A STUDY OF AQUIFER SYSTEMS AND GROUNDWATER CONTAMINATION DUE TO HEAVY METALS IN PARTS OF SAHIBABAD INDUSTRIAL AREA ALONG HINDON RIVER GHAZIABAD, U.P.

THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY
IN
ENVIRONMENTAL ENGINEERING

SUBMITTED BY

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CERTIFICATE

It is certified that the work presented in this thesis entitled "A Study of Aquifer Systems And Groundwater Contamination Due to Heavy Metals In Parts of Sahibabad Industrial Area along Hindon river, Ghaziabad,U.P" submitted by Chhavi Solanki(2K13/ENE/18) in partial fulfilment for the award of the degree of Master Of Technology (M-Tech) in Environmental Engineering, Delhi Technological University(Formerly Delhi College Of Engineering),New Delhi is an authentic record. The work is being carried out by her under my guidance and supervision in the academic year 2015.

The work embodied in this major project has not been submitted for the award of any other degree to the best of our knowledge.

Ms. GEETA SINGH

Assistant Professor

Supervisor

DATE:

PLACE: NEW DELHI

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CHHAVI SOLANKI
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DECLARATION

I, hereby, declare that the work which is being presented in this dissertation report entitled " A Study of Aquifer Systems And Groundwater Contamination Due to Heavy Metals In Parts of Sahibabad Industrial Area along Hindon river, Ghaziabad,U.P" submitted in partial fulfilment of the requirements for the award of the degree of Master of Technology with specialization in Environmental Engineering, to the Department of Environmental Engineering, Delhi Technological University (formerly Delhi College of Engineering),New Delhi, is an authentic record of my own work carried out from December 2014 to May 2015 under the guidance and supervision of **Ms. Geeta Singh, Assistant Professor**, Department of Environmental Engineering, Delhi Technological University (formerly Delhi College of Engineering),New Delhi.

To the best of my knowledge, the matter embodied in this dissertation report has not been submitted for the award of any other degree or diploma in any other Institute/University.

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LIST OF ABBREVIATIONS

AAS	ATOMIC ABSORPTION SPECTROPHOTOMETER
BIS	BUREAU OF INDIAN STANDARDS
CGWB	CENTRAL GROUNDWATER BOARD
EPA	ENVIRONMENTAL PROTECTION AGENCY
ICMR	INDIAN COUNCIL OF MEDICAL RESEARCH
IMD	INDIAN METEROLOGICAL DEPARTMENT
LPM	LITRE PER MINUTES
MAP	MASS AWARENESS PROGRAMME
MBR	MOVING BED REACTOR
MBGL	METER BELOW GROUND LEVEL
MCM	MILLION CUBIC METER
NTU	NEPHLO TUBID UNIT
SBR	SLUDGE BLANKET REACTOR
SQM	SQUARE METER
WHO	WORLD HEALTH ORGANIZATION
WQI	WATER QUALITY INDEX

ABSTRACT

Groundwater is the most easily available and exploited fresh water resource on earth. Requirement of water in various sectors are increasing with socio economic development. In order to fulfil this increasing demand, there is a necessity for sustainable management of surface and groundwater resources. It is important to distinguish aquifer systems so as to provide essential statistics to plan for its sustainability. In this study an attempt has been made to analyse the heavy metal concentration level of 16 bore and duck wells located at the different localities in and around Ghaziabad area. It is found that the study area is suffering from frequently water level declination and also severe heavy metal problems because the concentration of various heavy metals such as lead, chromium, zinc, iron etc. has been found above standard limit prescribed by BIS/WHO. This precious gift of nature to human being is getting polluted day by day with industrialization and urbanization**.** High amount of chemicals are used in industries and agricultural sectors which have resulted in huge build up of harmful organics in water (**Asia Alshikh,2011)** [1].The effluent comes from these industries has been discharged into water bodies without any proper treatment due to which toxic metals mix into groundwater through infiltration process. All these metals are highly toxic to human health and cannot be easily detected without any specialized or advanced treatment. Most affected area from heavy metals is slum areas near Hindon river and also the surrounded area of Sahibabad industrial site because the people of slum areas consume groundwater without any treatment. There are various methods to remove these hazardous metals from water such as filtration, pump and treat method, Bioremediation, Conventional treatment methods .Various biological treatment methods, both anaerobic and aerobic can be used for the detection of heavy metals.

CHAPTER 1 INTRODUCTION

1.1 GENERAL

Water is an essential source of life which is important for survival of all living being. It is not only the major constituent for animals, plants, and other living organisms but also water is necessary for the existence of human being in the biosphere. Groundwater prevails almost everywhere below the earth crust not only in a single layered widespread aquifer, but also in various regional aquifer systems. There are Several factors such as climate, topography of the area, soil characteristics, groundwater movement through rocks, existence of saline water in seaside areas and also natural and anthropogenic activities on the earth surface posses various effects on water quality. Quality of drinking water is the most important factor to secure human health from harmful disease. Water provides some essential elements to our body, but when getting polluted it may cause severe human health problems such as cancer, cardiovascular disease, adverse reproductive outcomes and neurological diseases. Some of the metals such as Cu, Mn, Fe, Zn and Ni are necessary micronutrients for flora and fauna. While few of them like Cd, Pb and Cr may be toxic beyond permissible limit. Therefore the concentration of heavy metal in drinking water should be maintained within permissible limit, **(Balakrishnan A *et a*l.,2014)** [2] **.**The study area, Ghaziabad exists in the upper Indo-Gangetic plain of north eastern part of India. Indo-gangetic plain is the largest alluvial plain of the world which was formed by the deposition of terrigenous clastic residues from Ganga, Brahmaputra and Indus river systems.

Due to rapid agricultural growth, urbanization and industrial development, the aquifer is under serious environmental stress in this plain. In this region, ‘‘vulnerability’’ and ‘‘self supply’’ are directly coupled. Also, there has been a shortage of adequate attention to use, reuse, and recharge of groundwater. Over the decades, this region which is the most industrialized zone of northern India, having different types of industries dealing mostly with steel, Iron, plastic, chemical, dyeing, pharmaceutical and battery making, etc., those dispose their treated, untreated or partially treated effluent haphazardly causing a broad range of heavy metal concentration**(Veer Singh *et al* ,2013)**[3] . Stress on water resources has been increasing over the decades mainly due to rising water demands and per capita

water consumption because of rapid population growth, and through rising water extraction for Irrigation and drinking water supply. Groundwater contamination through domestic, Agricultural activities and also from industries is a severe problem faced by the residents. The industrial effluent, domestic sewage and solid waste are directly being discharged into the rivers and streams and due to infiltration process this contaminated water mix into groundwater and pollute it. These harmful materials enter into subsurface aquifers and resulting in the pollution of drinking water, irrigation water.

Water provides some useful elements to living beings, but when getting contaminated, it may toxic to human health and cause severe disease such as neurological disease, cancers, cardiovascular disease and adverse reproductive outcomes. Some heavy metals such as Fe, Cu, Mn, Zn and Ni are necessary micronutrients for flora and fauna .While metal like Pb,Cr and Cd are harmful beyond permissible limit as prescribed by BIS/WHO. Therefore concentration of heavy metals should be maintained within permissible limit in drinking water.

1.2 AQUIFER SYSTEM OF INDIA

Groundwater is the widely used resource to meet various water demands and is the nation's main reserve of fresh water. India is the largest consumer of groundwater and irrigates near about 39 million hectare of land by groundwater followed by two countries, namely China and USA. It has been estimated that above 90% of rural and 50% of urban water supply is being fulfilled by groundwater. As per the recent well census, the amount of groundwater abstraction structures have been increased around 21 million in previous two decades with an estimated with drawl of about 22100 MCM annually from groundwater. In the last few decades, rapid development has been noticed in the water resource sectors, resulting in several undesirable environmental impacts. A large number of bore wells are getting dried in some areas of country due to decreasing groundwater level have had an immediate impact on water supply for domestic, irrigation and industrial purposes. Demand for safe and good quality drinking water to maintain ecosystem healthy and free from pollution are increasing. Different types of questions related to social

welfare have arisen day by day and also the remedies about how to assess the groundwater quality and manage groundwater resources**, (AQUIFER SYSTEMS OF INDIA REPORT)** [40]

