A DISSERTATION ON

"ANALYSIS OF PHYSICO-CHEMICAL PARAMETER TO EVALUATE THE WATER QUALITY OF GROUND WATER OF SUKHRALI VILLAGE, GURGAON".

SUBMITTED TO THE
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BY
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[1]

TO WHOM IT MAY CONCERN

This is to certify that **Ms. DEEPJYOTI YADAV** student of M. Sc. Biotechnology, (IV semester), Integral University has completed her four months dissertation work entitled **"ANALYSIS OF PHYSICO-CHEMICAL PARAMETER TO EVALUATE THE WATER QUALITY OF GROUND WATER OF SUKHRALI VILLAGE, GURGAON".** successfully. She has completed this work from the FARELABS PVT LTD, GURGAON under the supervision of **MR**. **SATISH SINGH.** The dissertation was a compulsory part of her M. Sc. degree.

I wish her good luck and a bright future.

Dr. SNOBER S.MIR

HEAD OF THE DEPARTMENT

DEPARTMENT OF BIOSCIENCES

02 June 2022

TRAINING CERTIFICATE

This is to certify that **Deepjyoti Yadav,** D/o Babulal Rai from, **Intergral University** MSc in Biotechnology has successfully completed her Major Project in **"Analysis of physico-chemical parameter to evaluate the water quality of ground water of sukhrali village."** from 17th Jan-2022 to 02 June 2022 at **FARE Labs Pvt. Ltd.** and has been awarded excellent grade on the basis of her performance.

She has accomplished the Major Project successfully. We have found her sincere and devoted during the training.

Kanishka Sharma
Human Resource Department
FARE Labs Pvt. Ltd.

DECLARATION

I, Deepjyoti Yadav student of MSc biotechnology, Department of Biosciences Integral University , Lucknow , Uttar Pradesh , Batch 2021-2022, Roll No. 2000102465 hereby declare that the dissertation entitled " Analysis of physico-chemical parameter to evaluate the water quality of ground water of Sukhrali Village, Gurgaon" - for the fulfillment of Master's degree in Biotechnology under the Supervision of Satish Singh Head of the Department of Water Department, Farelabs Pvt Ltd, Gurugram.

I hereby declare that the thesis is original report of my research , has been written by me and has not been submitted for any previous degree. The experimental work is almost entirely my own work ; the collaborative contributions have been indicated clearly and acknowledged. Due references have been provided on all supporting literatures and resources.

DEEPJYOTI YADAV

ACKNOWLEDGEMENT

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ABSTRACT

Ground water is an essential and valuable natural source of water supply all over the World. To meet out the rising demand it is crucial to identify and recognize the fresh water resources and also to find out the remedial method for the improvement of water quality.

Over burden of the human population has become a pressure to the society to deal with the unplanned urbanization, unrestricted exploration policies and dumping of the polluted water at inappropriate places enhance the infiltration of harmful compounds to the ground water.Globally, it has become the most concerned topic of natural resource as because of rapid urbanization and industrialization are causing threat to the water quality.

A laboratory study was conducted to monitor the ground water quality of selected areas of Gurgaon city by examining the various physico-chemical parameters. To assess the quality of ground water each parameter was compared with the standard desirable limits prescribed by World Health Organization (WHO), Bureau of Indian Standard (BIS) and Indian Council of Medical Research (ICMR).

The present study about the ground water quality of drinking water of different areas of Sukhrali Village Gurgaon, which includes tests for color, taste, odour, pH value, Total dissolved Solids, Turbidity, Conductivity, Total hardness, Total alkalinity, Calcium, Chloride, Fluoride, Magnesium, Nitrate, Sulphate, Biochemical Oxygen Demand (BOD) .

The quality of Gurugram groundwater is deteriorating with each passing year.The average annual rainfall in the district is about 550 mm and not able to recharge the depleted ground water level which is occurring with high pace due to huge population increase due to urbanization. Urban areas under the influence of multi-industrial activities with gradual changes in the environmental conditions witness the significant increase in environmental pollution especially in case of water sector.

The concentration of pH is from 6.92 to 8.36 which is under the acceptable limits according to IS 10500 and also the BOD is found under the acceptable limits which range from 2 to 4 mg/L. The value of other parameters like turbidity , TDS, Hardness , Alkalinity, Calcium, Chloride , which is found over the range of acceptable limits but under permissible limit. Nitrate and sulphate is found under the range of acceptable limit. The results obtained from the water quality criteria parameter are not within the acceptable limit of drinking water standards (IS:10500).

1.INTRODUCTION

Water is a most abundant physical substance and transparent liquid on earth. In water molecule two atoms hydrogen and one atom oxygen are present. Water is the foundation of all form of life. Water is an essential natural resource for life of human beings, plants and animals on water planet. All processes of life are directly or indirectly connected to water therefore human beings cannot survive much longer without water, as water plays a central and critical role for every cell and organ system in the human body to function properly. Water is responsible for every activity in human body. In developing countries safe and sufficient drinking water supply is a crucial issue in rural and in many urban areas. In rural areas groundwater is a reliable and finite source of water. The most common sources of water for irrigation and various purposes are surface water and groundwater.

Ground water and surface water are interconnected. The surface water is present in the form of oceans, rivers, lakes, ponds and streams on the earth's surface and the groundwater present below the earth's surface in porous soils and rocks.

1.1. GROUND WATER

Groundwater is a vital source of water throughout the world. Groundwater is extracted by a bore or a well. Groundwater is a fundamental component of the water resources for domestic, industries and drinking purpose.

Groundwater is a hidden resource that saturates the tiny spaces between sand, gravel, silt, clay and fractures in rocks. Water in the soil is referred to as soil moisture and spaces between soil, gravel and rock are filled with water. Most groundwater is found in aquifers. Below the water table, soil and rocks are saturated with water. Groundwater is stored in layers of soil, sand and rocks called aquifers. An aquifer is a layer of porous substrate that contains groundwater.

Ground water moves from locations of higher pressure to locations of lower pressure. Groundwater movement in rock fractures is relatively slow, whereas it is relatively rapid in sand and gravels. Upper level of an underground surface in which the soil is permanently saturated with water is known as water. The water table is affected by climate change therefore it fluctuates both with the seasons and from year to year.

Most ground water moves relatively slow through rock underground because the flow of ground water is affected by water pressure and elevation, water within the upper part of

the saturated zone tends to move downward. Water rock pores are small then water moves slowly while when openings are large then the flow of water is more rapid.

Groundwater is recharged by the addition of water to the saturated zone. A deep hole that is dug or drilled into the ground to penetrate an aquifer is called well. Groundwater contaminated by pesticides, herbicides, fertilizers that are applied to agricultural crops that can find their way into ground water when rain or irrigation water leaches the poisons downward into the soil.
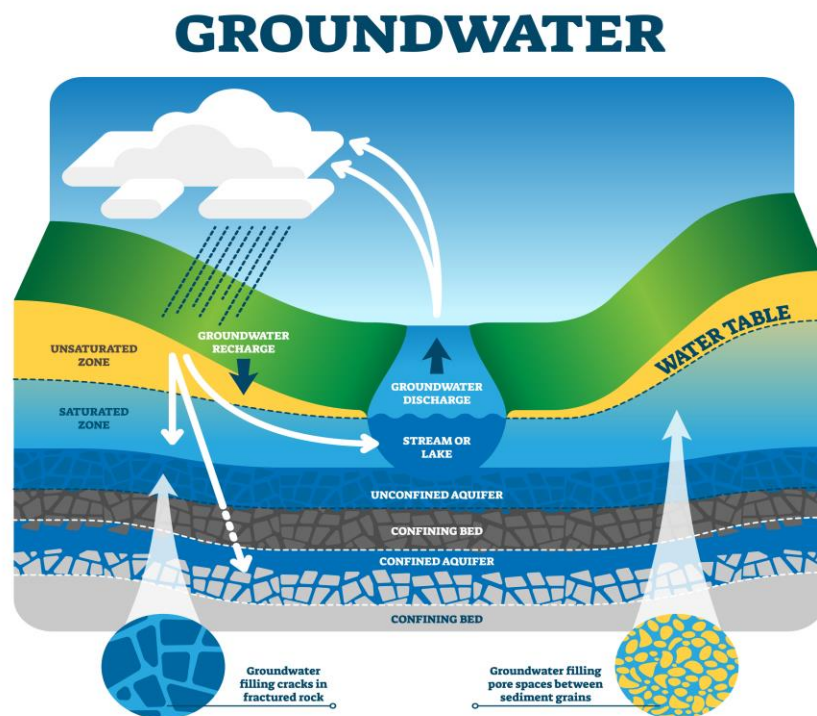
GROUNDWATER

1.2. GROUNDWATER QUALITY

Groundwater is an important natural resource of drinking water. The chemical and biological character of ground water is acceptable for most uses but the quality of ground water is changed as a result of man's activities. The natural quality of groundwater alters as groundwater flows from springs or rivers and recharge areas. Groundwater contains most common dissolved mineral substances such as sodium, potassium, magnesium, calcium, bicarbonate, chloride and sulfate. The suitability of

groundwater for various purposes depends on many factors such as dissolved minerals and organic substances present in ground water in different concentrations. Some constituents are harmless, others are harmful, and a few may be highly toxic.

Population growth is one of the major factors responsible for increased solid waste. Agriculture has wide impact on groundwater quality, where intensive practices take place. Urbanization and industrialization have significant impact on groundwater quality. In many parts of earth atmospheric conditions also alter the quality of the groundwater.

Groundwater is not considered desirable for drinking if the quantity of dissolved minerals exceeds from permissible limit, Groundwater in which dissolved minerals are present then its nature is saline. Dissolved minerals can be hazardous to animals and plants in large concentrations.

Groundwater that contains a lot of calcium and magnesium is called hard water. The hardness of water is represented in terms of the amount of calcium carbonate. In recent years, the growth of industries, technology, and population has increased the stress upon water resources. The quality of ground water has been degraded.

1.3. GROUND WATER CONTAMINATION

Groundwater contamination occurs when manmade undesirable products get into the groundwater and cause it to become unsafe and unfit for human use. Serious health effects may be caused by contaminated groundwater. It has been assumed that contaminants can either be above or below ground. Surface water percolate through soil then it picks up minerals, salt, and organic compounds. The water migrate downward therefore concentration of dissolved solids are increased.

In some areas minerals concentration is enough high so that the groundwater is unfit for drinking and irrigation purpose without treatment. When the contaminated water seeps into the soil and enters an aquifer it results into ground water contamination.

Groundwater is contaminated from waste disposal sites, animal waste, leaking underground storage tanks, industrial chemical waste by pesticides and fertilizers, used in broad agricultural lands. Contaminated groundwater can be unsuitable for various purposes and its remediation is difficult, time consuming and expensive. It may be harmful for human health as well as Environment Health. Groundwater is polluted when it contain enough impurities to make it unfit for intended use.

Groundwater contamination comes from point and non-point sources. Point sources

contamination comes from specific location such as septic system, underground storage tank and landfills but non-point sources contamination comes from a large area such as from agricultural waste (pesticides and fertilizers) and urban waste.

When the pollution originates from a single, identifiable source is known as a point source of contamination. Various types of point-source contaminants found in waters such as industrial, agricultural and of urban sources. Point sources of pollution from agriculture may include animal waste storage and cleaning areas for pesticides, fertilizers.

Municipal point sources include wastewater treatment plants, landfills. Due to all of these activities, hazardous substance may include in the raw material. Non-point sources pollution occur over extensive areas. When water moves over and through the ground it can pick up natural contaminates, synthetic contaminates depositing them into rivers, wetlands, lakes and underground water.

Non-point sources contamination also occur by sediments, seepage of septic tanks and use of fertilizers. Irrigated agriculture is a significant source of groundwater non-point contamination.

Contamination of groundwater from septic tanks occurs under various conditions such as poor placement of septic leach fields, badly constructed percolation systems and high density placement of tanks. If a septic system is not maintained properly then it can pollute drinking water. A pollutants leak from sewer lines and sewage enter groundwater directly. Sewer leaks occur from soil slippage, seismic activity, sewage back up and loss of foundation.

Residue of the chemical, biological, and physical treatment of municipal and industrial wastes is called sludge. Sludge contains organic matter, heavy matter and inorganic salts.

Other pollutants like as city waste, household chemicals and heavy metals such as mercury, lead, chromium, copper, and cadmium can also leach by rain into groundwater.

