3-4), pp 537-541.

6.Kistemann, T., Claben, T., Koch, C., Dangendorf, F., Fischeder, R., Gebel, J., Vacata, V., M., (2002). "Microbial load of drinking water reservoir Tributaries during extreme rainfall and runoff."Applied and Environmental Microbiology. 68, 2188–2197.

7.Mohamed Hatha, Abhiroshchandran, and Sherin Varghese, (2003). "Increased Prevalence of Indicator and pathogenic bacteria in the Kumarankom Lake: A function of salt water Regulator in Vembandu Lake, A Ramsar site, along west coast of India. The 12th World Lake Conference:" 250-256.

8.Mahananda, M.R, (2006). “Physico-Chemical analysis of surface water and ground water of Bargarh District, Orissa, India.” International Journal of Research and Review in Applied Sciences, 2 (3), pp 284-295.

9.Okpokwasili, G.C., Akujobi, T.C (2006). “Bacteriological indicators of tropical water quality.”Environmental Toxicology and Water Quality. Vol. (11), 77–81.

10.Pathak, S.P., Gopal, K (2007). “Rapid detection of Escherichia coli as an indicator of faecal pollution in water.”

11. Pipes, W.O (2008). “Bacterial indicators of pollution. CRC Press Inc., Boca Raton,”

12. River Rehabilitation: Literature Review, Case studies and Emerging Principles. WRC Report No. 1161/1/03. p. 242.

13. River Rehabilitation: Literature Review, Case studies and Emerging Principles. WRC Report No. 1161/1/03.

14. Scott, T.M., Salina, P., Portier, K.M., Rose, J.B., Tamplin, M.L., Farrah, S.R., Koo, A., Lukasik, J (2008). “Geographical variation in ribotype profiles of Escherichia coli isolates from human, swim, poultry, beef and dairy cattle in Florida.” Applied Environmental .Microbiology .

15. Sandy C, Richard F (2009). Quality and Standard for Drinking Water Chapter 3 Environmental Health Engineering in the Tropics. And Introductory Textbook Wiley Inter Science. 2nd Edition. ISBN 0471938858, p. 294 69 (2), 1089–1092.

16. Shehane, S.D., V.J. Harwood, J.E. whitelock, and J.B.Rose (2010). “The influence of rainfall on the incidence of Microbial faecal Indicators and the dominant sources of faecal pollution in a Florida river.”Journal of Applied Microbiology. 98,1127-1136.

17. USEPA, 1997Manual on Monitoring Water Quality. EPA 841-B-97-003.

18. Venkatesharaju K., Ravikumar. P., Somashekar. R. K., Prakash. K. L (2010). “Physico-Chemical and Bacteriological Investigation on the river Cauvery of Kollegal Stretch in Karnataka.” Journal of Science, Engineering and Technology, 6(1), pp 50-59.

19.Kataria, H.C. (2010). Turbidity measurement in groundwater of Bhopal city. J Natur

20.e Conservators, 7(1): 79-82.

21.Chandra, R., Y. Bahadur and B. K. Sharma (2010). Monitoring the quality of river Ramganga waters of Bareilly. Poll Res., 15(1): 31-33.

22.Lal, A. K. (2011). Effects of mass bathing on water quality of PushkarSarovar. Indian J Environ Prot, 16(11): 831-836.

23.Banerjee S.K., M. Banerjee and K.M. Agarwal (2012). Study of Tikara and Brahmani river ecosystems.Env Eco, 17(2): 296-305.

24.Gambhi, S.K. (2016). Physico-chemical and biological characteristics of water of Maithon Reservoir of D.V.C. Poll Res.,18(4): 541-544.

25.Jain, P. K. (2017). Assessment of water quality of Khnop reservoir in Chatarpur, MP India. Eco Env Conserv, 5(4): 401-403.