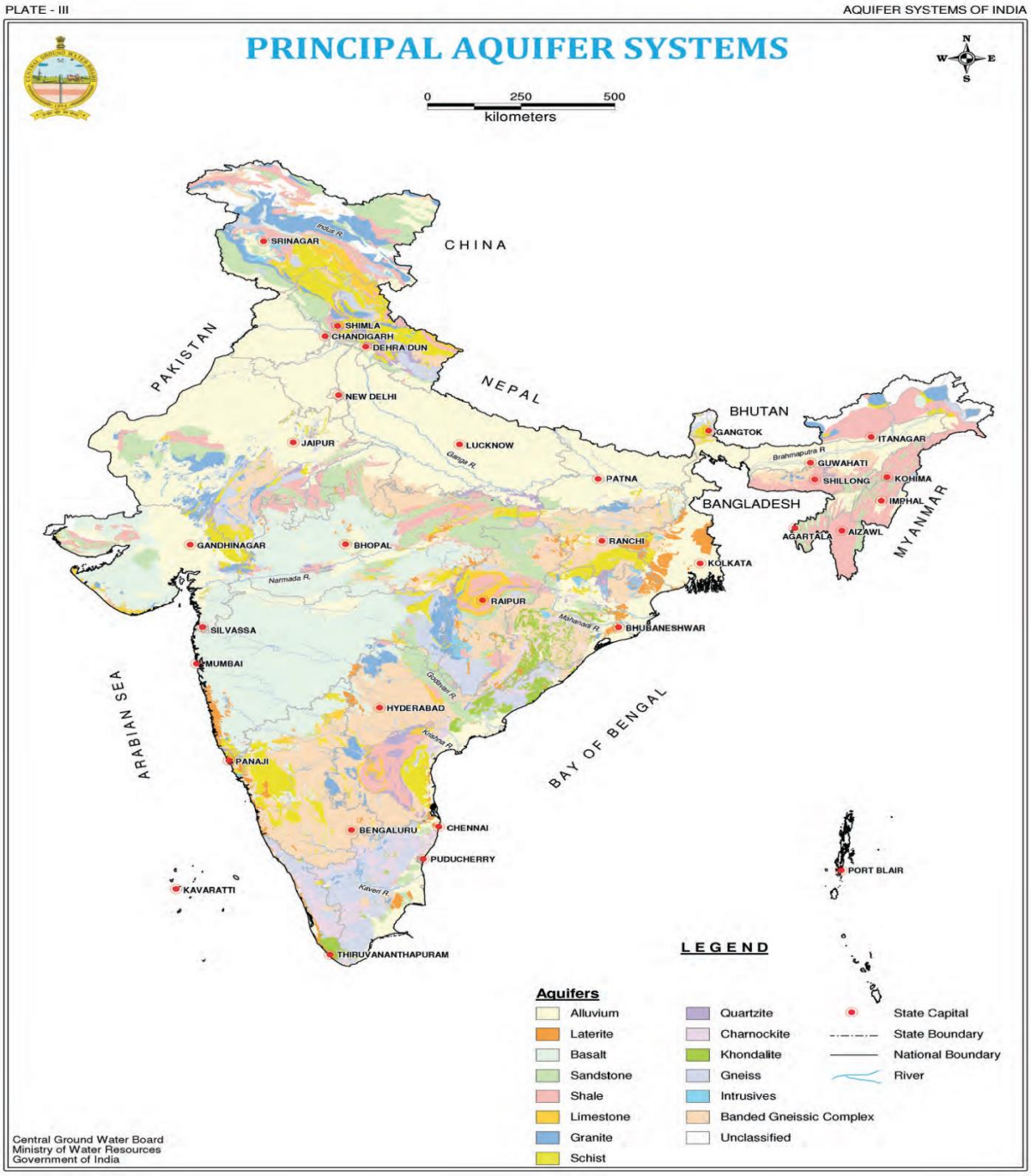


Figure1.1 AQUIFER SYSTEMS OF INDIA MAP

1.3 AQUIFER SYSTEM OF GHAZIABAD

Ghaziabad district is situated in the centre of Ganga-Yamuna doab and expands over 1966 sq Km and administratively divided into 4 different tehsils and further divided into 8 different development blocks.

As per census 2011, the population of district Ghaziabad is 4,681,645 out of which 2,488,834 are male and 2,192811 are female respectively. The latest data declared by census 2011, shows that the population density of Ghaziabad district is 3,971 people persq km. District Ghaziabad is drained by river Ganga, Yamuna and their tributaries Hindon and Kali river and also their minor distributaries. Irrigation in the major parts of the district is done by various water resource structures such as tube wells, bore wells,rainy wells and also from surface irrigation systems like canals, rajwaha etc. Western region of the district is irrigated by Upper Gnaga canal and also from its tributaries, while eastern part of the district is irrigated by its Anup Shalon branch.

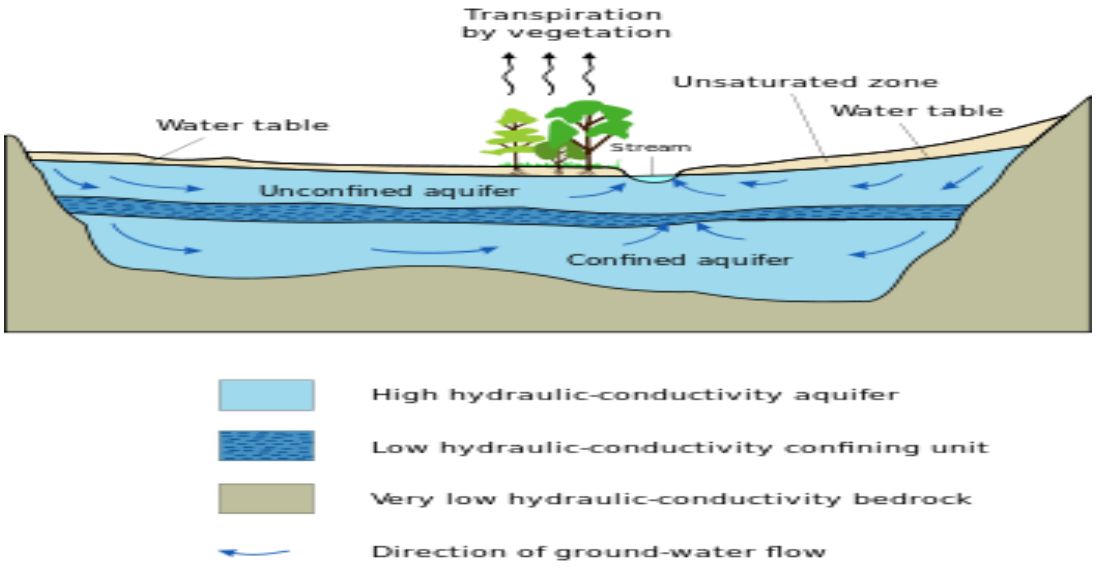


Figure1.2 AQUIFER CROSS SECTION

Source: https://en.wikipedia.org/wiki/Aquifer#/media/File:Aquifer_en.svg

Ghaziabad is a well planned industrial city with 2.5 km long Grand Trunk road along the Hindon River between latitude (28400 and 28670 N) and longitude(77250 and 77420E). Ghaziabad city is densely populated and having various industries in surrounding areas that use high level of chemicals, fertilizers and pesticides. Several waste disposal sites like Urban as well as industrial waste disposal sites exist in that area due to the close proximity of Delhi and other big townships**(Groundwater brochure of Ghaziabad)**[5].

On the basis of analytic drilling carried out in the Ghaziabad region three tier aquifer systems have been identified up to a depth of around 450 mbgl. The very first aquifer system extends up to a depth of 125 mbgl and it enlarges up to a depth of 200 mbgl in the northern part of the district. Thickness of the aquifer diminishes in the western part of the district and also the depth of substratum is shallow. Second aquifer system exists in a depth of 170–350 mbgl and this aquifer mainly contains sand medium- to fine-grained with occasional coarse-grained. Third and the last aquifer system exists below a depth of 350 m and continuously expands up to a depth of 450 m**(Uday Veer Singh *et al*.,2013)** [30] .

1.4 GROUNDWATER BACKGROUND

Groundwater is one of the predominant natural resource which is often not identified. Groundwater is the essential major source of fresh and safe water for various purposes such as drinking, agriculture, and industrial sectors and vital for our day to day survival but with the time anthropogenic or manmade activities have degraded its quality as well as quantity**.** For its sustainable usage, both the quantity as well as quality affairs have to be marked together.

Most of the ground water regions are contaminated due to direct disposal of untreated effluents from domestic and industrial sectors. Large amount of waste water is also indiscriminately released into natural systems particularly in nearest water bodies. Primary anthropogenic accumulation of heavy metal into groundwater is mainly through point sources like mines, smelters, foundries and coal based power plants and also from diffuse sources like combustion of by-products and vehicular emissions. Human activities have increased the natural and artificial redistribution of the heavy metals resulting bioaccumulation of these toxic metals in animals, plants and also in different organs of human body.

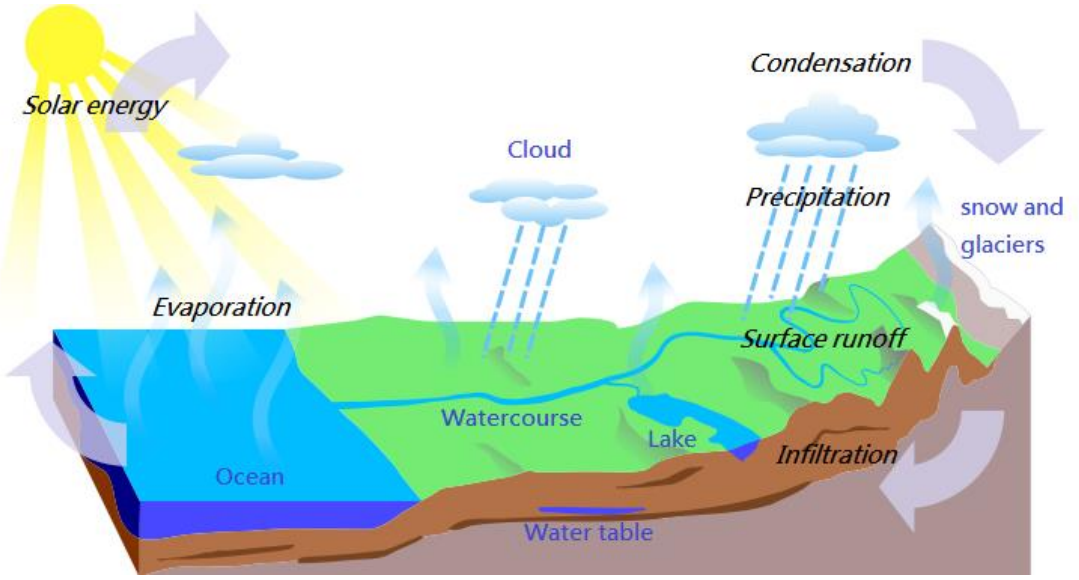


Figure1.3 HYDOLOGIC CYCLE

Source: https://www.google.co.in/search?q=hydrological+cycle

Thus human health has now become a severe issue of heavy-metal related pollution. The level of various heavy metals like Cd, Ni, As and Hg beyond prescribed limit by BIS/WHO in groundwater can be harmful to our ecosystem, animals and plants causes severe health problems in human beings. Contamination of the ecosystems by radioactive components has also arisen from extractive industries like phosphorus, iron, coal, mineral sands and oil. **Giri *et al.*,2012** have estimated the health risk due to heavy metal through ingestion of groundwater nearby area of uranium mine in Jharkhand, India and estimated that Mn and Fe exceeded beyond the permissible limit as per given in IS: 10500 standards at many places while Zn exceed the limits at few places only but Pb and Cu did not cross the permissible limits. Ghaziabad, a developing industrial city in Uttar Pradesh, having thousands of small scale, medium and large scale industries which discharge their treated, untreated or partially treated effluent into nearby water bodies , causing wide spread contamination of heavy metals.