Groundwater can contaminate by liquid and solid wastes from sewage plants, septic tanks, and animal waste and slaughterhouses. Radioactive waste can cause the pollution of ground water due to liquid radioactive wastes from the nuclear power industry. Contaminated groundwater can be decontaminated by expensive long-term procedures. The groundwater quality must, in all cases, be controlled both before its use and during its use.

1.4.   MAJOR SOURCE OF GROUND WATER CONTAMINATION

For a long time, groundwater was known to be clean and free from contamination. However, due to rapid industrialization and increased use of chemicals, numerous contaminants often find their way into the groundwater. The significant sources of contamination in groundwater are farming chemicals, septic waste, landfills, uncontrolled hazardous waste, storage tanks, and atmospheric pollutants.

Agricultural Chemicals

Agricultural production has been scaled up in most **developed nations**. This large-scale production of farm goods means increased use of farm chemicals such as pesticides, herbicides, and fertilizers. These chemicals used on farms settle on the ground, and when it rains, they mix with the rainwater and seep through the porous ground to reach the underground water. That way, the chemicals pollute the groundwater.

Septic Waste

It is essential that septic waste is treated before it is disposed into the ground. Treatment prevents harmful substances from getting into the ground and spreading to the water. Additionally, the septic systems are structured to release the waste into the ground at an extremely slow rate which is harmless to the environment. However, poorly designed septic systems release viruses, bacteria, and household chemicals into the groundwater and make it unfit for human consumption. Poorly maintained septic tanks also result in leaks which cause groundwater contamination.

Landfills

As the human population grows, so does the garbage produced daily. This garbage is collected and taken to particular locations known as landfills where it is buried. Landfills are required to have a protective layer at the bottom to stop the waste from seeping into the ground. Nonetheless, some landfills lack that protective layer, and in some cases, it is cracked. Such landfills result in leaks of contaminants such as household chemicals, car battery acid, oil, and medical products into the groundwater.

Hazardous Waste Sites

There are numerous sites around the world where hazardous products such as radioactive components, war chemicals, electronic waste, and similar products are disposed. The number of these waste sites keep growing by the day. In many cases,

hazardous products' disposal sites are not adequately monitored. The lack of proper monitoring and maintenance of such sites leads to leakage of dangerous substances into the groundwater.

Storage Tanks

Chemicals, oil, minerals, and other products are often kept in storage tanks above or below ground. In the **United States** alone, it is estimated that more than 10 million storage barrels containing different substances are stored underground. Over time, the storage containers erode, and this may result in harmful substances leaking into the ground. Subsequently, the contaminants move through the soil and reach the groundwater making it unfit for human use.

Atmospheric Pollutants

Groundwater is maintained through the **hydrological cycle** which is the movement of water above, below, and on the surface of the earth. As the water moves, it comes into contact with pollutants in the atmosphere such as harmful gases. When it rains, the water carries these contaminants into the ground and pollutes the groundwater.

Underground Pipes

As nations develop, they invent new methods of transporting different products using the underground pipes. Products such as oil, farm chemicals, cooking gas, and drinking water are mainly transported through underground pipes. In many instances, the underground pipes burst and release their content into the ground. These incidents often lead to groundwater contamination.

Road Salts

Road salts are mainly used in places that have snowfall during winter. Road salts are chemical products used to melt ice on the road. Once the ice melts it flows with the chemicals through the ground and into the groundwater hence contaminating the water.

1.5. EFFECTS OF GROUND WATER CONTAMINATION

Contaminated groundwater can lead to severe effects on the environment, animals, and human beings. Firstly, groundwater is the primary source of drinking water for most people and animals around the globe. Once the groundwater is contaminated with harmful chemicals and bacteria, the humans and animals consume the harmful substances through drinking water and subsequently suffer health problems such as amoeba, typhoid, diarrhea, and even cancer. Secondly, the trees and vegetation that rely on groundwater are likely to dry up after absorbing contaminated water. As a result, the loss of vegetation leads to an imbalance in the ecosystem. Thirdly, contaminated groundwater may seep into rivers and streams and lead to the loss of marine life which is detrimental to the environment. Lastly, when groundwater is contaminated with reactive substances, it may result in harmful chemical reactions that destroy the soil around the area. The consequences of destroyed soil include poor plant development and bad soil quality.

OBJECTIVES OF THE PRESENT STUDY:

1. To assess the physico-chemical parameters of the ground water of different areas for the quality check-up.

2. To study about the ground water quality of Sukhrali Village to analyze about the condition of that area that how much it is contaminated.

3. Physio-chemical characteristics of ground water to find out whether it is fit for drinking or not.

2. REVIEW OF LITERATURE

According to Swain S et al. (2022) the ground water quality over the two constituent districts (Faridabad and Gurgaon) of the National Capital Region (NCR),India. Over 28 sites was analysed for the quality parameterof pH, electrical conductivity (EC), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), fluoride (F^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), silica (SiO_2), and total hardness (TH) and found that the water quality index (WQI) of 10 out of 28 sites found to be unsuitable for drinking purpose, the deteriotated water quality may be due to anhtropogenic activities i.e. industrial growth, urbanisation.

According to Robert Pitt et al. (1999) Water sources available for drinking and other domestic purposes must possess high degree of purity, free from chemical contamination and micro organisms. But the rapid increase in population and industrialization had led to the deterioration of good quality of water thus causing water pollution. The study of ground water samples of Tekanpur in Gwalior city of M.P. India were studied to assess its suitability for public consumption. The Parameters measured were Colour, Odour, Temperature, pH, Electrical Conductivity, Total Dissolved Solid, Total Alkalinity, Total Hardness, Calcium, Magnesium, Chloride, and Dissolved Oxygen. Almost all the parameters satisfy the guidelines except a few. The analysis reveals that the ground water of that area needs some treatment before consumption. The constituents of most concern include chloride, certain pesticides (lindane and chlordane), organic toxicants (1,3-dichlorobenzene, pyrene and fluoranthene), pathogens, and some heavy metals (nickel and zinc). Reported instances of groundwater contamination associated with stormwater was rare in residential areas where infiltration occurred through surface soils (except for chloride), but was more common (especially for toxicants) in commercial and industrial areas where subsurface infiltration was used.

According to Siakot R Ullah et al. 2009 Contamination of groundwater due to heavy metals is one of the most important concerns that have received attention at regional, local and global levels because of their toxicological importance. The present study is designed to assess the quality of groundwater in relation to heavy metal pollution and its implication on human health. The groundwater quality of Sialkot, was evaluated using water samples collected from 25 localities during October-November 2005. Twenty-two differernt physiochemical parameters were studied. The results were compared with standard guidelines of World Health Organization (WHO) and Pakistan Standard Quality Control Authority (PSQCA) for groundwater quality. Cluster Analysis (CA) grouped all

sites into four zones based on spatial similarities and dissimilarities of physiochemical properties. Zone 1 was highly contaminated with high level of turbidity; EC, TDS, SO4, Cl, total hardiness, Zn, Pb and Fe concentrations were above the permissible levels of WHO and PSQCA. Cr+6 was detected in nineteen sampling sites and its concentration ranged between 0.01 - 0.30 mg/L. Factor Analysis (FA) and Discriminant Analysis (DA) revealed significant variables including pH, EC, TDS, SO4, NO3, Cl, Total Hardness, Iodide, Total Chlorine, Fluoride, alkalinity, Pb, Fe and Mn which are responsible for variations in groundwater quality and affect water chemistry. The results revealed that the groundwater of the study area cannot be considered of good quality as it is highly turbid (57% of total sites) with high level of Zn, Fe and Pb, which were above WHO and PSQCA permissible limits.

According to D Dohare et al.2014 People on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and man-made activity water is highly polluted with different harmful contaminants. Natural water contaminates due to weathering of rocks and leaching of soils, mining processing etc. 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 varied of water borne diseases. It is necessary to know details about different physico-chemical parameters such as color, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity used fortesting of water quality. Heavy metals such as Pb, Cr, Fe, Hg etc. are of special concern because they produce water or chronic poisoning in aquatic animals. Some water analysis reports with physic-chemical parameters have been given for the exploring parameter study. Guidelines of different physic-chemical parameters also have been given for comparing the value of real water sample.

 Vijender Kumar Malik, Ram Karan Singh & S. K. Singh et al. in the year 2010 studied the depletion of ground water in Gurgaon and its adjoining areas is alarming proportions,creating high water scarcity conditions in the district. The average annual rainfall in the district is about 550 mm which is why they are not able to recharge the depleted ground water level which is occurring with high pace due to huge population increase due to urbanization. The total annual ground water availability of the district is 20215.12 ham and existing overall stage of ground water development in the block is of the order of 209% which has exceeded the available recharge and thus the district has been categorized as over exploited region. Sustainable utilization of ground water holds the key to counter the problem of declining water table. An attempt has been made in this paper to highlight the prevailing ground water scenario and the need for scientific

management of this vital resource. Optimal utilization of ground water through properly designed abstraction structures constructed at suitable location can mitigate the problems of water scarcity faced during summer. Rainwater harvesting, proper run off management measures and optimal ground water conservation practices will be helpful for eradicating the problem of declining water table in the district.

Munesh Kumari & S. C. Ra et al. 2020 study was aimed to evaluate the hydrochemistry of groundwater in southern Haryana. An assessment of measured physico-chemical parameters of 64 samples sites have shown that groundwater is contaminated by higher concentrations of HCO3, Na, Mg, and SO4 beyond the permissible limit of BIS standards. Water quality index (WQI) result indicates that 45.31% area has poor and very poor quality of water for drinking purposes. Among these parameters, SAR, RSC and PI, water samples fall in excellent and safe water quality, while SP, KR and MH imply to unsuitable and unsafe for irrigation. Piper diagram indicates that the water chemistry is dominated by Sodium and Potassium (Na+K) type, followed by mixed type. According to the USSL classification more than 85% of the samples fall under C3S1, C3S2, C4S1, C4S2 classes of irrigation water indicating very high salinity which is alarming considering the use of this water for irrigation.

According to Vyas, M. R. Mittal, S. B. et al. 2010 the ground water quality of Pataudi and Farukhnagar blocks of Gurgaon district was assessed through extensive sampling from running tube wells. Majority (>60%) of the collected samples were safe (EC <2 dSm-1) in both the blocks. Maximum number of samples (108) of Pataudi were in the EC range 1.0-2.0, followed by 54 samples falling in EC range of 0.0-1.0 dS m-1; in Farukhnagar, there was almost equal distribution of samples in 0-1 and 1-2 dS m-1. After this, with increase in EC, the number of samples decreased gradually. Unsafe waters varied from 16-20 per cent and were evenly spread in western parts of Pataudi whereas in Farukhnagar, these waters were confined to north and western parts. It was observed that underground waters of area were Na+ > Mg+2 > Ca+2 > K+ type for cations and Cl- > HCO3- > SO4-2 > CO3-2 type for anions. In Pataudi, 53, 13, 5, 18 and 11 per cent water samples were in good, marginal, saline, sodic and saline sodic whereas in Farukhnagar, 60% water samples were good with 11, 9, 8 and 11 per cent waters being categorized as marginal, saline, sodic and saline-sodic, respectively.

According to Sucheta et al. in the year 2019 High fluoride concentration in groundwater occurs in majority of the dry and semidry regions of the Indian subcontinent. Mahendergarh district of Haryana state has been identified as Red Alert zone of high fluoride by Geological Survey of India (GSI). Most of the residents of Mahendergarh district are using ground water for drinking and irrigational purposes. The main purpose of the present study was to analyze the level of fluoride in ground water in all the eight

blocks, i.e., Satnali, Sihma, Narnaul, Mahendergarh, Nizampur, Ateli, Kanina and Nangal Chaudhary of Mahendergarh district. Water samples were collected from 355 villages of the study area during December 2016 to May–June 2017 and were analyzed to find out the fluoride concentration with ion-selective electrode method. The fluoride distribution in Mahendergarh district ranged from 0.3 to 16.0 mg/l in ground water samples. Lowest value of 0.3 mg/l was reported in Dalanwas village of Satnali block and highest value of 16.0 mg/l in Narnaul city of Narnaul block. The outcome of the study revealed that out of 355 villages of the district, the fluoride level in 205 villages was found within the upper acceptable limit prescribed by WHO, i.e., 1.5 mg/l. The fluoride concentration in 150 villages was above permissible limit that may cause fluorosis among residents of the district. The fluoride distribution pattern showed that the high fluoride level was observed in the central part and the lowest in northwest part of the study area.

According to Sumit Vij et al. 2016 paper describes how urbanization processes and urban expansion intersect with social and power relations to reduce the access of periurban communities to common property resources (CPRs). Unequal power structures mean that certain groups are deprived of access to village CPRs. Processes of urban expansion further reduce access to CPRs, as the latter are acquired to support urban expansion. Though rural–urban transformations are characterized by the emergence of new sources of irrigation such as wastewater, not all are able to benefit from them. The acquisition of common property grazing lands to support the drinking water needs of the city affects the livelihood of livestock dependent population, that shift to casual labor. This also translates into a shift from grazing, the domain of men in the household, to stall-feeding, the domain of women, and thereby creating additional responsibilities for women in natural resource collection. The demise of CPRs such as village ponds with the increased pressure on groundwater resources increase the drudgery of women and marginalized groups in accessing water.

According to P Singh et al. 2010 the characterization of the physiochemical parameters of groundwater from fifteen different locations in Ambala, Haryana (India) was carried out. To assess the quality of ground water each parameter was compared with the standard desirable limits prescribed by World health organization (WHO), Bureau of Indian Standard (BIS) and Indian council of medical research (ICMR). Systematic calculation was made to determine the correlation coefficient 'r' amongst the parameters. Elemental analysis of three samples was carried out using the EDXRF technique. It is concluded that the water quality of water supply systems in different locations of Ambala is of medium quality and can be used for domestic use after suitable treatment. Suitable suggestions were made to improve the quality of water.

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3. METHODS AND METHEDOLOGY

3.1. STUDY AREA

Study area comprises of Sukhrali Village which is a census town in Gurgaon district, Haryana India. In the present study, a growing industrial area in the Gurgaon district Haryana, India, is considered to investigate the groundwater quality. Gurgaon lie in the periphery of Delhi and are also the prominent constituents of India's National Capital Region (NCR). Haryana is a land-locked state in the northwest of India and is located between 27° 39' and 30° 35'N latitude and between 74°27' and 77°36' E longitude with just 1.37% of the total geographical area and less than 2% of India's population

Due to the rapid growth of urbanization, industrialization, and population, the groundwater of this districts is under a severe threat of deterioration in terms of quality and quantity.
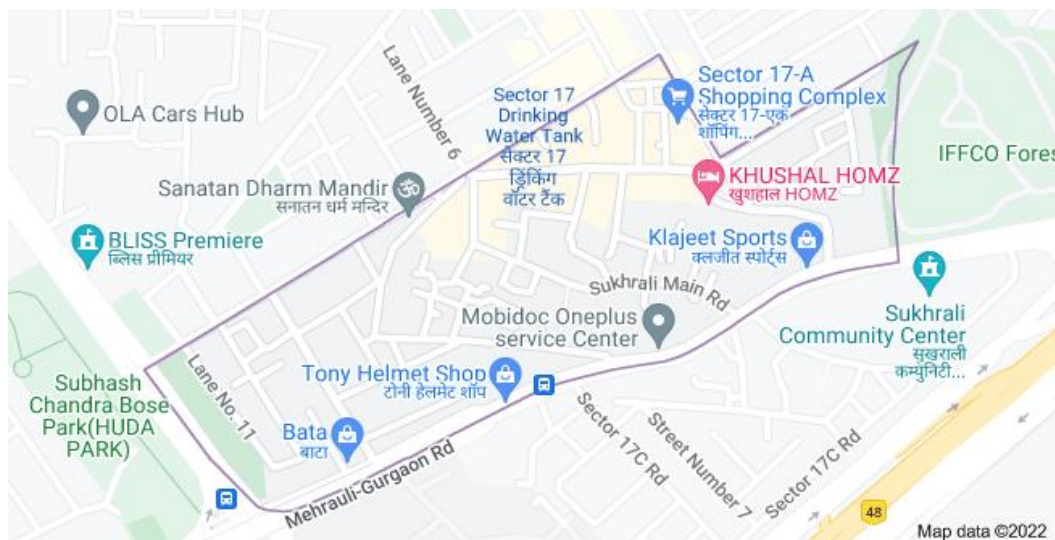
The groundwater quality of Gurgaon continuously degrading due to industrial activities and the soils of the nearby fields are also being affected. Therefore, we have decide to analyze its groundwater so that some remedies for the improvement could be possible.

3.2. SAMPLING

Groundwater samples were collected from eight different locations of Sukhrali Village during summer season from the seven bore wells and one well located near the study area. The samples were collected from nearby areas of Sukhrali.

Samples were collected in good quality bottles wrapped in aluminium foil of one-liter capacity. Sampling of water is truly representative of any aquatic environment. Once a sample has been taken it should have no possibility of transporting trace elements either to or from the sampling container walls. Natural water in its different forms has been interesting material of study. Sampling was carried out without adding any preservative. The bottles were well rinsed before sampling and tightly sealed after collection and labeled in the field.

3.3. PHYSIO-CHEMICAL ANALYSIS

Physico-chemical analysis was carried out for various water quality parameters such color, taste, odour, pH , Conductivity, Turbidity, Total dissolved solids (TDS) , Total Hardness , Total alkalinity , Calcium, Magnesium , Chloride , fluoride, Sulphate, Nitrate, Biochemical Oxygen Demand (BOD) as per standard procedure described "Standard methods for the examination of water and waste water American public Health Association (APHA)" .

SL NO.	PARAMETERS	SPECIFICATION (Acceptable limits)	STANDARD
1.	COLOR	5	IS 10500
2.	TASTE	Agreeable	IS 10500
3.	ODOUR	Agreeable	IS 10500
4.	pH	6.5-8.5	IS 10500
5.	TDS	500	IS 10500
6.	TURBIDITY	1	IS 10500
7.	TOTAL HARDNESS	200	IS 10500
8.	CALCIUM	75	IS 10500
9.	TOTAL ALKALINITY	200	IS 10500
10.	CHLORIDE	250	IS 10500
11.	MAGNESIUM	30	IS10500
12.	CONDUCTIVITY	-	APHA 23rd Ed.
13.	NITRATE	45	APHA 23rd Ed.
14.	SULPHATE	200	APHA 23rd Ed.
15.	FLUORIDE	1.0	IS 10500
16	BOD	NIL to 5	APHA 23rd Ed.

(Except PH and turbidity other parameters are in mg/L)

APHA stands for American Public Health Association

3.4. PARAMETERS

3.4.1. COLOR

Principle - Color characteristics are measured at pH 7.6 and original pH of the sample by obtaining the visible absorption spectrum of the sample on a spectrophotometer. The percent transmission at certain wavelengths is used to calculate the results which are expressed in terms of dominant wavelength, hue, luminance and purity.

Two methods are there for the determination of color.

  a) Platinum cobalt (visual-comparison) method,

  b) Spectrophotometric method.

1. Platinum cobalt (visual comparison) method is applicable to nearly all samples of potable water and is not applicable to colour measurements on water containing highly colored industrial wastes.

 2. Spectrophotometric method is applicable for all types of water including domestic land industrial wastes. It is generally used in case of industrial wastes that cannot be determined by platinum - cobalt method.

3.4.2. TASTE

Principle - Each panelist (tester) is presented with a list of nine statements about the water, ranging from very favourable to very unfavourable. The tester selects a statement that best expresses his opinion. The scored rating is the scale number of the statement selected. The panel rating is the arithmetic mean of the scale numbers of all testers.

This method is applicable only to water not to wastewater.

Procedure - For test efficiency, a single rating session may contain up to 10 samples, including the reference samples given. Observers should work alone after receiving thorough instructions and trial or orientation sessions followed by questions and discussion of procedures. Select panel members on the basis of performance in trial sessions. Rate the samples as follows:

a) Initially taste about half of the sample by taking the water into the mouth, holding it for several seconds, and discharging it without swallowing; b) Form an initial judgement on the rating scale c) Make a second tasting the same manner as the first; d) Make a final-rating for the sample and record the results on the appropriate data form; e) Rinse the

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mouth with taste-and odour-free water; and f) Rest for one minute before repeating steps (a) to (e) on the next sample.

3.4.3. ODOUR

Odour is recognised as a quality factor affecting acceptability of drinking water and food prepared from it, tainting of fish and other aquatic organisms, and aestheties of recreational waters. Most organic and some inorganic chemicals contribute taste or odour. These chemicals may originate from municipal and industrial waste discharges, natural sources, such as decomposition of vegetable matter or from associated microbial activity. Odour of water, though very important, cannot be determined in absolute units. Olfactory sense, which is the most sensitive means of detecting small concentration of odoriferous substances,' lacks precision and mathematical expression nevertheless a qualitative test is prescribed. In case of doubt as to the intensity or character of odour, a majority opinion of several observers should be recorded.

Procedure – As soon as possible after collection of sample, fill a bottle (cleaned as in 2.1) half-full a sample, insert the stopper, shake vigorously for 2 to 3 seconds and then quickly observe the odour. The sample-taken for observation of odour shall ba at room temperature. When it is desired to record the odour at an elevated temperature, make the observation after Harming the sample in a clean stoppered bottle to about 60°C.

3.4.4. pH VALUE (ELECTROMERIC METHOD)

PRINCIPLE

The pH value is determined by measurement of the electromotive force of a cell consisting of an indicator electrode (an electrode responsive to hydrogen ions such as a glass electrode) Immersed in the test solution and a reference electrode (usually mercury/calomel electrode). Contact between the test solution and the reference electrode is usually achieved by ' means of a liquid junction, which forms part of the reference electrode. The electromotive force is ~ measured with a pH meter, that is, a high impedence voltmeter calibrated in terms of pH.

Calibration- NIST standard is used for the calibration of pH meter.

(1) pH 4.01 buffer

(2)   pH 7.00 buffer

(3) pH 10.01 buffer

APPARATUS

1. pH meter - With glass and reference electrode (saturated calomel), preferably with temperature compensation. 2. Thermometer - With least Count of 0.5°C.

PROCEDURE

After required warm-tip period, standardize the instrument with a buffer solution of pH near that of the sample and check electrode against at least one additional buffer of different pH value.

Measure the temperature of the water and if temperature
compensation is available in the instruments adjust it accordingly. Rinse and gently wipe the electrodes with solution. If field measurements are being made, the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to ensure sufficient sample movement across the electrode sensing element as indicated by drift free readings (< 0.1 pH unit). If necessary, immerse them into the sample beaker or sample stream and stir at a constant rate to provide homogeneity and suspension ofsolids. Rate of stirring should minimize the air transfer rate at the air-water interface ofthe sample.
Note and record sample pH and temperature However, if there is a continuous drift, take a second reading with the fresh aliquot of sample without stirring and report it as the pH value.

3.4.5. TOTAL DSSOLVED SOLIDS [TDS]

The total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Therefore, the total dissolved solids test provides a qualitative measure of the amount of dissolved ions but does not tell us the nature or ion relationships. BIS prescribed that the desirable limit of TDS is 500 ppm and the maximum permissible level is 2000 ppm.

PROCEDURE

1) Heat the clean evaporating dish to 180°C for 1 hour. Cool in the desiccator, weigh and store in the desiccator until ready for use.

2) Filter a portion of the sample through any of the filters mentioned. Select volume of the sample which has residue between 25 and 250 mg. preferably between 100 to 200 mg. This volume may be estimated from values of specific conductance. To obtain a measurable residue. successive aliquots of filtered sample may be added to the sample dish,

3) Pipette this volume to a weighed evaporating dish placed ona steam-hath.

[26]

Evaporation may also be performed in a drying oven. The temperature shall be lowered to approximately 9 sec to prevent boiling and splattering of the sample. After complete evaporation of water from the residue. Transfer the dish to an oven at 103-105°C or 179·181°C and dry to constant mass, that is, till the difference in the successive weighings is less than 0.5 mg. Drying for a long duration (usually 1 to 2 hours) is done to eliminate necessity of checking for constant mass. The time for drying to constant mass with a given type of sample when a number of samples of nearly same type are to be analysed has to be determined by trial.

4) Weigh the dish as soon as it has cooled avoiding residue to stay for long time as some residues are hygroscopic and may absorb water from desiccant that is not absolutely dry.

3.4.6. TURBIDITY

PRINCIPLE

It is based on comparision of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the intensity of scattered light, the higher the turbidity.

Naphelomeretric turbidity is a measured by determining the sideward-scattered light intensity. A light beam is passed through the flow cell and the scatterd light produced by solid particles is detected at a specific angle. This measurement method eliminates the light that passes straight through the cells.

CALIBERATION- For the caliberation of the turbidity meter primary caliberation standards are used and the stock standard of 4000 NTU which is provided by thermo orion.