Groundwater contributes nearly 20% world's fresh water supply, which consists of 0.61% of entire world's water, comprising frozen ice and ocean. Recently, It was found out that the groundwater quality of Lohia Nagar industrial sector of Ghaziabad city has been adversely contaminated with chromium. It clearly indicates that these entire incidence occurred due to rapid industrialization and urbanization in the last few years in

Ghaziabad.It was also described that Chromium may have anthropogenic point sources. It becomes a issue of great consideration when the contaminated ground water or untreated effluent is drained for production of seasonal vegetables and fruits or directly discharged into water bodies causing food chain contamination. It has reported various health problems associated with trace metals in the soil irrigated with contaminated ground water near industrial site in Ghaziabad. The current study was initiated to estimate the physicochemical parameters of groundwater including concentration of various micronutrients and other carcinogenic metals and also metalloids in both pre and post monsoon seasons. **(Savita Kumari August 2013)** [6] .

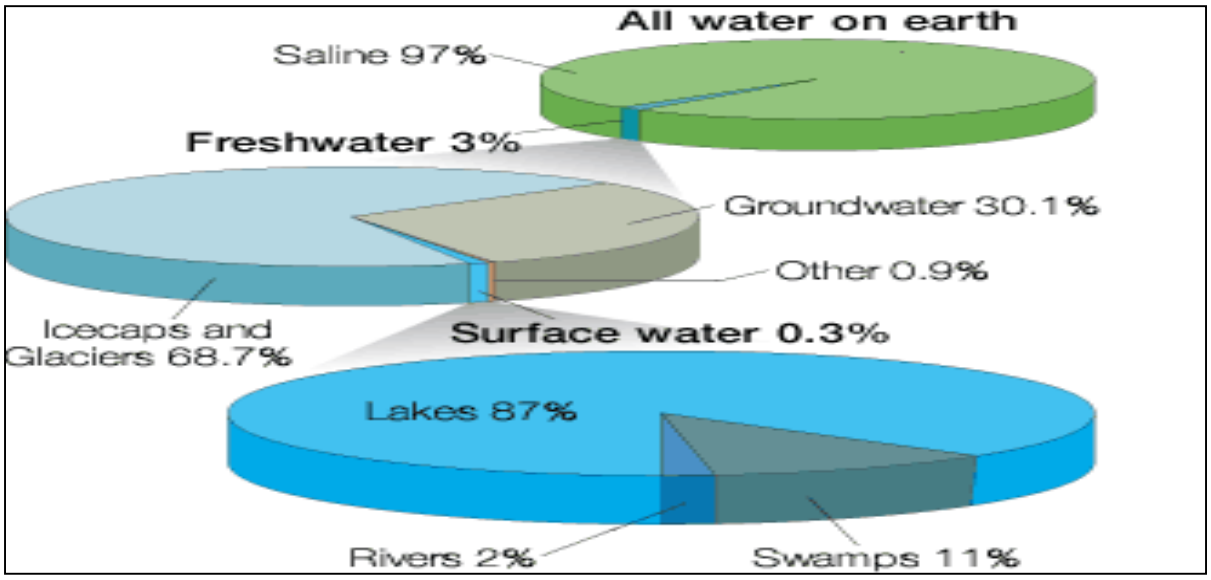


Figure1.4 DISTRIBUTION OF WATER ON EARTH

Source: https://www.google.co.in/search?q=water+distribution+on+earth

Groundwater is the most important natural reservoir on earth surface. The Indo-gangetic plain is the largest alluvial plain of the world which was formed by the deposition of terrigenous clastic residues from Ganga, Brahmaputra and Indus river systems.

Due to rapid agricultural growth, urbanization and industrial development, the aquifer is under serious environmental stress in this plain. The study area, Ghaziabad exists in the upper Indo-Gangetic plain of north eastern part of India. In this region, ‘‘vulnerability’’ and ‘‘self supply’’ are directly coupled. Also, there has been a shortage of adequate attention to use, re-use, and recharge of groundwater. Over the decades, this region which is the most industrialized zone of northern India, having different types of industries

dealing mostly with steel, Iron, plastic, chemical, dyeing, pharmaceutical and battery making, etc., those dispose their treated, untreated or partially treated effluent haphazardly causing a broad range of heavy metal concentration **(Uday veer singh *et al.*,2013)**[3].Stress on water resources has been increasing over the decades mainly due to rising water demands and per capita water consumption because of rapid population growth, and through rising water extraction for irrigation and drinking water supply

1.5 GROUNDWATER POTENTIAL ASSESMENT

On the basis of analytical drilling carried out in the Ghaziabad region, three tier aquifer systems have been identified up to a depth of around 450 mbgl.

- The very first aquifer system extends up to a depth of 125 mbgl and it enlarges up to a depth of 200 mbgl in the northern part of the district. Thickness of the aquifer diminishes in the western part of the district and also the depth of substratum is shallow.
- Second aquifer system exists in a depth of 170–350 mbgl and this aquifer mainly contains sand medium- to fine-grained with occasional coarse-grained. The yield of tube wells is 1000-2000 lpm at a substantially high drawdown.

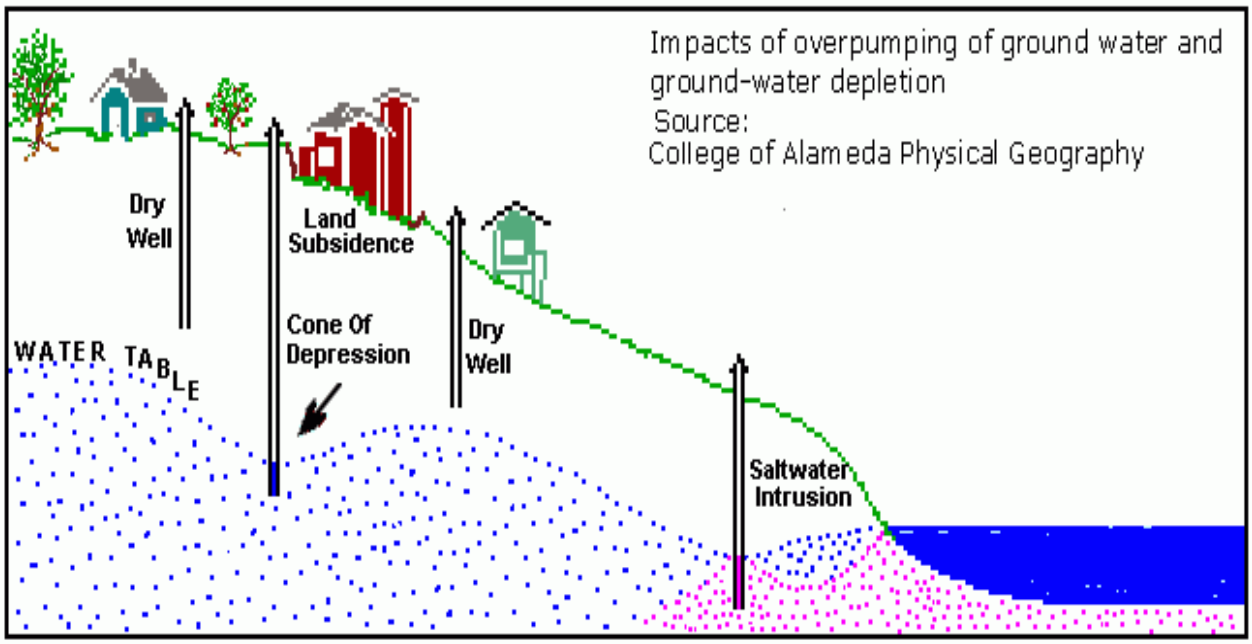


Figure1.5 WATER LEVEL DEPLETION DUE TO OVER PUMPING

Source: https://www.google.co.in/search?q=aquifer+depletion+image

- Third and the last aquifer system exist below a depth of 350 m and continuously expand up to a depth of 450 m. The yield varies from 1000 to 2500 lpm.

Generally ground water exists under unconfined conditions and the range of depth to water level lies between 1.70 - 24.60 mbgl during the period of pre monsoon and during post monsoon season it lies between 2.20 - 23.37 mbgl. The normal slope of groundwater table is north to south which predominantly follows the path of surface slope and the hydraulic gradient varies from 0.4 to 4.8 m/Km. The maximum groundwater level fluctuation has been observed as 4.83 in Rajapur block**(CGWB annual report 2011-12)**[7] .

1.6 GROUNDWATER QUALITY AND CONTAMINANTS

Ground water exists in the shallow aquifer is suitable for the usage of various purposes. While The quality of water in deep aquifers changes from place to place also found suitable for many common uses. Groundwater quality has been noticed unsuitable for specific usage due to contamination because of natural and anthropogenic reasons.

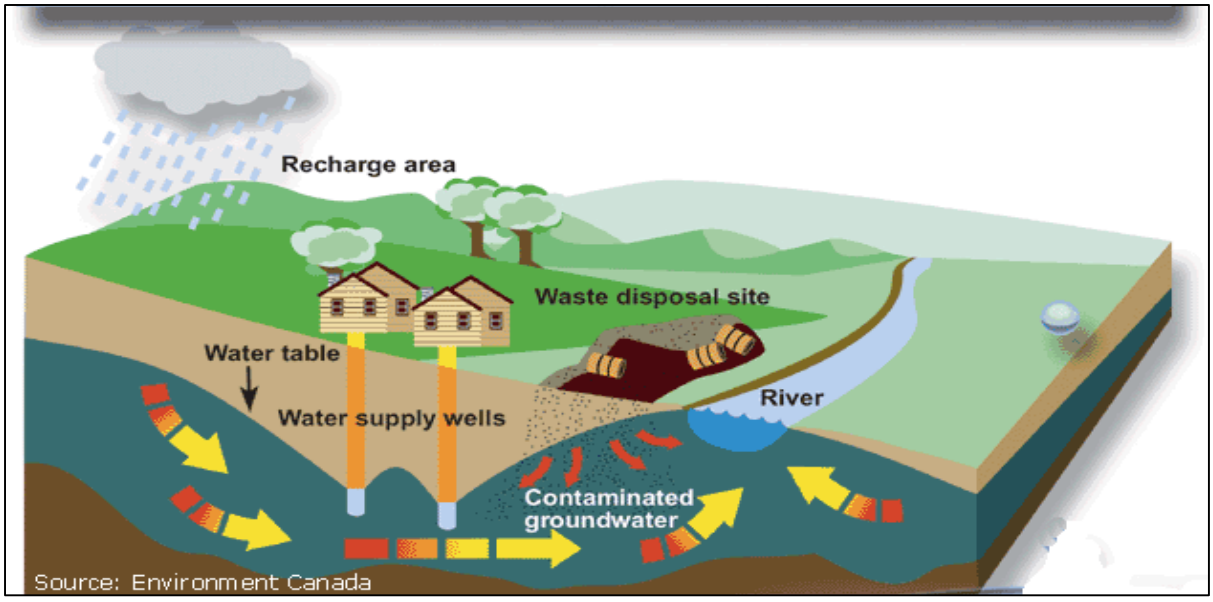


Figure1.6 GROUNDWATER CONTAMINATIONS

source: https://www.google.co.in/search

There are many water quality problems in India has been analysed which are as follows. Fluoride, salinity,Iron, Nitrates and Heavy metal etc. Most of the groundwater regions are contaminated due to direct discharge of treated or untreated effluents coming from domestic and industrial sectors into water bodies. A huge quantity of waste water are also directly discharged into natural water systems like river, canal etc. Primary anthropogenic accumulation of heavy metal into groundwater is mainly through various point sources such as mines, smelters, foundries and coal based power plants and also from diffuse sources like combustion of by-products and vehicular emission etc.

Human activities have increased the natural and artificial redistribution of the heavy metals resulting bio-accumulation of these toxic metals in animals, plants and also in different organs of human body. Thus human health has now become a severe issue of heavy-metal related pollution. The level of various heavy metals like Cd, Ni,As and Hg beyond prescribed limit by BIS/WHO in groundwater can be harmful to our ecosystem, animals and plants causes severe health problems in human beings.

1.7 SOURCES OF GROUNDWATER POLLUTION

As human needs are increasing and civilization is changing, more number of finished products of different types is required.

Simultaneously, large number of industries are born and grown in every country i.e.; process waste streams from the mining operations, metal plating facilities, power generation facilities, electronic devices manufacturing units, and tanneries may contains heavy metals at concentrations exceeding the local discharge limits. These waste streams contain poisonous heavy metals such as chromium, cadmium, lead, sulphur, mercury, nickel, zinc, iron and copper. They can't be easily removed without specialized or processed treatment. Chromium is a frequent pollutant introduced into natural waters / ground water due to the discharge of a variety of industrial wastewaters or chromium hazardous wastes. Over the years, this zone which runs through the most industrialized zone of northern India, having different types of industries dealing mainly with iron, steel, plastic, dyeing, chemical, pharmaceutical, battery making, etc., which dispose their treated or partially treated effluents indiscriminately causing a vast range of heavy metal contamination**. (Uday Veer Singh *et al*.2013)[3].**Various sources of groundwater contamination such as natural, agricultural, industrial etc. are defined below.

1.5.1 NATURAL SOURCES

Groundwater carries some small impurities, even if it is preserved by human activities. The class and concentration of these impurities depends on the formation of the geological matters through which groundwater travels and also the quality of recharged water. Groundwater goes through soils and sedimentary rocks may contain a wide range of elements .Some of the aquifers have high concentration of natural dissolved elements The impact on the groundwater quality of all these sources of contamination mainly depends on the class and concentration of components.

1.5.2 AGRICULTURAL SOURCES

There are various different sources of groundwater contamination due to agricultural activities like Pesticides, insecticides, herbicides, fertilizers, and animal wastes etc. The agricultural contamination sources vary from place to place because it depends on the variety of agricultural resources, soil type and climatic conditions. spillage of various compounds like fertilizers, pesticides during handling, runoff of pesticide sprayers during loading and washing and also using some chemicals upland from a few hundred feet away of a well.

1.5.3 INDUSTRIAL SOURCES

Groundwater pollution exists when used water is discharged into the hydrological cycle. At this time various economic activities are required for many purposes like transportation, construction and storage of material required in manufacturing process. Along the way, some quantity of this material is lost through leakage, spillage, or improper handling. The discharge of waste water associated with above activities caused various sources of groundwater contamination.

1.5.4 RESIDENTIAL SOURCES

Residential wastewater system is the main origin of many types of contaminants, including fungus, bacteria, nitrates and viruses from human wastes, and also organic compounds comes from kitchens. Injection wells are used for domestic effluent disposal are of great concern to improve or protect groundwater if placed near drinking water wells. Improperly storage and discharge of household chemicals like synthetic

detergents, paints, oils, medicines, solvents, disinfectants, pesticides, batteries, pool chemicals, diesel and gasoline fuel can cause groundwater contamination.

1.8 AIMS AND OBJECTIVES OF THE STUDY

- The main objective of this study is to clarify the main sources and extent of rapid declination in groundwater level and groundwater quality.
- To detect the groundwater contamination in the study area and also to assess the heavy metal concentration from groundwater. The chemical quality of groundwater in the aquifers of Ghaziabad has been scarcely documented and there exists various harmful heavy metals in the groundwater.

Over the years, this region which runs through the most industrialized and densely populated zone of northern India, has many industries in surrounding areas that use high rate of chemicals, fertilizers/pesticides, dyeing, pharmaceutical, battery making, etc. and Urban and industrial waste disposal sites also exist in the region due to the close vicinity of Delhi and several big townships, which dispose their untreated or partially treated effluents indiscriminately causing a wide range of heavy metal contamination.

CHAPTER 2 LITREATURE REVIEW

A number of studies regarding rapidly increased aquifer depletion and groundwater contamination due to heavy metals have been carried out by different authors.

2.1 M.A.O. Badmus *et al.*[11],2007 have studied that the removal of heavy metals, Pb, Zn and Cu using H_2O_2 was found to be effective. The process efficiency was enhanced by activating the H_2O_2 with Cu^{2+}, increasing the breaking down of H_2O_2 molecule to H_2O and O_2.

- The results obtained show that hydrogen peroxide can be used effectively in the removal of heavy metal ions from industrial wastewaters.
- It has been studied that the main causes of industrial pollution is the discharge of effluents containing heavy metals. Heavy metals can have serious effects on human and animal health.
- Ther effective recovery of heavy metals is as important as their removal from waste streams. Disposal of industrial wastewater has always been a major environmental issue. Pollutants in industrial wastewater are almost invariably so toxic that wastewater has to be treated before its reuse or disposal in water bodies.
- Industrial processes generate waste water containing heavy metal contaminants. Since most of heavy metals are non-degradable into non-toxic end products, their concentrations must be reduced to acceptable levels before discharging them into environment.

2.2 Rizwan Ullah *et al* [12],2009 have examined the quality of groundwater in correlation to heavy metal pollution and its implication on human health. The groundwater quality of Sialkot, an industrial city of Pakistan, was assessed using water samples collected from 25 localities during October-November 2005.

- The present study was depicted to assess the quality of groundwater in correlation to heavy metal pollution and its implication on human health.
- Water quality is getting worsen due to untreated discharge of industrial and urban sewage. The urban population depend on dug wells, boreholes, hand pumps and tube wells for all their groundwater demand.

- The unrestrained disposal of industrial and urban sewage and the use of chemical materials in agriculture (fertilizers, herbicides and pesticides) are the primary causes of the groundwater contamination. Two sites were found to contain high, concentration of Cr+6, marking contamination from tanning industries.
- This study also presents the usefulness of Multivariate Statistical Techniques in groundwater quality assessment, identification of notable parameters. The analytical results of sampling sites, monitored in this study irrespective of pollution source, revealed that groundwater from these sites required further purification to ensure its suitability for human consumption.
- The study highlights the direct need to control heavy metals contamination of groundwater and if this issue is left unattended to, this will pose problems to provide safe drinking water for human beings.
- The results of this study stress the need for environmental awareness, adequate regulations and proper management of waste sites by the local municipal authorities. There is a need to check industrial water pollution by implementing strictly the pollution control laws and strict control on the disposable of untreated effluents around the industries needs to be enforced.

2.3 Asia Alshikh [1],2011 has analysed that water-related diseases are responsible for 80% of all illnesses/deaths in developing countries, and they kill more than 5 million people every year. Water, the precious gift of nature to human being is going to be polluted day by day with increasing urbanization.