1NTU 10NTU 100NTU 1OOONTU

APPARATUS

1. Sample Tubes - The sample tubes should be of clear and colorless glass.
2. Turbidity meter- The turbidity meter shall consist of a nephelometer with a light source for
illuminating the sample and one or more photo electric detectors with a readout
device to indicate the intensity of light scattered at right angles to the path of the
incident light. The turbidity meter should be so designed that little stray light reaches the
detector in the absence of turbidity and should be free from significant drift after a
short warm-up period.

PROCEDURE
Turbidity meter Calibration- Follow the manufacturer's operating instructions. Measure the
standards on turbidity meter covering the range of interest. If the instrument is already
calibrated in standard turbidity units, this procedure will check the accuracy of
calibration.
Turbidity less than 40 units - Shake the sample to disperse the solids. Wait until
air bubbles disappear. Pour sample into turbidity meter tube and read turbidity directly from
the instrument scale or from calibration curve.

3.4.6. CONDUCTIVITY

Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions in the solutions, which in turn is related to the concentration of ionized substances in the water. Most dissolved inorganic substances in water are in the ionized form and hence contribute to conductance.

PRINCIPLE

This method is used to measure the conductance generated by various ions in the solution/water. Rough estimation of dissolved ionic contents of water sample can be made by multiplying specific conductance (in mS/cm) by an empirical factor which may vary from 0.55 to 0.90 depending on the soluble components of water and on the temperature of measurement.

[29]

Conductivity measurement gives rapid and practical estimate of the variations in the dissolved mineral contents of a water body.

APPARATUS

a. Self-contained conductance instruments: (Conductivity meter). These are commercially available.

b. Thermometer, capable of being read to the nearest 0.1^0C and covering the range $10\text{-}50^0C$.

c. Conductivity Cells: The cell choice will depend on the expected range of conductivity and the resistance range of the instrument . Experimentally check the range of the instrument results with the true conductance of the potassium chloride solution.

PRINCIPLE

Conductivity can be measured as per the instruction manual supplied with the instrument and the results may be expressed as mS/m or mS/cm. Note the temperature at which measurement is made. Conductivity meter needs very little maintenance and gives accurate results. However few important points in this respect are:

a. Adherent coating formation of the sample substances on the electrodes should be avoided which requires thorough washing of cell with distilled water at the end of each measurement.

b. Keep the electrode immersed in distilled water.

c. Organic material coating can be removed with alcohol or acetone followed by wasing with distilled water.

[30]

3.4.7. TOTAL HARDNESS

PRINCIPLE

This method depends on ability of ethylenediamin tetraacetic acid (C10 H16 O8 N2) or its disodium salt to form stable complexes with calcium and magnesium ions. When the dye eriochrome black T (EBT) (C2OH13.N3O7S) is added to a solution containing calcium and magnesium ions at pH 10.0 a wine red complex is formed. This solution is titrated with standard solution of disodium salt of EDTA, which extracts calcium and magnesium from the dye complex and the dye is changed back to its original blue color. Erichrome black T is used to indicate the end-point for the titration of calcium and magnesium together.

PROCEDURE

Standardization — Pipette 25.0 ml of standard calcium solution in a porcelain basin and adjust the volume to 50 ml with distilled water. Add 1 ml buffer solution.
2. Add 1 to 2 drops of indicator.
3. Titrate slowly with continuous stirring until the redish tinge disappears, adding last few drops at 3 to 5 second interval. At the end point the colour is sky blue.

[31]

CALCULATION

Calculate the hardness as follows:

Total hardness as = [1 000 (V1 – V2)/V3] × CF (CaCO3), mg/l where V1 = volume in ml of the EDTA standard solution used in the titration for the sample, V2 = volume in ml of the EDTA solution used in the titration for blank, V3 = volume in ml of the sample taken for the test, CF = X1/X2 = correction factor for standardization of EDTA, X1 = volume in ml of standard calcium solution taken for standardization, and X2 = volume of ml of EDTA solution used in the titration.
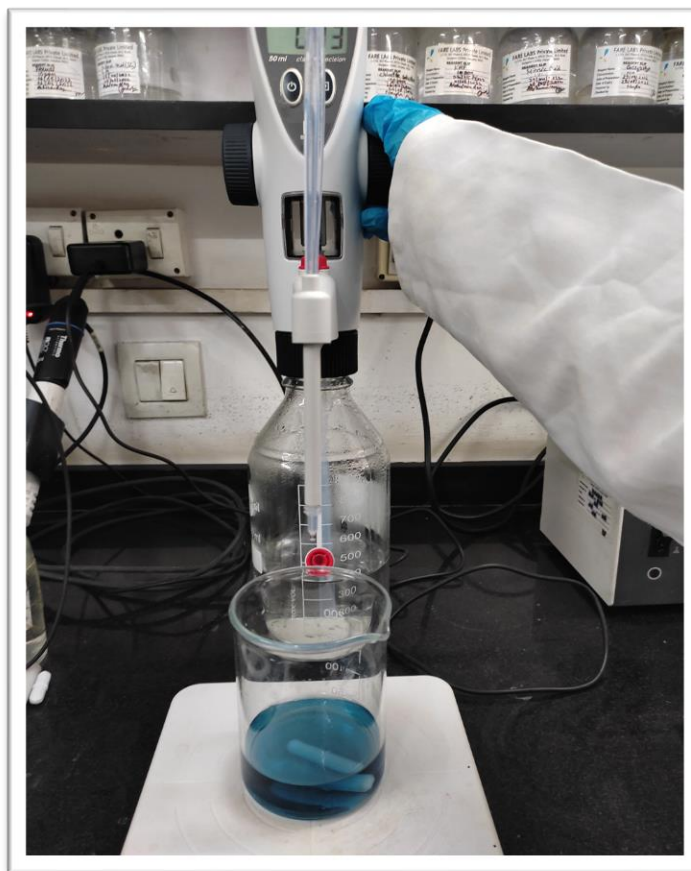
3.4.8. CALCIUM

In a solution containing both calcium and magnesium, calcium can be determined directly with EDTA (ethylene diamine tetra-acetic acid or its salts.) when the pH is made sufficiently high (J2 to 13) so that the magnesium is largely precipitated as the hydroxide and an indicator is used which combines, only with calcium. At higher pH i.e. about 12.0 Mg++ ions precipitate and only Ca++ ions remain in solution.

Ca++ gets complexed resulting in a change from pink to purple which indicates end point of the reaction. The acceptable limit of Calcium is 75mg/L max.
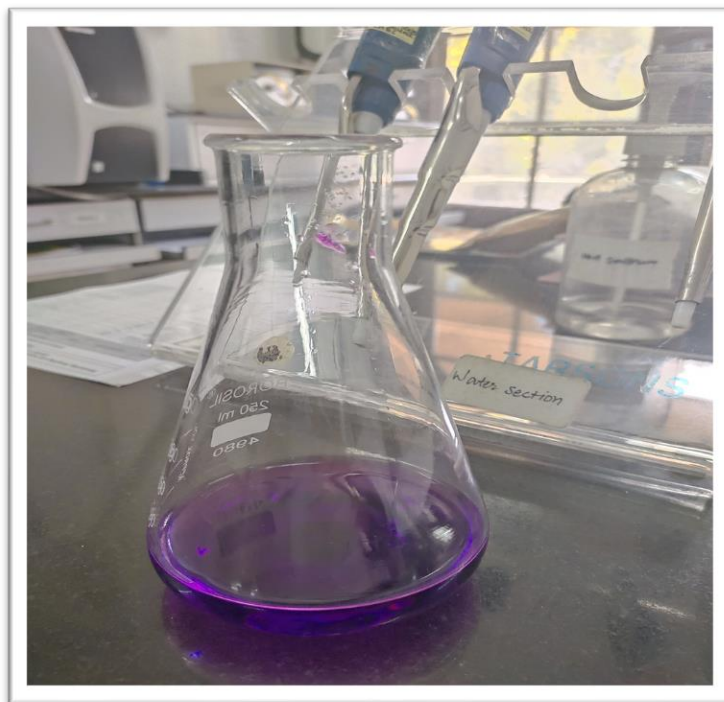
3.4.9. MAGNESIUM

Magnesium (Mg) occurs commonly in the minerals magnesite and dolomite. Magnesium is used in alloys, pyrotechnics, flash photography, drying agents, refractories , fertilizers, pharmaceuticals and foods. The average abundance of Mg in the earth's crust is 2.1 % ; in soils it is 0.03 to 0.84% in streams it is 4mg/L and in groundwater it is greater than 5mg/L.

PRINCIPLE

Diammonium hydrogen phosphate quantitative!y precipitates magnesium in ammonical solution as magnesium ammonium phosphate. The precipitate is ignited and weighed as magnesium pyrophosphate. Below 1 mg/ l, atom ic absorption spectrophotometric method is desirable.

APPARATUS

Vacuum Pump or Other Source of Vacuum

Filter Flasks

Filter Crucibles - medium porosity

PROCEDURE

Pre-treatment of Polluted Water and Waste Water Samples

Mix the sample pretreated if so required and transfer a suitable volume (50 to 100 011) to 250 ml conical flask or a beaker. Add 5 ml concentrated nitric acid and a few boiling chips or glass beads. Bring to a slow boil and evaporate on a hot plate to the lowest volume possible (about 10 to 20m l) before precipitation or salting occurs. Add 5 ml concentrated nitric acid cover with a watch glass and heat to obtain a gentle refluxing action. Continue heating and adding concentrated nitric acid as necessary until digestion is complete as shown by a light-coloured clear solution. Do not let sample dry during digestion. Add I to 2 ml concentrated nitric acid and warm slightly \0 dissolve any remaining residue. Wash down beaker walls and watch glass with water and then filter, if necessary. Transfer filtrate to 100 ml volumetric flask, with two 5-ml portions of water adding these rinsings to the volumetric flask. Cool, dilute to mark and mix thoroughly. Take portions of this solution for the determination.

Removal of Calcium and Other Metals as Oxalates

To 200 ml of the sample pretreated if so required containing about 50 mg of calcium, add a few drops of methyl red indicator and I: I hydrochloric acid. Sufficient acid must be present in the solution to prevent the precipitation of calcium oxalate when ammonium oxalate solution is added. Introduce SO ml of ammonium oxalate solution and I5g of urea. Boil the solution gently until the methyl red changes its colour to yellow. Filter the precipitate and wash with small volume of cold water until free from chloride.

[34]

Determination of Magnesium

To the combined filtrate and washings from 5.5.2 containing not more than 60mg magnesium add 50 ml of concentrated nitric acid and evaporate carefully to dryness on a hot plate. Do not let reaction become too violent during the later part of the evaporation stay in constant attendance to avoid losses through spattering. Moisten residue with 2 to 3 ml of concentrated hydrochloric acid, add 20 ml of distilled water, warm, filter and wash. To the filtrate add 3 011 of concentrated hydrochloric acid 2 to 3 drops of methyl red solution, and 10 ml of (NH,).HPO, solution. Cool and add concentrated ammonium hydroxide drop by drop, stirring constantly until the colour changes to yellow, stir for 5 minutes add again S ml of concentrated ammonium hydroxide and stir vigorously for 10 minutes more. Let it stand overnight and filter through filter paper. Wash with 1: 19 ammonium hydroxide. Transfer to an ignited, cooled and weighed crucible. Dry precipitate thoroughly and burn paper off slowly, allowing circulation of air. Heat at about SOO°C until residue is white. Ignite for 30 minutes at 1 100°C to constant mass.

CALCULATION

Magnesium, mg/L= $\frac{M}{V}$ x 21S·4x 10^3

where M = mass in mg of magnesium pyrophosphate, and V = volume in ml of sample.

3.4.10. ALKALINITY

It is also the measure of buffering capacity or its ability to resist changes in pH upon the addition of acid and bases. Bicarbonates present in the water represents the major form of alkalinity in natural water.

PRINCIPLE

Alkalinity of a sample can be estimated by titrating with standard sulphuric acid (0.02N) at room temperature using phenolphthalein and methyl orange indicator. Titration to decolorisation of phenolphthalein indicator will indicate complete neutralization of OH and ½ of CO_3, while to pH 4.5 or sharp change from yellow to orange of methyl orange indicator will indicate the complete neutralization of OH, CO_3 and HCO_3.

APPARATUS
pH Meter
Burette - 50ml capacity.

Magnetic Stirrer Assembly

PROCEDURE

Pipette 20 ml of sample into a 100-ml beaker. If the pH of the sample is over 8.3, then add 2 to 3 drops of phenolphthalein indicator and titrate with standard sulphuric acid solution till the pink color observed by indicator just disappears (equivalence of pH 8.3). Record the volume of standard sulphuric acid solution used. Add 2 to 3 drops of mixed indicator to the solution in which the phenolphthalein alkalinity has been determined. Titrate with the standard acid to light pink color (equivalence of pH 3-7). Record the volume of standard acid used after phenolphthalein alkalinity.