- But growth rate in population compared to olden days, industrialization and hence greater load of wastewater and use of numerous chemicals in industry and agriculture have resulted in tremendous build up of organics in many forms in water. Many unexpected organics are reported to be found even in remote parts like hills of Himalayas, Alaska and North Pole due to man-made devastation of our environment.
- The environmental education has aroused much awareness about the toxicity of traces of environmental pollutants in general and organics in particular.
- The aim of this study was to investigate the quality of the ground water of the Jazan wells samples in the southwest of K.S.A. The use of synthetic organic pesticides has grown rapidly since the 1950s because, when used in conjunction with fertilizers, they increase crop yields. Pesticides are, however, a risk to human health.

- In the case of a pesticide spill or misapplication near a well, the levels of pesticides in drinking water may reach high enough levels to cause immediate health problems, such as the damage of the nervous system, some pesticides can cause cancer; some can also result in birth defects.
- One of the best known classes of ground water contaminants includes petroleum-based fuels such as gasoline and diesel. Nationally, the U.S. Environmental Protection Agency (EPA) has recorded that there have been over 400,000 confirmed releases of petroleum-based fuels from leaking underground storage tanks. Gasoline consists of a mixture of various hydrocarbon that dissolve to some extant in water, and often are toxic**.**

2.4 M. Ackah *et al.*[13], 2011 have found that number of factors influence water chemistry-Gibbs (1970) proposed that rock weathering, atmospheric precipitation, evaporation and crystallization control the chemistry of water.

- The influence of geology on chemical water quality is widely recognized. The influence of soils on water quality is very complex and can be ascribed to the processes controlling the exchange of chemicals between the soil and water.
- Apart from natural factors influencing water quality, human activities such as domestic and agricultural practices impact negatively on groundwater resources. Pollution of water bodies as a result of metal toxicity has become a source of concern among consumers. This concern has become alarming in response to increasing knowledge on their toxicity to human health and biological systems.
- Water quality data is essential for the implementation of responsible water quality regulations for characterizing and remediating contamination and for the protection of the health of humans and the ecosystem.
- Regular monitoring of groundwater resources thus play a key role in sustainable management of water resources. This study conducted seeks to serve as a preliminary study to assess the groundwater quality in terms of drinking and agricultural uses for a rapidly developing community located in Ghana.

2.5 Sarla C *et al.* [14] ,2012 have studied about the groundwater quality limit in the neighbourhood wells of upper Musi catchment area of Jawahar nagar Ranga Reddy district in Andhra Pradesh and acquire the concentration of major components are within the

permissible limits of IS (10500-1994), But in few areas fluoride concentrations and total hardness are high.

- From this study, she has been analysed that the groundwater is contaminated throughout the study area. During the monsoon season the rainwater drains into the solid waste and the land leachate is polluting the groundwater of surrounding areas.
- The utilization of surface and groundwater for various purposes like drinking, industrial and agricultural has been increased during last few years but consequently it has been observed that the water is getting polluted and affecting human being, soil nutrients, biomass, livestock, and surrounding environment. Hence it is necessary to protect the environment and various resources.

2.6 Mohd. Saleem *et al.* [15],2012 have suggested that the rain water harvesting is the best procedure to improve the quantity and quality of groundwater.

- The rain water harvesting technique depends upon the quantity of rain water recharged and the environment of rainwater collection and recharging. But the availability of ground water is not infinite nor is it secured from deterioration.
- In most of the occasion, the extraction of excessive quantities of ground water has resulted in drying up of wells, damaged ecosystems, land subsidence, salt water intrusion and depletion of the resources.
- Ground water quality is being increasingly terrorized by agriculture, urban & industrial wastes, which drain or are injected into underlying aquifers. It has been created that once pollution has entered the subsurface environment; it may remain hidden for many years, becoming scattered over wide areas of ground water aquifer and rendering ground water supplies inappropriate for consumption and other uses.
- The rate of depletion of ground water levels and deterioration of ground water quality is of concern in major cities and towns of the country. Being a National Capital Territory, Delhi is facing multifaceted problems regarding water availability and quality**.**

2.7 Mahmood and Ishrat[16],2012have studied that the ground water restoration through artificial recharge technique would to some extent help in mitigating water crises in Dwarka Sub-City & other urban areas.

- The study aims to formulate the strategies to mitigate the water crisis in urban areas of India through Rainwater Harvesting technology and it lays emphasis on in-situ

conservation of surplus monsoon runoff for future use i.e. Aquifer storage & Recovery technique. This besides augmenting the qualitative & quantitative potential of Ground Water would help in preventing soil erosion & flooding in urban areas.

- For the purpose of study Dwarka Sub-city has been taken for reference. Since the whole infuse of the study is optimized recharging of ground water reservoir through Rainwater Harvesting system, for dilution of Salinity, hence it involved the detailed study & analysis of the Rainfall Pattern, its Quality and Rainfall potential.
- The rainfall pattern in the area was analyzed based on the rainfall data available from Indian Metrological Department, for a sufficiently long period. The distribution of rainfall in the area was found to be non-uniform in time & space, varying from year to year and mostly concentrated to the monsoon months from July to September. The unsustainable
- Ground water extraction in the area has resulted in decline in water table at alarming rate in last few years and depletion of the fresh water layer. To make the water supply system sustainable it is utmost important that the most precious gift of nature i.e. rainwater is harnessed for its beneficial use in most rational manner, by resorting to Rainwater Harvesting.
- There is need to dovetail the ground water extraction with the ground water recharge in a sustainable manner. The Government has made mandatory requirement for adoption of Rain Water Harvesting System for a Plot area of 100 sqm and above.
- The Central Ground Water Board (CGWB) also gives emphasis to Roof Top Rain Water Harvesting only. However, this is very small quantity as compared to the withdrawal rate.
- Hence, this study recommends the adoption of Total rainwater harvesting technique and from present study it has been established that implementation of the Rainwater Harvesting techniques in Urban area is a very attractive and technically feasible technique for Ground water restoration in Urban areas.

2.8 Jameel[7],2012 has studied that Industrial production without adequate regard for environmental impacts has increased water and air pollution, and has led to soil degradation and large scale global impacts such as acid rain, global warming and ozone depletion.

- As the urbanization process continues, water pollution problems have become increasingly evident and have led to serious ecological and environmental problems. All

metabolic and physiological activities and life processes of aquatic organisms are generally influenced by water temperature.

- The sources for ground water supply mostly depend upon the rainfall and the resulting percolation of the water into the earth. Another important factor is the quality of the soil.
- The heavy metals play a vital role in the normal functioning of human body. Imbalance of any of the heavy elements will disturb the normal function of human beings. Heavy metals are added to water system both from natural and man-made sources.
- The major anthropogenic sources of heavy Metals are industrial wastes from mining sites, manufacturing and metal finishing plants, and domestic waste water and run off from roads.
- Their presence in surface and underground water at above background concentrations is undesirable. Some heavy metals such as Hg, Pb, As, Cd, Fe, Co, Mn, Cr etc., have been identified as deleterious to aquatic ecosystem and human health.
- The human activities like agriculture and domestic release large number of pollutants into the water bodies. In India ponds, rivers and ground water are used for the domestic and agriculture purposes.
- The major origins of water are rainfall, surface water including rivers, lakes and groundwater including wells bore wells etc. In current years, the growth of industry, technology, population and water utilization has increased the stress upon both our land and water resources.
- Mainly, the quality of ground water has been degraded. Municipal and industrial sewage, chemical fertilizers, herbicides and pesticides have penetrated the soil, infiltrated some aquifers and degraded the ground-water quality. Other pollution issues include sewer leakage, faulty septic-tank operation and landfill leachate.

2.9 Patil *et al.* [18],2013 have suggested that In present review we have collectively giving information about the trace metals present in the polluted water and their health effects with methods of analysis. We tried to present detail causes of occurrence of these trace metals in water body and effects of these metals on living organism.

- Some methods for determination of trace metals are also been incorporated in brief. Analytical chemistry has very important role in the modern science due to new technologies developed for determination of trace metals in the all kinds environmental, industrial, food and material required for day to day use.

- There are various sophisticated instruments can be used for the determination of these trace metals has given a method for the estimation of trace metals such as for Fe, Zn, Cu, Pb, Ni in the industrial effluent.

2.10 Meitei L *et al.* [50],2013 have found from the recent investigation it can be said that the water qualities of ponds are not an alarming threat to human beings though the concentrations of some parameters like turbidity, alkalinity, sodium, mercury and cadmium levels in few sites are alarming. They are above the permissible limit thus required treatment for secure human consumption.

- If proper monitoring and remedial measures are not taken up as soon as possible the hazard and health risk of heavy metals could be prevalent in the study area. Further, ponds can be brought to a better condition for public utility by restricting the disposal of sewage, organic wastes, bathing and washing. Otherwise, the degradation of such important water resources would continue in the near future and water crisis in the region will be worsened.
- Regarding the ground water seven parameters such as total dissolved solids, alkalinity, hardness, sodium, potassium, iron and cadmium showed very wide variations and crossed the maximum permissible limit lay down by WHO and ICMR. Hence, adoption of suitable remedial measures is the prime solution to protect the important water recourses for future generation**.**

2.11 Jadhao[19],2013 has studied that the Ranney wells in the Yamuna river bed show indication of faecal pollution with some wells having high gathering of ammonia and iron.

- The quality of natural surface water is such that it requires processing. This is largely to pass out with turbidity, which is usually low but can reach seasonally very high levels (5000 NTU).
- Some pollutions of Yamuna River water has been eminent in the past (high ammonium) but this is presently controlled to an satisfactory level. The quality of groundwater differs with zone and depth of some areas as Delhi has brackish water at shallower depths.
- Significant proportions (30%) of groundwater samples surpass the permissible limit for fluoride. Nitrate pollution is also perceptible in the south-west and north-east areas.