CALCULATIONS

Calculate alkalinity are as follows:

$$\frac{BR X 0.02 X 50,000}{Volume\ of\ sample}$$

Where, BR is burette reading.
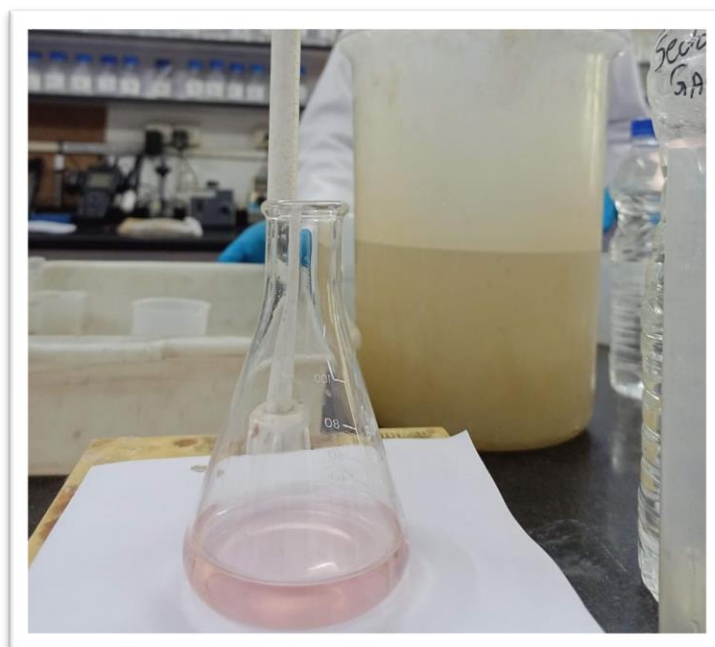
3.4.11. CHLORIDE

PRINCIPLE
Chloride can be titrated with mercuric nitrate because of the formation of soluble, slightly dissociated mercuric chloride. In the pH range 2.3 to 2.8. diphenyl carbazone indicates the end point by the formation of a purple complex with excess mercuric ions.

Chloride, in the form of chloride (cl⁻) ion, is one of the major inorganic anions in water and wastewater. The salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water.

The chloride concentration is higher in wastewater than in raw water because sodium chloride (Nacl) is common article of diet and passes unchanged through digestive system.Potassium chromate can indicate the endpoint of the silver nitrate titration of chloride. Silver chloride is precipitated quantitatively before red silver chromate is formed.

It can also be done by Potentiometric method . Chloride is determined by potentiometric titration with silver nitrate solution with a glass and silver-silver chloride electrode system.

Potentiometric titration principle is based on when the pair of electrodes are placed in

the sample solution or analyte , it shows the potential difference between the two electrodes by addition of the titrant or by the change in the concentration of ions.

During titration an electromotive volt meter is used to detect the change in potential between the two electrodes. The endpoint of the titration is that the instrument reading at which the greatest change in voltage has occured for a small and constant increment of silver nitrate added.

PROCEDURE

Use a 100 ml sample that the chloride content is less than 10 mg. Add 1.0 ml indicator-acidifier reagent. For highly alkaline or acid waters, adjust pH to about 8 before adding indicator-acidifier reagent. Titrate with 0.41 1 N mercuric nitrate to a definite purple end point. The solution turns from green blue to blue a few drops before the end point. Determine the blank by titrating 100 ml distilled water containing 10 mg of sodium bicarbonate.

CALCULATION

$$\frac{(BR - 0.5) X 0.0141 X 35,450}{Volume\ of\ sample}$$

where, BR= burette reading.

3.4.12. SULPHATE

The sulfate ion is one of the major anion occuring in natural waters. Mine drainage wastes may contribute large amount of Sulphate (SO_4^{2-}) .Sulphate (SO_4^{2-}) ion is precipitated in an acetic medium with barium chloride ($BaCl_2$) so as to form barium sulfate crystals of uniform size. The reaction involved is given below: $Ba^{++} + SO_4 = BaSO_4$

PRINCIPLE

This method is used for the determination of sulphate ions. Sulphate ion (SO_4^-) is precipitated in the size. The reaction involved is given below:$Ba^{++} + SO_4$ $BaSO_4$ (White suspension)

Light absorbance of the $BaSO_4$ suspension is measured by a photometer or the scattering of light by Nephelometer.

APPARATUS

   a. Magnetic stirrer

   b. Colorimeter for use at 420mm or turbiditymeter/nephelometer

   c. Stopwatch

   d. Nessler tubes, 100Ml

   e. Measuring spoon 0.2 to 0.3 mL

PROCEDURE

   a. Take suitable volume of sample and dilute to 100mL into a 250mL Erlenmeyer flask.

   b. Add 20mL buffer solution, mix well

   c. Keep the flask constantly stirred with the help of stirrer. Add 1- spatula $BaCl_2$ crystals with stirring . Continue stirring for 1min after addition of $BaCl_2$.

   d. Pour suspension into an absorbance cell of photometer an measure turbidity at 5+_ 0.5min.

   e. To correct for sample colour and turbidity, run a blank to which $BaCl_2$ is not added.

CALCULATION

$MgSO_4$--/L={mg(SO_4) x 1000}/ {mL of sample}

3.4.13. NITRATE

Nitrate is the most highly oxidised form of nitrogen compounds commonly present in natural waters. Significant sources of nitrate are chemical fertilizers , decayed vegetables and animal matter , domestic effluents , sewage sludge disposal to land, industrial discharge , leachates from refuse dumps and atmospheric washout.

[41]

The method is useful for the water free from organic contaminants and is most suitable for drinking. dcaliberation curve follows Beer's law upto 1-11mg/LN.

Nitrate is determined by measuring the absorbance at 220nm in sample containing 1ml of hydrochloric acid (1N) in 100ml sample. The concentration is calculated from graph from standard nitrate solution in range 1-11 mg/L as N.

APPARATUS

a. Spectrophotometer, for use at 220nm and 275nm with matched silica cells of 1cm or longer light path.

b. Filter : One of the following is required.

   1. Membrane filter: 0.45μm membrane filter

   2. Paper filter

c. Nessler tubes, 50Ml, short form.

PROCEDURE

Read the absorbance or transmittance against redistilled water set at zero absorbance or 100% transmittance. Use a wavelength of 220nm to obtain the nitrate reading and, if necessary, a wavelength of 275nm to obtain interference due to dissolved organic matter.

3.4.14. FLUORIDE

Fluoride may occur naturally in water or it may be added in controlled amounts. Some fluorisis may occur when the fluoride level exceeds the recommended limits. In rare instances, the naturally occuring fluoride concentration may approach 10mg/L.

Fluoride is more common in ground water than in surface water. The main source of fluoride in ground water are different fluoride bearing rocks. A fluoride concentration of approximately 1mg/L in drinking water effectively reduces dental care or tooth decay without any harmful effects on health.

PRINCIPLE

The colour (red to yellow with increasing concentration of fluoride) obtained with zirconium alizarin reagent is matched against that produced with a series of standard fluoride solutions.

A total ionic strength Adjustment buffer (TISAB) is a buffer solution which increases the ionic strength of a solution to a relatively high level. It is important for ion selective electrodes because they measure the activity of analyte rather than its concentration.

Fluoride measurement is done by ion-selective electrode. Its acceptable unit is 1.0 and its permissible limit is around 1.5.

APPARATUS

Nessler Tubes, 100 ml capacity.

Distillation Apparatus - The distillation apparatus shall consist o f a Claisen flask of 100 ml capacity.

A large flask for generating steam and an efficient condenser. The main neck of the Claisen flask shall be filled with a two-holed rubber stopper through which shall pass a thermometer and a glass tube (for connecting with the steam supply) . both the thermometer and tube extending almost 10 the bottom of the flask . The Side neck of the flask shall be closed with a rubber stopper and the side an connected with the condenser. Steam shall be generated from water made alkaline with sodium hydroxide. Local overheating of the Claisen flask shall be avoided by use of an asbestos board with a hold which shall fit closely to the lower surface of the flask.

3.4.15. BIOCHEMICAL OXYGEN DEMAND (BOD)

PRINCIPLE

The biochemical oxygen demand (BOD) test is based on mainly bio-assay procedure which measures the dissolved oxygen consumed by micro-organisms while assimilating and oxidizing the organic matter under aerobic conditions. The standard test condition includes incubating the sample in an air tight bottle, in dark at a specified temperature for specific time.

APPARATUS

i) Incubation Bottles
300 ml capacity narrow neck special BOD bottles with planed mouth with ground glass stoppers. New bottles should be cleaned with 5 N hydrochloric acid or sulphuric acid followed by rinsing with distilled water. In normal use, bottles once used for Winkler's procedure should only be rinsed with tap water followed by distilled water. During incubation (if incubator is used) to ensure proper sealing, time to time, add water to the flared mouth of the bottle.
ii) Air Incubator
Air incubation with thermostatically controlled 27°C ± 1°C. Avoid light to prevent possibility of photosynthetic production of oxygen.

[44]

PROCEDURE

After taking water in incubation bottles, 4 capsules (or 4 gm) of NaOH has been kept at the neck of the bottle. A magnetic stirrer is put inside the bottle. The magnetic stirrer continuously rotates inside the bottle. Then it is kept air tight by the special caps attached

with an electronic meter, which directly records BOD reading at every 24 hour. Now the bottles are preserved in the incubators for days as per requirement of study. The same procedure follows for BOD 3 days and BOD 5 days.

Picture showing BOD Incubator.

4. OBSERVATION AND RESULT

4.1. COLOR

The color of the different water samples for the analysis were found to be clear water in color. The acceptable limit is 5 hazen while the permissible limit of color is 15 hazen maximum.

The samples of groundwater for color were found below the permissible limit.

4.2. TASTE

The taste of different water samples of groundwater were found to be agreeable as per the guidelines IS:10500.

4.3. ODOUR

The odour for the samples of different groundwater were found to be agreeable as per the guidelines IS:10500.

4.4. 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 sample is from 6.74 to 8.36 which is under the acceptable limits.
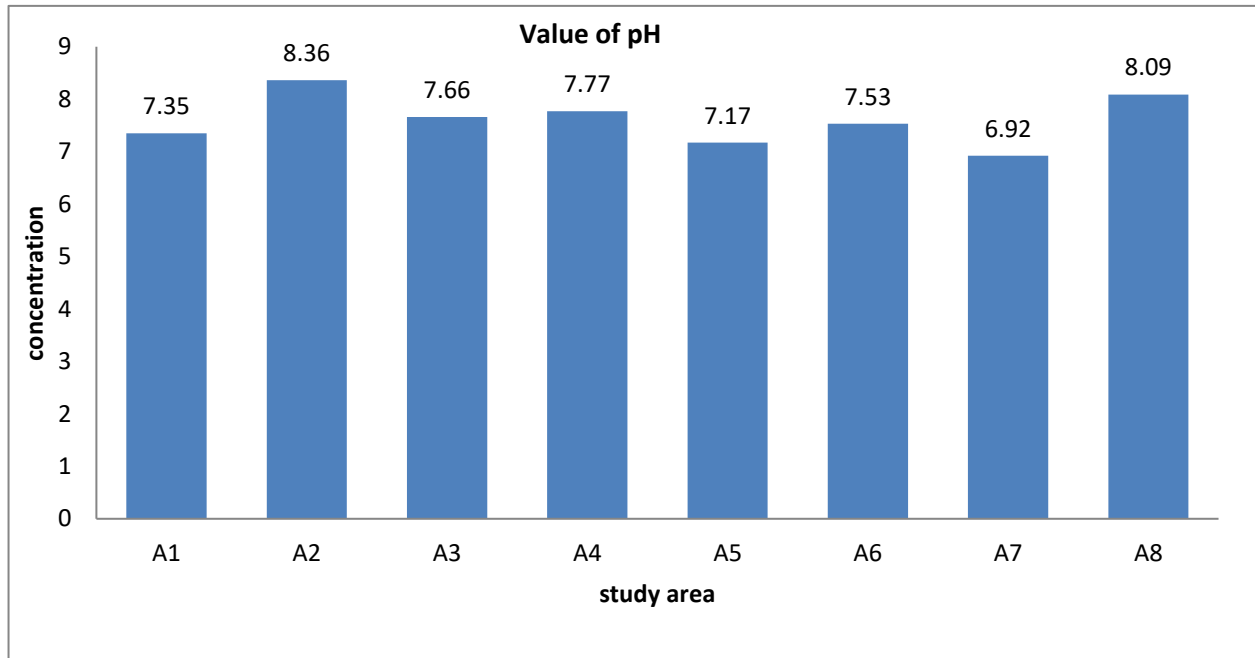
Fig 1.1. - Average pH of the water samples from different areas