- Exploration of surface water follows a standard process of sedimentation, coagulation and rapid sand filtration at each of five water treatment plants (WTPs).The water from the Ranney wells undergo special treatment (aeration and bacteriological filtration) at a sixth treatment plant, Okhla. Water is chlorinated both pre and post treatment plants. However, water from the innumerable tube wells is not chlorinated.

2.12 Singh *et al.*[10], 2013 have studied that Metal squander represents a censorious loss of non renewable resources and pose significant health and ecological risk.

- In today's industrial society, materials are among the most commonly used raw material. Mining, metal refining use of metals in manufacturing and the endmost disposition of manufactured product represent activities resulting in metal loses.
- Industrial waste has been badly managed and is becoming a major issue in industrialized regions. Agriculture, chemical, textile and metallurgic industries swallow large amounts of water that are delivered into the environment after processing and contain dissolved poisonous substances, all probably harmful to the environment.

2.13 Kumari[6] **,2013** has analysed that the results of the existing study have clearly brought out that all the samples, based on WQI, are in the non potable category and unsuitable for human consumption.

- Groundwater is getting polluted at an alarming rate due to quick industrialization and becoming unsuitable for not as drinking but also agricultural use. The inappropriate disposal of effluents and the existence of radioactive elements along with other contaminants is a matter of serious trouble.
- To meet the fundamental requirement and ensure potable groundwater quality and minimize contamination, groundwater should be recharged through rainwater harvesting and inappropriate disposal of industrial/domestic effluents must be stopped immediately.
- An effectual monitoring and regulatory mechanism needs to be put in place. In view of the poisonous concentrations of many elements, one can confidently state that the groundwater is not only unsuitable for drinking but also contains many elements which can cause a significant health threat and remedial measures should be taken immediately to halt further degradation.

Dhokpande and Kaware[20],2013 have studied Various methods tried by the researchers include adsorption, biological methods, electro coagulation, electro dialysis and various membrane separation techniques among others. Studies on biological methods are very important area of research with huge potential for research and applicability for removal of heavy metals.

- Heavy metals present in waste water and industrial effluent is major concern of environmental pollution. Heavy metals have a great tendency to bio-accumulate and end up as permanent additions to the environment.
- Biological methods are found to be effective for heavy metal removal. The presence of heavy metals in the form of complex on the biological mass is cause of concern.
- The recovery of heavy metals from this biomass is very important area of research. Biomass has been used effectively for the removal of heavy metals by researcher.
- Studies also show that the chemical and physically modified biomass has higher potential for removal of heavy metals than untreated.

2.14 Bisht *et al*[21],2013 have studied that Fluoride is liberate into the ground water through weathering of main silicates and associated supplement minerals. Mineral fluorides are available in underground water structures in the form of leachate. fluorospar, Apatite and fluorosilicates.

- When rain water evacuate through the ground, fluoride ions are picked up. In dry regions with limited water recharge and with fluoride bearing minerals deposits present, the ground water becomes rich in fluoride.
- Very low doses of fluoride (<0.6 mg/L) in water promote tooth decay. However, when consumed in excessive doses (>1.5 mg/L), it cause to dental fluorosis or mottled enamel and excessively high concentration (>3.0 mg/L) of fluoride may cause to skeletal fluorosis.
- All physiochemical specification was found to be under the maximum permissible range for drinking purposes except nitrate and fluoride. Such high concentration of nitrate in drinking water may be ascribed to the leaching of organic material biodegradation products into water sources.
- Nitrate has long been associated with the phenomenon of blue baby disease in infants or infantile methaemoglobinaemia, which is caused due to bacterial reduction of nitrate into nitrite in stomach.

2.15 Abbas et al[22],2014 have found that there are extreme changes in the hydro-geochemical environment and the standard of groundwater varying from alkaline to acidic environment due to inter-mixing of glacial melt water which may further be acidified due to moderate increase in global warming.

- In this respect correlation have been developed among the key factors of hydro geochemical manure and the impact assessment of groundwater quality in the underneath part of Upper Ganga basin from Rishikesh to Muzaffarnagar.
- The study area constitute of upland hilly topography from Rishikesh to Dehradun, the geo-morphology indicates that the region has got unconfined shallow aquifers and confined deeper aquifers, and however at small locations in rocky areas perched aquifer system was also experienced.
- The groundwater in this area is found to be alkaline, thus it is not found to be pretentious by glacial melt water. The shallow aquifers are accomplish by recharging through snow-melt water in the higher region at present, however the deeper aquifers are found to be unaltered by the snow-melt water.
- In may be concluded that at present the alter of pH towards acidity confined to shallow aquifers for a short time which does not have any direct or visible impact, however likely the deeper aquifers shall also be accomplish by snow-melt recharge factor and then the smack on the crops, human health and complete eco-system will be observe, if the rate of global warming goes at this speed,
- However there is no accurate prediction of climate change, hence it is difficult to forecast the bio-diversity factors for futuristic ecological systems.

2.16Balakrishnan A *et al.*[2],2014 have analysed that there is a variation in the concentration of trace metal (Mn, Cd, As, Hg, Cu, Cr, Pb and Zn) in the groundwater during pre monsoon, monsoon and post monsoon of study area .

- A measurements and analysis shows that rocks weathering and anthropogenic inputs are found to be the main sources for heavy metals in ground water. The concentrations of heavy metals were compared with drinking water standard prescribed by WHO, BIS.
- Based on the experimental data, the concentration of heavy metals during pre monsoon is high compared to post monsoon. This is due to evaporation during pre monsoon.

- This study shows that, most of the groundwater samples have high content of Hg, Mn, Pb, Cd and Cu.
- On the basis of above discussion it may conclude that the underground drinking water at almost all sites in Gulf of Mannar is highly contaminated.
- Therefore the use of ordinary hand pump and bore well should be discouraged. People dependants on this water are often prone to health hazards due to contaminated potable water. Therefore indigenous technologies should be adopted to make water fit for purpose.

2.17 Faisal and Majumder[23],2014 have analysed that the results of the study revealed that water in Savar industrial area are considerably contaminated by heavy metals like Fe, Mn, Cr, Zn, As, Ni, and Pb with their concentrations beyond threshold average values of WHO safe limits in water which may give rise to various health hazards.

- The significantly positive correlation of Zn, As, Pb with Cr and Fe, As with Mn in river water indicates that these variables were derived from common origin, especially from industrial effluents and agricultural inputs.
- On the other hand strong positive correlation of Cr with As and Ni with Pb in groundwater reveal their common source especially from various industrial processes, agricultural inputs as well as geogenic sources in the study area.
- The results suggest that the observed heavy metals in river and groundwater are of anthropogenic origin. Industries in Savar area including various industries.In the study area the industries discharge waste water with heavy metals, toxic chemicals. The uneducated farmers randomly use fertilizers and pesticides in agricultural lands.
- The industries discharge large amounts of effluents everyday which are being directly discharged into the surrounding land, agricultural fields, irrigation channels, surface water and finally rivers after partial treatment or without any treatment.
- The uncontrolled dumping of huge industrial wastes of point and non-point sources is even extremely hazardous when the pollutants are heavy metals and cannot be treated easily by conventional methods.
- Industries cause environmental degradation thought the life cycle of a product starting from exploration of raw materials and energy resources to disposal of waste and end products.

- Surface waters are most vulnerable to pollution due to their easy accessibility for disposal of waste waters. River plays a major role in assimilation or carrying off the municipal and industrial wastewater and runoff from agricultural land.
- Ultimately metallic components leach to groundwater and lead to contamination due to accumulation and may cause series problems for living things.

2.18 Subba Raju et al [24],2014 have suggested that amid environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bio accumulate in aquatic ecosystems.

- Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota, which generally exist in low levels in water and attain considerable concentration in sediments and biota.
- The overexploitation of ground water resources and discharge of untreated effluents induces degradation of ground water quality.
- Heavy metals enter in ground water from variety of sources; it can either be natural or anthropogenic.
- Because of the importance of the heavy metal ions on human metabolism, trace heavy metal analysis is an important part of public health studies .Some transition metals at trace levels in our metabolism are important for good health.
- . The main sources of the heavy metal ions directly are food and water and, indirectly, industrial activities and traffic. In most of the villages of SPS The main sources of the heavy metal ions directly are food and water and, indirectly, industrial activities and traffic.
- In most of the villages of SPSR Nellore district the public is using ground water for drinking and house hold purpose. There might be chances to get contamination of ground water with different elements and ions at higher concentration levels.

2.19 Mkude[25],2015, have studied that In Tanzania surface water and ground water are used to supply water in urban and rural areas. The use of surface and ground water in different parts of the country differs caused by differences in topography, rainfall pattern and climate, also in each region.

- It is the most viable alternative supplements especially the central and northern parts of the country in the drier regions. Ground water, these consists of both boreholes and

shallow wells a source believed to be safe due to natural protection by the aquifers may be highly polluted by different sources.

- Pollution from industrial discharges and domestic seepage like the use of latrines and septic tanks or that from improper management of solid waste, lack of sanitation or even open defecation practices may pose a serious pollution to the groundwater.
- Heavy metals are sometimes called “trace elements”, they become of particular interest in recent decades within the framework of environmental investigation.
- Highly sensitive analytical procedures are available for determining and detecting metal content with high precision.
- Improper construction, without consideration of proposed distances to water sources and poor or lack of maintenance of these sanitation facilities causes contamination to the ground water used for domestic purposes and hence poses risk to human health.