4.5. TURBIDITY

Measurement of turbidity reflects the transparency of water. It is caused by the substances present in water suspension. In natural water it is caused by clay, slit, organic matter and other microscopic organisms. It ranged from 0.306 to 2.029. However the permissible limit of drinking water is 5 NTU (IS:10500). Turbidity was found within the permissible limit in all the water samples.
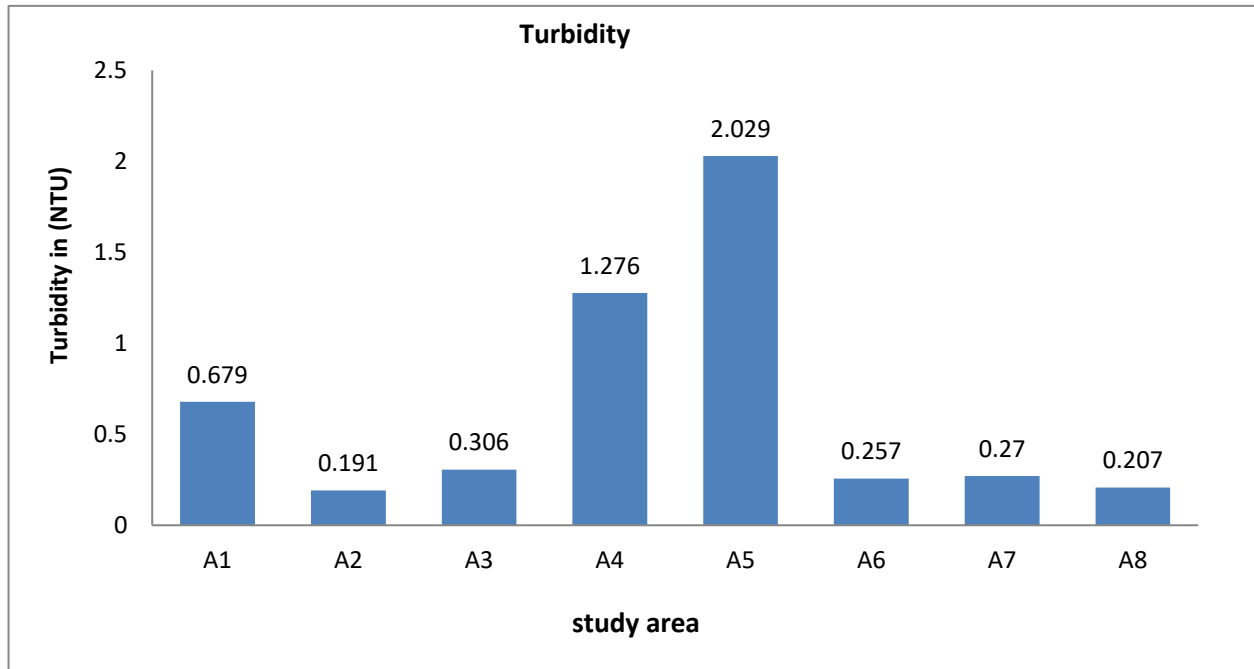
Fig 1.2. - Average Turbidity of the water samples from different areas.

4.6. TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids may be considered as salinity for classification of groundwater. The TDS in groundwater is due to the presence of Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride and Sulphate ions. TDS varied from 153 to 1432 mg/L. As the acceptable limit of TDS is around 500 mg/L. It is found that in some of the water samples the TDS is exceeding the acceptable limit.
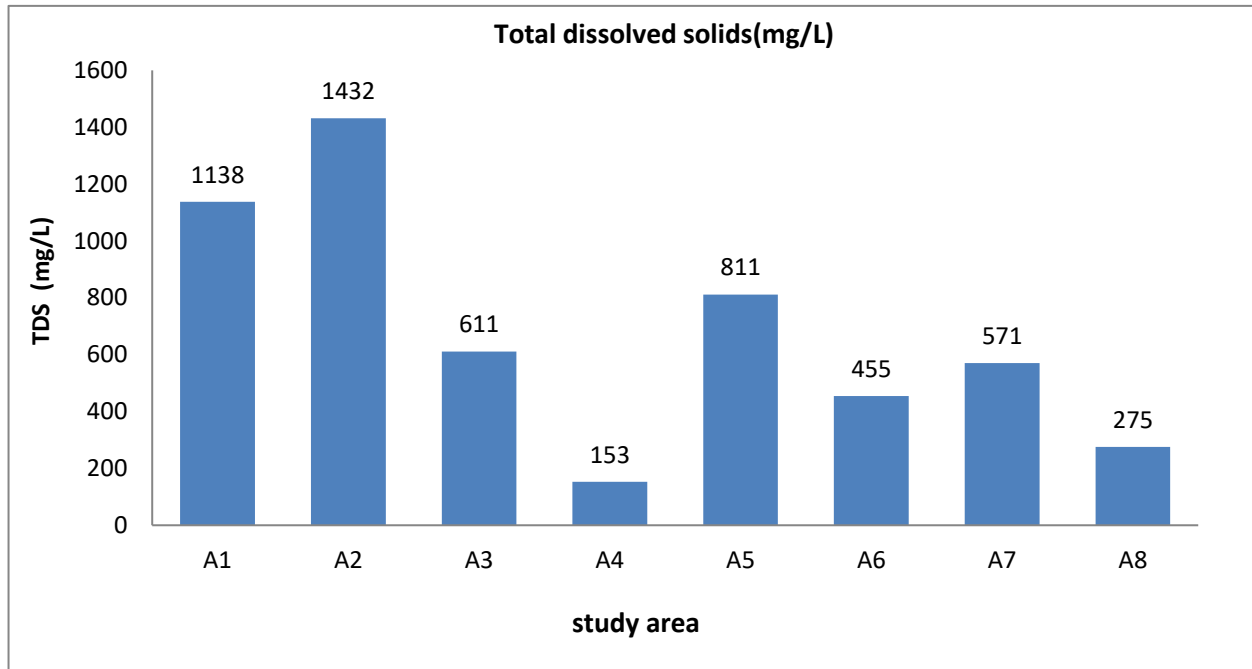
Fig 1.3. - Average Total Dissolved Solids of the water samples from different areas

4.7. TOTAL HARDNESS

The simple definition of water hardness is the amount of dissolved calcium and magnesium ions present in the water. Hard water is high in dissolved minerals, largely calcium and magnesium.

Hardness of water generally comes from laundry and domestic purposes since it consumes a large quantity of soap. As per the present day analysis the hardness of water found between 106 to 610 mg/L. However the acceptable limit of hardness of drinking water is 200 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 below in the table. It is found that the water supply of different localities varies as the hardness exceeds the acceptable limits. Hardness of water varied from 106 to 610 mg/L. Some of the samples of ground water exceeds the acceptable limit.

 The degree of hardness of drinking water has been classified in terms of the equivalent CaCO$_3$ concentration.

[49]

Table 2- Classification of the water sample according to hardness.

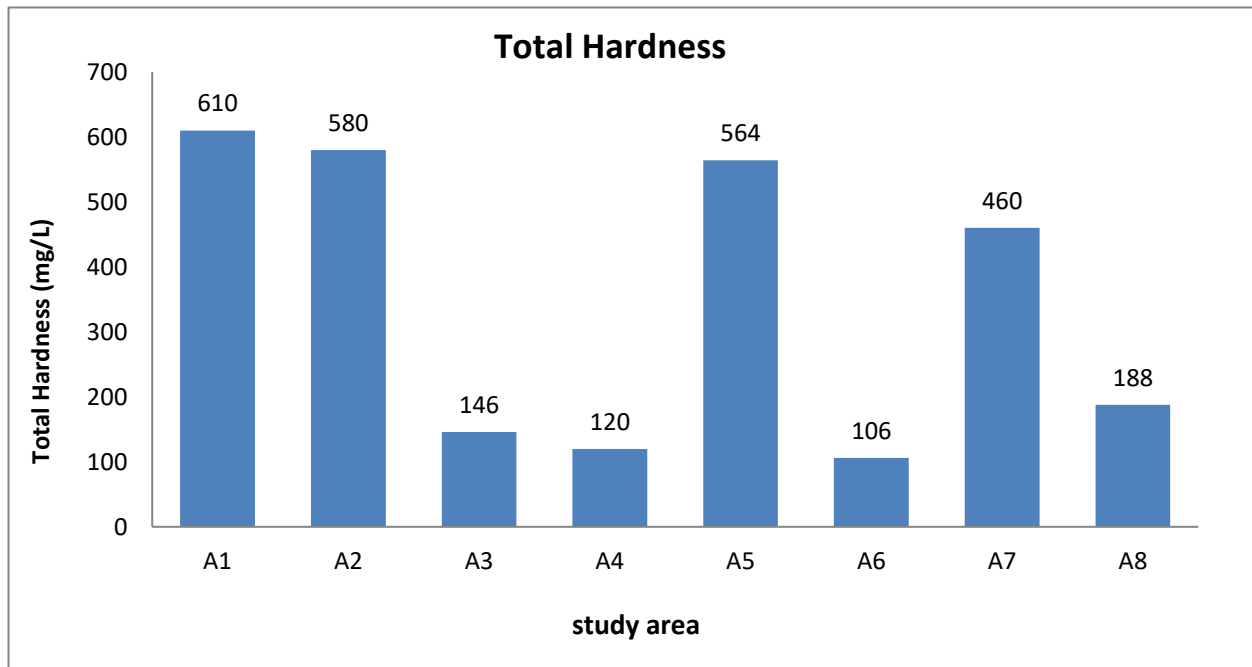| TDS Range	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
>180	Very Hard

Total Hardness

Fig 1.4. - Average hardness of the water samples from different areas

4.8. TOTAL ALKALINITY

The alkalinity refers to the measure of the capacity of water to neutralize the acids. It can measure the bicarbonate, carbon dioxide, hydroxide ions, and carbonate naturally present in the water.

In the present study Phenolphthalein Alkalinity was only present in one of the sample and the Methyl Orange alkalinity or the total alkalinity was ranged from 80 mg/L to 880 mg/L. This indicates the presence of Hydroxyl and Carbonate ions in water.

The acceptable limit of Alkalinity of drinking water is 200 mg/L. Almost all the samples exceeds the acceptable limit of Alkalinity of drinking water except a few is found lying in the range of acceptable limits.
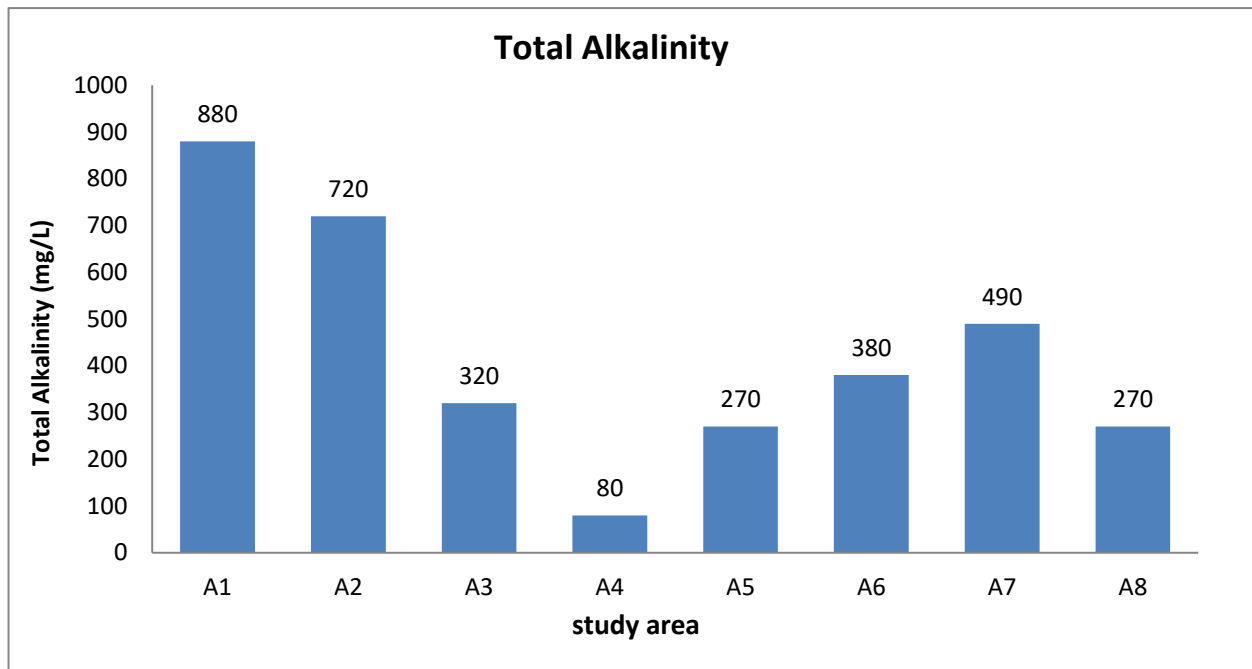

Fig 1.5. - Average alkalinity of the water samples from different areas

4.9. CALCIUM

Calcium, in the form of the Ca^{2+} ion, is one of the major inorganic *cations*, or positive ions, in saltwater and freshwater.