CHAPTER 3 METHODOLOGY

3.1 STUDY AREA

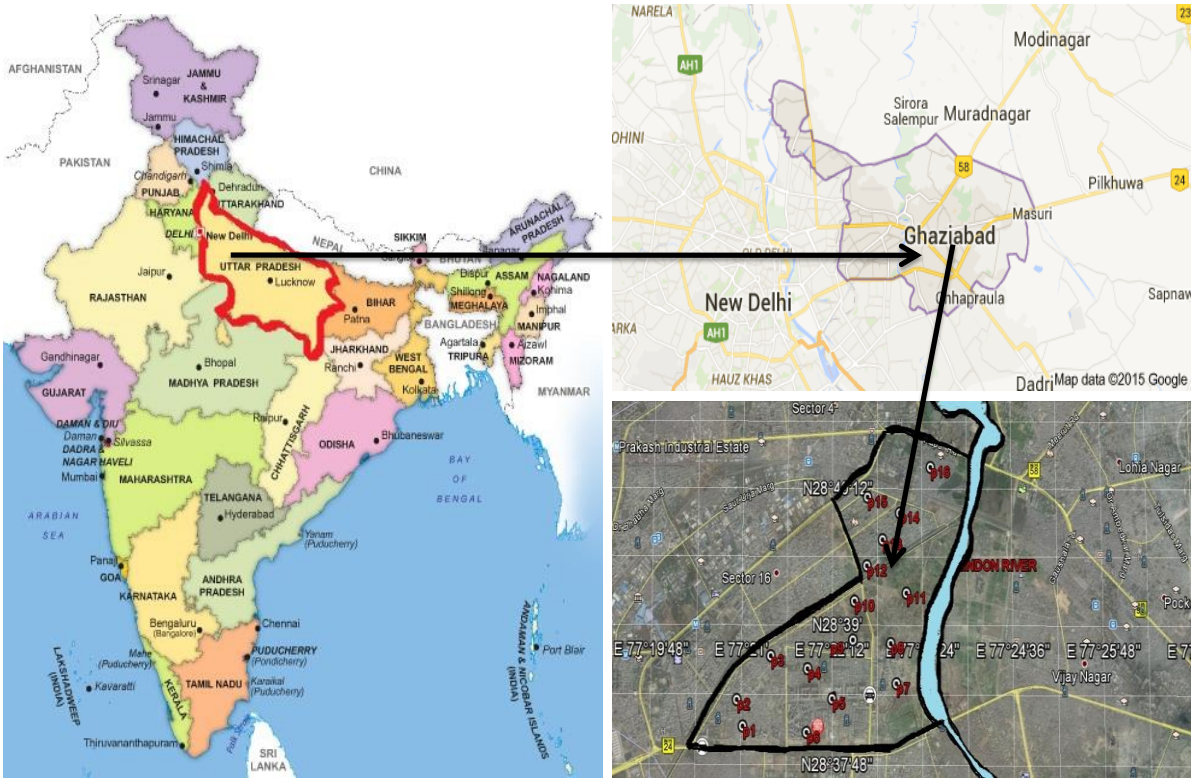
Ghaziabad district is situated in the centre of Ganga-Yamuna doab and expands over 1966 sq Km and administratively divided into 4 different tehsils and further divided into 8 different development blocks. As per census 2011, the population of district Ghaziabad is 4,681,645 out of which 2,488,834 are male and 2,192811 are female respectively. The latest data declared by census 2011, shows that the population density of Ghaziabad district is 3,971 people per sq km. District Ghaziabad is drained by river Ganga, Yamuna and their tributaries Hindon and Kali river and also their minor distributaries. Irrigation in the major parts of the district is done by various water resource structures such as tube wells, bore wells, rainy wells and also from surface irrigation systems like canals, rajwaha etc.

Western region of the district is irrigated by Upper Gnaga canal and also from its tributaries, while eastern part of the district is irrigated by its Anup Shalon branch. Ghaziabad is a well planned industrial city with 2.5 km long Grand Trunk road along the Hindon River between latitude (28400 and 28670 N) and longitude(77250 and 77420 E). Ghaziabad city is densely populated and having various industries in surrounding areas that use high level of chemicals, fertilizers and pesticides. Several waste disposal sites like Urban as well as industrial waste disposal sites exist in that area due to the close proximity of Delhi and other big townships**.**

3.1.1 GEOLOGY OF STUDY AREA

Different types of rocks have been exposed in the study area. These rocks are mainly covered by quaternary deposits and introduced in isolated residuals, structural hills and sediments. Geologically the study area forms the plain of Indo-Gangetic alluvium, which consist of clay, sand, reh and Kankar. In the study area, the strata mainly consists of sandy soil that is fully fertile and loamy.

Water table exists at a depth of 10-15 m below ground level in this area and the seasonal fluctuation is about 5 m. Ghaziabad district is situated in a fertile agricultural region of western UP**, (Uday Veer Singh et al ,2013)** [3]. Winter spreads from middle of November month to middle of February and summer months spread from April to middle of June and which ends with monsoon. The entire area of Ghaziabad comprises



Source: https://earth.google.com/

Figure3.1 LOCATION MAP OF GHAZIABAD

the plain of Ganga-Yamuna doab. The Ganga River introduces the eastern boundary of that area while western boundary is introduced by the Yamuna river.

The area states almost a monotonous flat plain analysed by drainage of different series. Ghaziabad district is situated in the historic flood plain of Hindon river. Morphologically, this area can be differentiated into 3 morpho units such as older Alluvial Plain, Older Flood Plain and Active Flood Plain. The slope of river is steep and

ravenous. The older alluvium plain occupies the whole upland area and the interfluves area exists between major drainage ways i.e. Yamuna river and Hindon river , Hindon river and Ganga river. The development of soil in the district can be diagnosed by erosion and expulsion agencies. Different morphological modules have been granted different types of soil. The soil spans from pure sand to rigid clay with composition of these two utmost litho units. The pure sand is introduced as Bhur while Clay is known as Matiyar (**Aquifer Systems Of India Report)** [4] **.**

3.1.2 RAINFALL & CLIMATE OF STUDY AREA

The rainfall in this region occurs mainly caused by southwest monsoon and about 80-85% of the annual rainfall occurs between July and September and remaining 15- 20% rainfall is distributed unevenly because sometimes rainfall also comes in January and March.

The average annual rainfall of Ghaziabad district has been reported 731 mm given in the report of Indian Meterological Department (IMD).A large fluctuation has been noticed in rainfall with space and time. The district is enriched with typical climatical conditions like extremes in summer as well as in winters. The mercury reaches upto 400 degree Centigrade during peak summer and goes down to less than 50 during peak winters**.** **(Groundwater brochure of Ghaziabad)** [5] .

3.2 GROUNDWATER CONTAMINATION

As human needs increase and civilization changes, more and more finished products of different types are required. The effluent discharges from the various industries, sometimes infiltrates through sub soil and reaches to the ground water table forming polluting pool, which disturbs the whole natural ground water quality by changing the chemical composition. Accordingly, large numbers of industries are grown in the study area and the partially treated or untreated effluent of these industries has been discharged into nearby stream due to which after percolation or infiltration process, this waste mix into groundwater and contaminant the whole aquifer system.

TABLE 1.1 CLASSIFICATION OF WATER QUALITY

CLASS	WQI	WATER QUALITY
I	90-100	UNFIT FOR DRINKING
II	70-89	VERY POOR
III	50-74	POOR
IV	25-49	GOOD
V	0-24	EXCELLENT

Source: ISSN:2347-2200/V1N1/pp-09-14/©IJSE

3.3 SOURCES OF GROUNDWATER CONTAMINATION IN STUDY AREA (INDUSTRIES IN GHAZIABAD)

3.3.1 OIL AND GAS INDUSTRIES

Usage of water by the many upstream oil and gas industries has now become a serious issue of public concern. The gas and oil industries utilize water in various different ways, based on the resources being exploited and their locations. Key activities that utilize water including conventional oil production. The single largest usage of water by the conventional oil wells is attached with oilfield injection. When a conventional oil well is drilled, the oil may enter to the surface due to its own pressure or can be pumped up mechanically [36].

3.3.2 PAINT MANUFACTURING INDUSTRIES

India has manufactured tremendous strides in developing latest and quicker processing methods. The industry has moved to use of lead and chromium in various manufacturing

and processing sectors. The effluent contains both form of chromium such as hexavalent and trivalent Chromium.