Most calcium in surface water comes from streams flowing over limestone, $CaCO_3$, gypsum, $CaSO_4.2H_2O$, and other calcium-containing rocks and minerals. Groundwater and underground aquifers leach even higher concentrations of calcium ions from rocks and soil. Calcium carbonate is relatively insoluble in water, but dissolves more readily in water containing significant levels of dissolved carbon dioxide.

The acceptable limit of Calcium of drinking water is 75 mg/L. In the present study, only in two of the samples were found to be exceeding the acceptable limits.
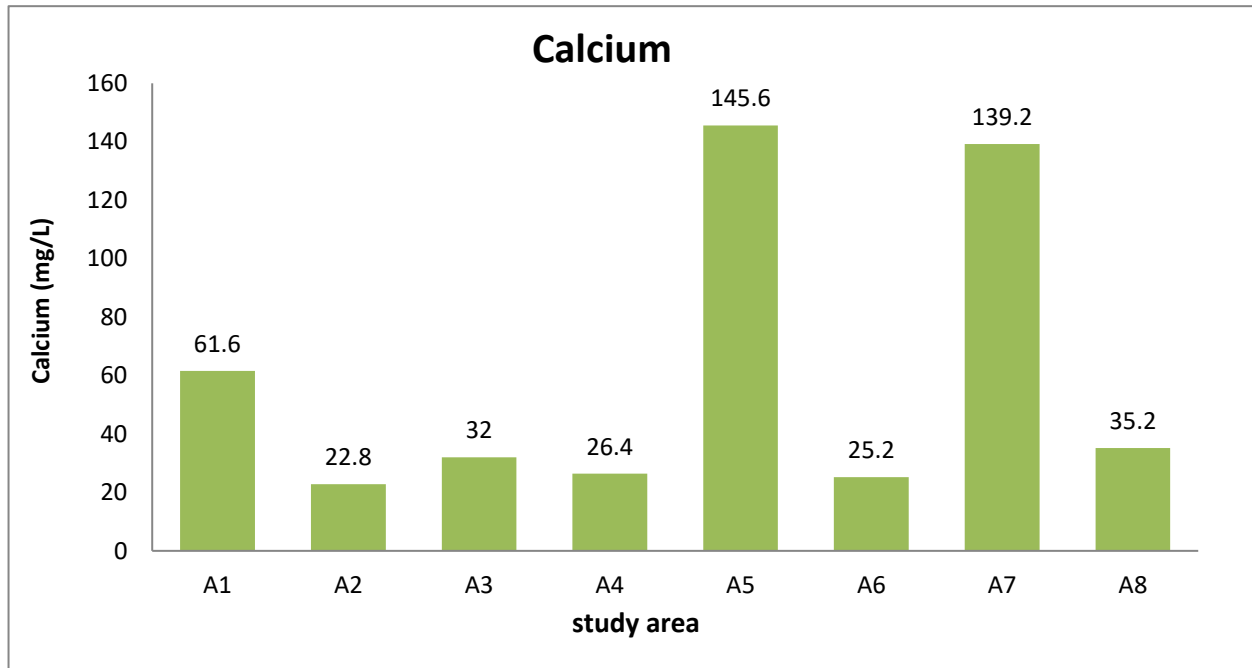

Fig 1.6. - Average Calcium of the water samples from different areas

4.10. CHLORIDE

Chloride is a naturally occurring element that is common in most natural waters and is most often found as a component of salt (sodium chloride) or in some cases in combination with potassium or calcium. The presence of chloride in groundwater can result from a number of sources including the weathering of soils, salt-bearing geological formations, deposition of salt spray, salt used for road de-icing, contributions from wastewaters and in coastal areas, intrusion of salty ocean water into fresh groundwater sources. In PEI, chloride levels in groundwater are relatively usually fairly low, but can become elevated in areas near the coast, or in areas of heavy salting of roads.

In the study area there is frequent change in chloride concentration and it's ranged from 14.99 to 749 mg/L. Chloride which have been associated with pollution as an index are found above the acceptable limit in few of the area. The acceptable limit of chloride is

250 mg/L. Chloride in excess (>250 mg/L) imparts a salty taste to water and people who are not accustomed to high chlorides can be subject to laxative effects.
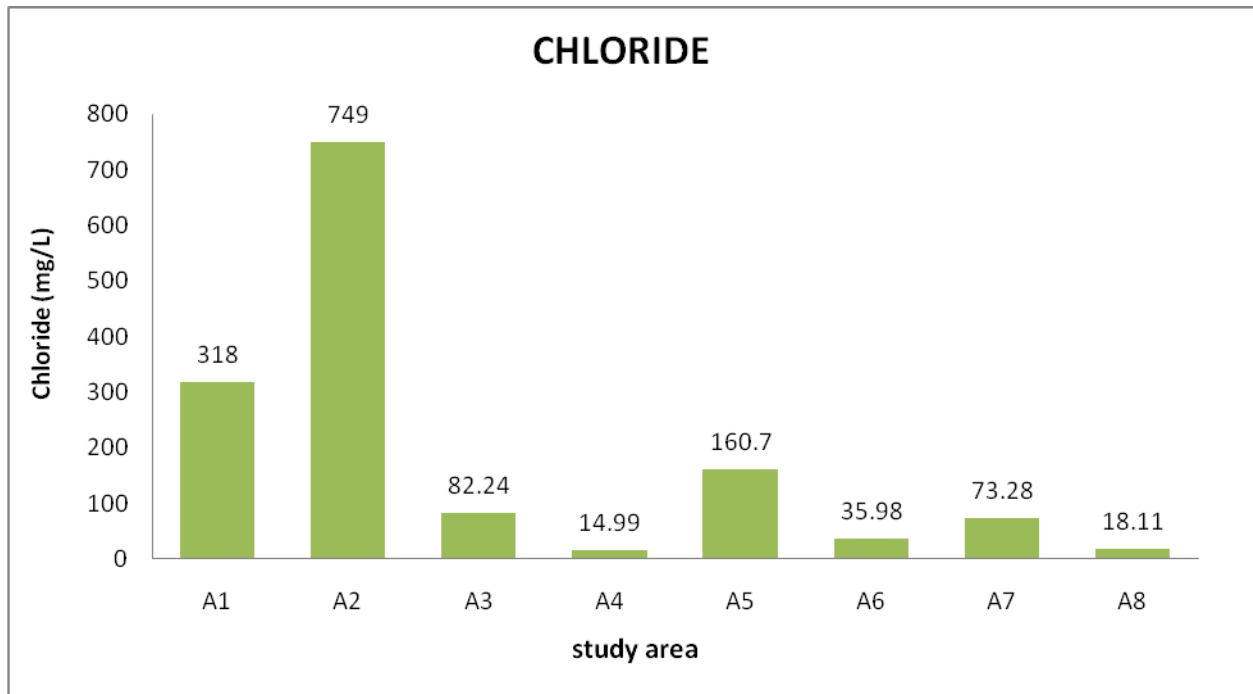

Fig 1.7. - Average chloride present in the samples from different areas

4.11. SULPHATE

Sulphate occurs naturally in most of the groundwater. Higher levels of sulphate are common in the western part of the state. At high levels, sulfate can give water a bitter or medicinal taste and can have laxative effects.

People who are not used to drinking water with high sulphate can get diarrhea and dehydration from drinking the water. Infants are often more sensitive to sulfate than adults. To be safe, only use water with a sulfate level lower than 500 milligrams per liter (mg/L) to make infant formula. Older children and adults may get used to high sulfate levels after a few days.

Sulphate levels above 250 mg/L may make the water taste bitter or like medicine. High sulphate levels may also corrode plumbing, particularly copper piping. In areas with high sulfate levels, plumbing materials more resistant to corrosion, such as plastic pipe, are

commonly used.

As water moves through soil and rock formations that contain sulfate minerals, some of the sulphate dissolves into the groundwater. Minerals that contain sulphate include magnesium sulphate (Epsom salt), sodium sulphate (Glauber's salt), and calcium sulphate (gypsum).
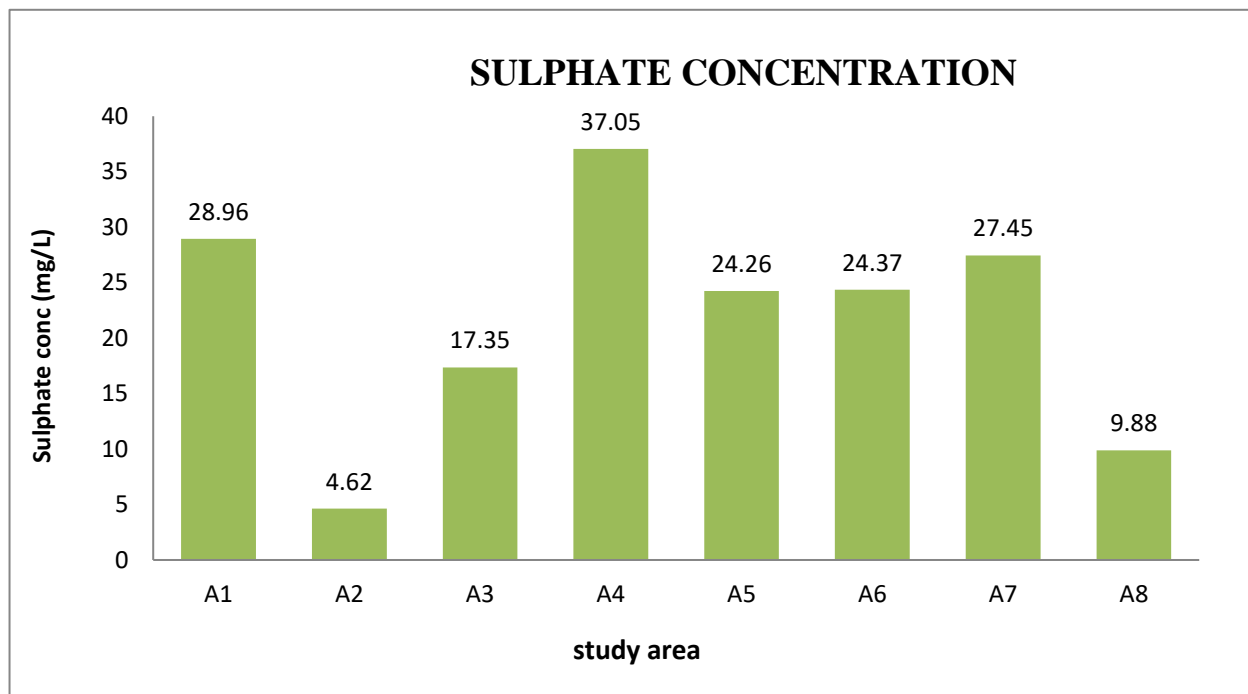

Fig 1.8. - Average sulphate content present in samples from different areas

The sulphate ion produces effect upon human beings if it is present in excess amount. The higher values of sulphate content may be contributed due to chemical, anthropogenic sources and industrial process etc.

The sulphate ion concentration in ground water samples ranged from 4.62 to 37.05 mg/L and is found under the acceptable limits.

4.12.   NITRATE

Nitrate (NO3) is a compound of nitrogen and oxygen found in nature and in many food items in our diet. Generally, the concentration of nitrates in the ground water is found to

be low. The main adult human intake of nitrates is from food rather than from water. Vegetables such as spinach, lettuce, beets and carrots contain significant amounts of nitrate. Drinking water normally contributes only a small percentage of our total nitrate intake.
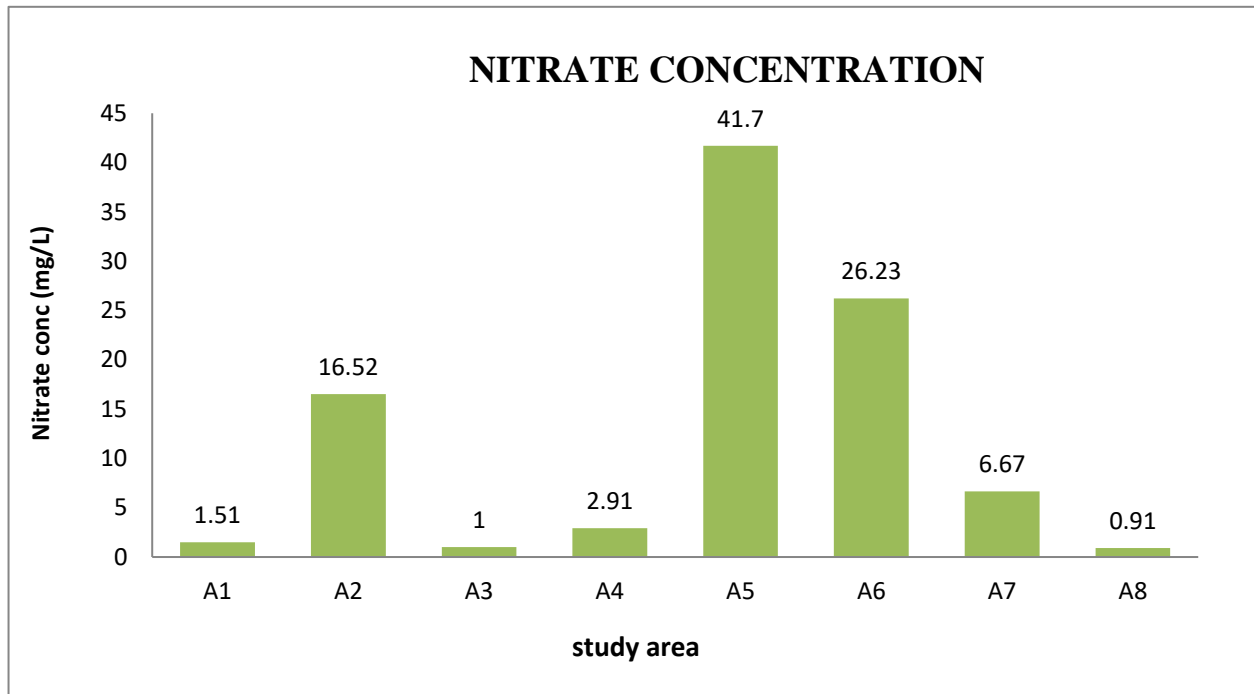

Fig 1.9. - Average nitrate content present in the water samples from different areas

The acceptable limit of nitrate in drinking water as per IS:10500 is 45 mg/L.

Nitrate concentration in samples of ground water varies from 0.91 to 41.7 mg/L and is found under the acceptable limits.

4.13. BIOCHEMICAL OXYGEN DEMAND

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 area of Sukhrali Village is within the permissible limit (3 to 4 mg/l).
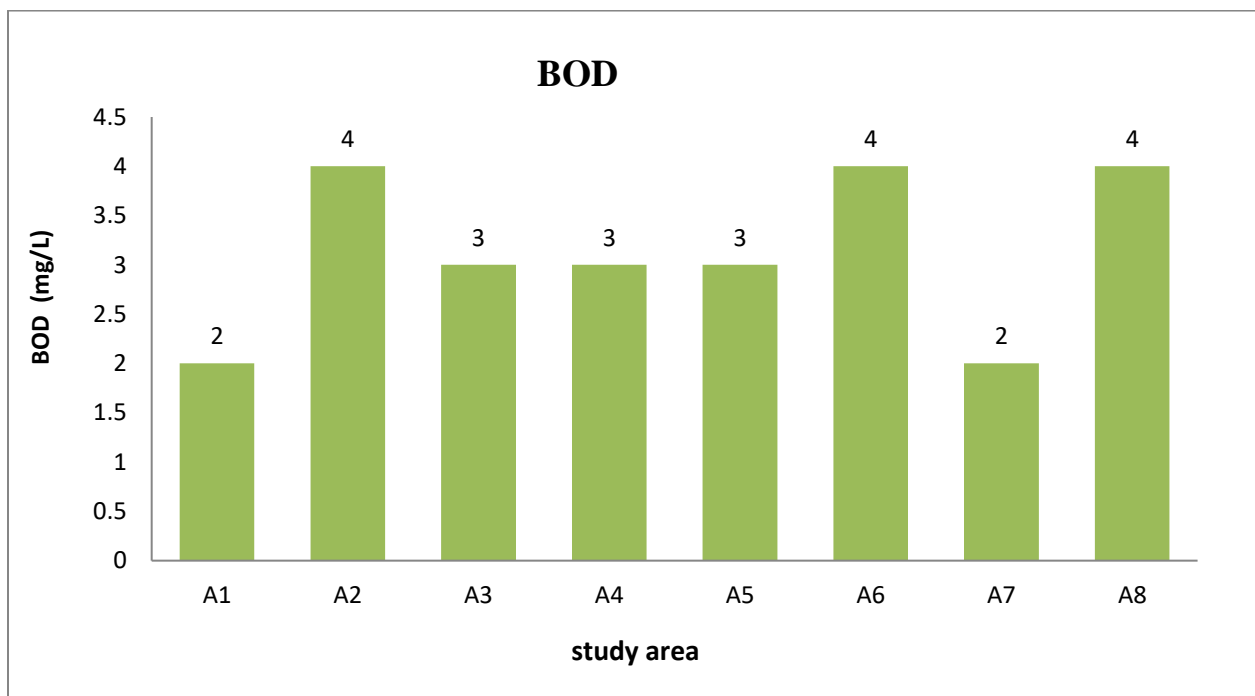

Fig 1.10.- Average BOD present in the water samples from different areas

4.14. FLUORIDE

Fluoride is the second-most common pollutant of drinking water in India, according to the National Health Portal. Intake of excess fluoride affects the teeth and bones, and can even cause arthritis, cancer, infertility in women, brain damage and Alzheimer's disease, according to doctors.
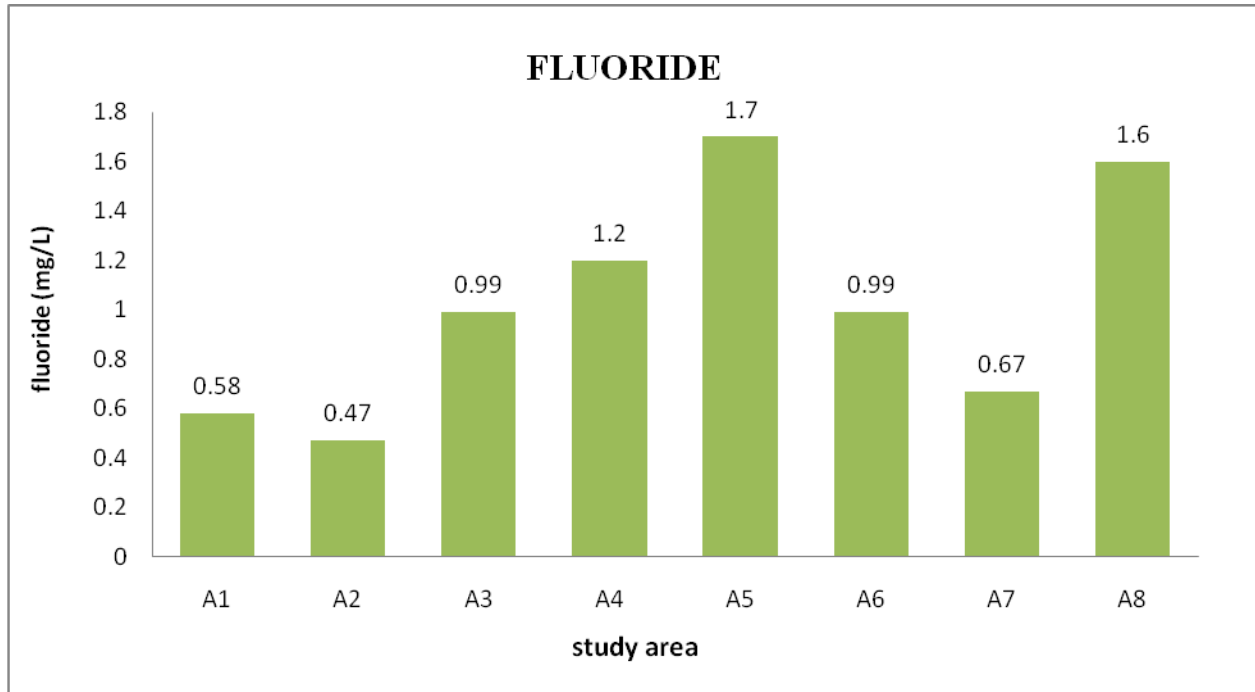

Fig 1.11.- Average Fluoride content present in the water samples from different areas

The acceptable limits of fluoride is 1 mg/L and the permissible limit is 1.5 mg/L.

In the samples of ground water fluoride content ranges from 0.47 to 1.6 mg/L. Some of the samples of ground water exceeds the acceptable and permissible limits.

5.CONCLUSION

The average ranges of physical and chemical characteristics of water quality are as per as the ground water quality. The pH ranges from 6.92 to 8.36 which is under the permissible limits. Turbidity ranges from 0.191 to 2.029. Some of the samples exceeding the acceptable limits in turbidity. Total Dissolved Solids ranges from 153 to 1432 and is found to be exceeding the acceptable limits according to IS:10500.

Hardness of water ranges from 106 to 610 mg/L and is found to be exceeding the acceptable limits. Alkalinity of water ranges from 80 to 880 mg/L and is found to be exceeding the the acceptable limits.

Calcium ranges from 22.8 to 145.6 and found to be above the acceptable limits. Chloride value differ from 14.99 to 749 and it is also found above the acceptable limits. Sulphate concentration ranges from 4.62 to 37.05 and the sulphate concentration is found to be under the acceptable limits. Nitrate concentration ranges from 1.51 to 41.7 and it is under the acceptable limits. Biochemical Oxygen Demand ranges from 2 to 4 and is found to be under the permissible limit as per as the guidelines of IS:10500.

These parameters resembles the drinking water quality of ground water of Sukhrali Village, Gurgaon, most of the parameters are exceeding the acceptable limits but all the samples were found under the permissible limit as per the guidelines in IS:10500.

At ast I want to conclude that precautionary steps should be taken so that the people living in that area will have safe water for drinking.

6.RECOMMENDATIONS AND SUGGESTIONS

6.1. RECOMMENDATIONS

There are various measures which made to control the water pollution;

1. Proper planning should be executed before drawing the underground water.

2. Ground water must be pretreated so as to ensure less health threats.

3. People awareness campaigning should be organized/implemented by the government and non-government organization.

4. The overall quality of groundwater is poor and this situation needed urgent treatment.

5. Programs should be implemented to monitor the bore wells and hand pumps exceeding the limitation of guidelines

6. Domestic waste and agricultural activities affect groundwater quality so the monitoring of fertilizers and pesticides is needed.

7. Water quality index is a manual way in order to understand the water quality.

6.2. SUGGESTIONS

1. The household discharged water should be treated so that it become Environ.ly safe. In order to prevent water pollution, human and animal excreta should be prevented from mixing with water sources.

2. Treatment of wastes before discharge is necessary. Toxic material must be treated chemically and converted into harmless materials. Factories should try to recycle the waste water.

3. Laws relating to pollution should be strictly enforced on people.

4. The water that flows through the drainage system should be properly treated. Harmful pollutants should be removed, before they can are introduce into groundwater.

5. Big cities usually have treatment plants which filter out undissolved materials but dissolved remain as such.

6.Chemical treatment can be given to separate out unwanted dissolved chemicals materials.

7. The treated water can be used for farming / cleaning purpose.

8. Washing, bathing of animals in the pond that is used by human should not be done.

9. Washing of clothes and bathing of animals make the pond water dirty and unsuitable for use.

10. Drinking water kept undercover in a clean place. One should not put his hands into the drinking water containers.

11. The water meant for drinking should be made microorganisms free boiling generally kills microorganism prior to use.

12. Sanitation system must be improved. The benefits of cleanliness on human health need to be understood.

13. People should be aware about the effect of water pollution. Voluntary organizations can render door-to-door services to educate the people about Environmental Problems.

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