TABLE 1.2 WATER QUALITY CRITERIA RECOMMENDED BY CPCB, MINISTRY OF ENVIRONMENT AND FORESTRY, GOVERNMENT OF INDIA

DESIGNATED BEST USE	**CLASS OF WATER**	**CRITERIA**
Drinking Water Source without conventional treatment but after Disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH betwwn 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l

Source:http://www.cpcbnic.in/classi.htm

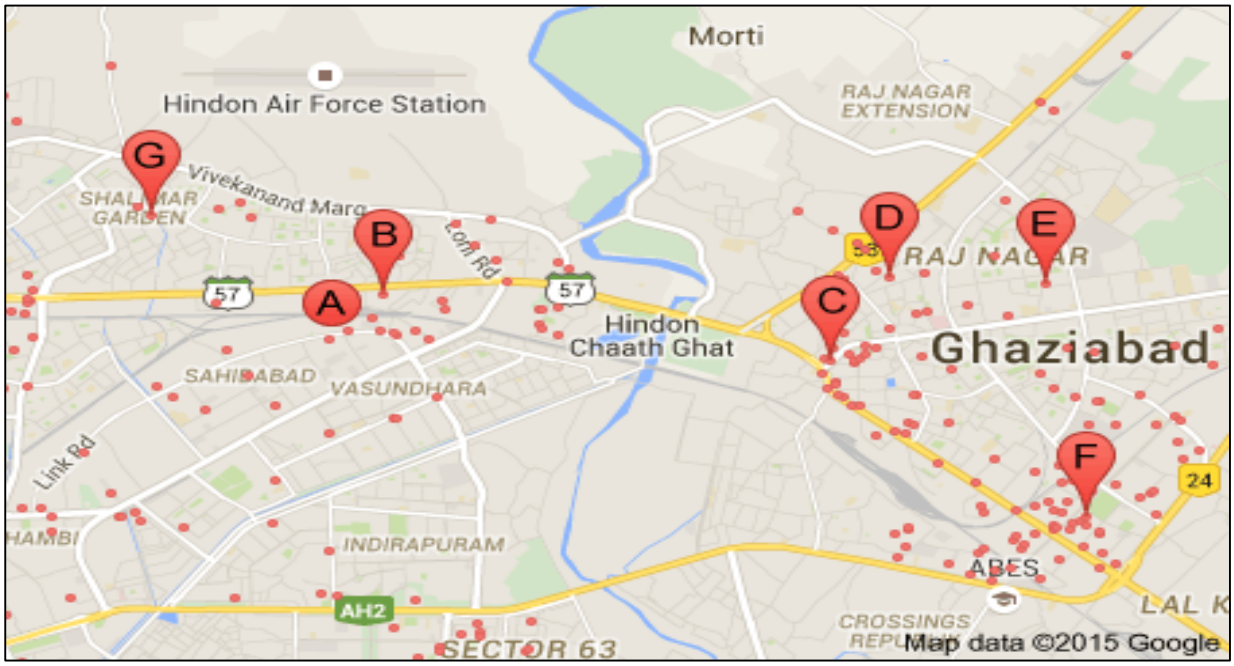


Figure 3.2 INDUSTRIES IN GHAZIABAD

Source :https://www.google.co.in/maps/search/industry+in+ghaziabad

Different types of metals are being used in paints those have raised a great concern due to its toxicity at a very high level of exposure and therefore these metals may accumulate in the food chain. Lead is also used in paint to speed drying, expand durability, keep a fresh appearance and also resist moisture that can cause corrosion. Primer paint containing hexavalent chromium which is widely used for automobile refinishing and in aerospace. It has also been utilized as a pigment for painter's paint, known as zinc yellow or yellow which is highly toxic[28].

3.3.3 ELECTRODE INDUSTRIES

Sediment contamination comes from different sources that release to receiving waters including: municipal sewage, industrial waste and storm water runoff from streets, farms, waste dumps, mining operations, industrial manufacturing, Heavy metals and metalloids, Polychlorinated biphenyls (PCBs), pesticides, polycyclic aromatic hydrocarbons (PAHs) and other organics are the most recently reported contaminants in sediments. The degradation rate of some chemicals is generally slow, and these chemicals try to persist in substances for a long time. [29] .

TABLE 1.3 INDUSTRIES IN GHAZIABAD

S. No.	Name & Address of Unit	Products
A	Pace Marketing Specialities Ltd., Site-IV, Sahibabad	Poly Vinyl Asitate Razins
B	Checko plast (India) Ltd., A-48/11-12-13, Site-IV, Sahibabad, Ghaziabad	HDPE Containers with caps and Seal
C	Aditya Steel Industries,73 Shalimar Garden Ghaziabad,	Cable Trays, Storage solutions, Heavy Duty Racks
D	Ferro industries, site iv, sahibabad industrial area, Ghaziabad.	Machinery, Machine Tools
E	Dabur (India) Ltd., 22, Site-IV, Sahibabad, Ghaziabad	Ayurvedic Medicines, Syrup & etc.
F	Modi Paint & Varnish works, Modi Nagar, Ghaziabad	Paint & Varnish
G	Oriental carbon and Chemical Ltd., south of GT road, Ghaziabad	Activated carbon
H	Swadeshi Detergent Ltd., 37/3, Site-IV, Sahibbad, Ghaziabad	Soap & powder
I	Rathi Gases Ltd., A-4/2, south of GT road, Ghaziabad	Industrial Gases
J	Easter(India) Chemical Ltd., C-40/41, Site-IV, Sahibabad	Chemicals
K	Guru Nanak Engineering Company, Patel Nagar, GZB	Oil Expeller, Diesel Engine
L	Uptron Devices Ltd., S-44/2, Site-IV, Sahibabad, Ghaziabad	Electronic Components
M	odi Arc Electrodes, Modi Nagar, Ghaziabad	Electrodes
N	B.P.L. Display Device Ltd., A-41,42, Site-IV, Sahibabad	T.V. Picture Tubes

Source: http://ghaziabad.nic.in/industry.htm

3.3.4 SOAP AND DETERGENT INDUSTRIES

Home laundry is the major household task in which a huge amount of water and detergents are used. Now a days, various soaps and detergents are easily available in the market.

TABLE 1.4 HEALTH IMPACTS DUE TO HEAVY METALS

S.No	Heavy Metal	Effect on human health	Sources of heavy metals
1	**Zn**	Zinc causes severe disease including pulmonary distress, chills, fever and gastroenteritis**.**	Sources of Zinc include production of galvanizing steel and iron products, corrosion-resistant alloys and brass, oxide of Zinc is used in rubber as a white pigment. **Patil et al,2013 [18]** .
2	**Pb**	Lead Causes damage to nervous system, reproductive system, kidney, learning ability, intestines and nerve and red blood cells.	Sources of lead include paint, mining wastes, and incinerator ash, water from lead pipes and solder, and automobile exhaust. **Patil et al,2013 [18]** **.**
3	**Cr^6**	Hexavalent chromium is a carcinogenic element can cause cancers and also damage kidney circulatory and nerve tissues; skin irritation, liver, lungs etc. **Patil et al,2013 [18]** **.**	Chromium found in metal alloys like stainless steel and pigments for cement, paints, rubber, paper, composition floor covering and other materials. **Patil et al,2013 [18]** .
4	**Fe**	Iron is an essential nutrient for health. Iron is a major component of haemoglobin, which is used to supply oxygen and carbon dioxide in the blood.	It exists naturally in lakes, rivers and underground water. Iron may also be released to water from industrial wastes, natural deposits, corrosion of iron containing metals , refining of iron ores etc. **Patil et al,2013 [18]** **.**

These detergents consist of different chemical compounds: surfactants, builders, bleaches, anti-redeposit agents, fillers, enzymes, perfume and colour, optical brighteners. It is a reality that detergents are non degradable by-products that keep in the environment as such for a long period. The suffering aquatic organism often shows sign of damage we are imposing on it in the form of many fishes and other aquatic organism dying (**Kamla-Raj 2012)** [30] .

3.3.5 SUGAR INDUSTRIES

Sugar industries are playing a very important role in the economic development of the country but the effluent discharged from the sugar industries create a high degree of organic load of pollution in both terrestrial and aquatic ecosystems.

Sugar mills effluent creates obnoxious colour and intolerable odour when discharged into the water. Sugar mills play a principal role in contaminating the land surface and water bodies by

discharging a huge amount of wastewater. Numerous chemicals are used in sugar factories during manufacturing process chiefly for coagulation of impurities and purifying of the end products.

Sugar industry effluent consists of a number of physicochemical components of suspended solids and dissolved solids with a great amount of biological oxygen demand, chemical oxygen demand , chlorides, nitrates, sulphate, calcium and magnesium. **(Yadav and Daulta)**[31] .

3.4 METHODOLOGY

The samples were collected from 16 different places along Hindon river stretch of Ghaziabad which are given as follows.

1)Nyay khand 2)Abhay khand 3)Niti khand 4)Gyan khand, 5)Indirapuram border 6) Shipra Suncity police chowki 7) Ashiana greens apartments 8)Ahinsa Khand 9)Shakti khand-2 10) Shakti khand-1 11)Kanawali Village 12)Vasundhara sec-5 13)Vasundhara sec-7 14)Vasundhara sec-8 15)Vasundhara sec-9 16)Balaji Vihar etc.

3.4.1 CRITERIA FOR SAMPLING

TABLE 1.5 INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER IS:10500

S.NO.	Parameter Requirement	Desirable Limit	Remarks
1	Colour	5	May be extended up to 50 if toxic substances are suspected
2	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3	pH	6.5-8.5	May be relaxed up to 9.2 in the absence
4	Total Hardness	300	May be extended up to 600
5	Nitrates	45	No relaxation
6	Iron	0.3	May be extended up to 1
7	Fluoride	0.6 to 1.2	If the limit is below 0.6water should be rejected, Max. Limit is extended to 1.5
8	Manganese	0.1	May be extended up to 0.5
9	Chlorides	250	May be extended up to 1000
10	Sulphates	150	May be extended up to 400
11	Arsenic	0.05	No relaxation
12	Cyanide	0.05	No relaxation
13	Lead	0.1	No relaxation
14	Chromium as Cr+6	0.05	No relaxation
15	Zinc	5.0	May be extended up to 10.0

The samples were collected in a 1 litre polyethylene bottles which had been thoroughly washed and then taken to the sampling site. The bottles were rinsed several times with the water to be collected. One ml of con.HNO_3 is added to each sample. The sample bottles were covered immediately after collection .All the heavy metals have been analyzed using atomic absorption spectrometer as per the standard methods**.** The prepared sample is kept in the dark place and the trace elements were analyzed by using Atomic Absorption Spectrometer using air –acetylene flame.

Figure 3.3 EXPERIMENTAL ANALYSIS IN LABORATORY

CHAPTER 4 RESULTS AND DISCUSSIONS

Groundwater samples were collected from 16 different places of Sahibabad industrial area of Ghaziabad along Hindon river which are given below.

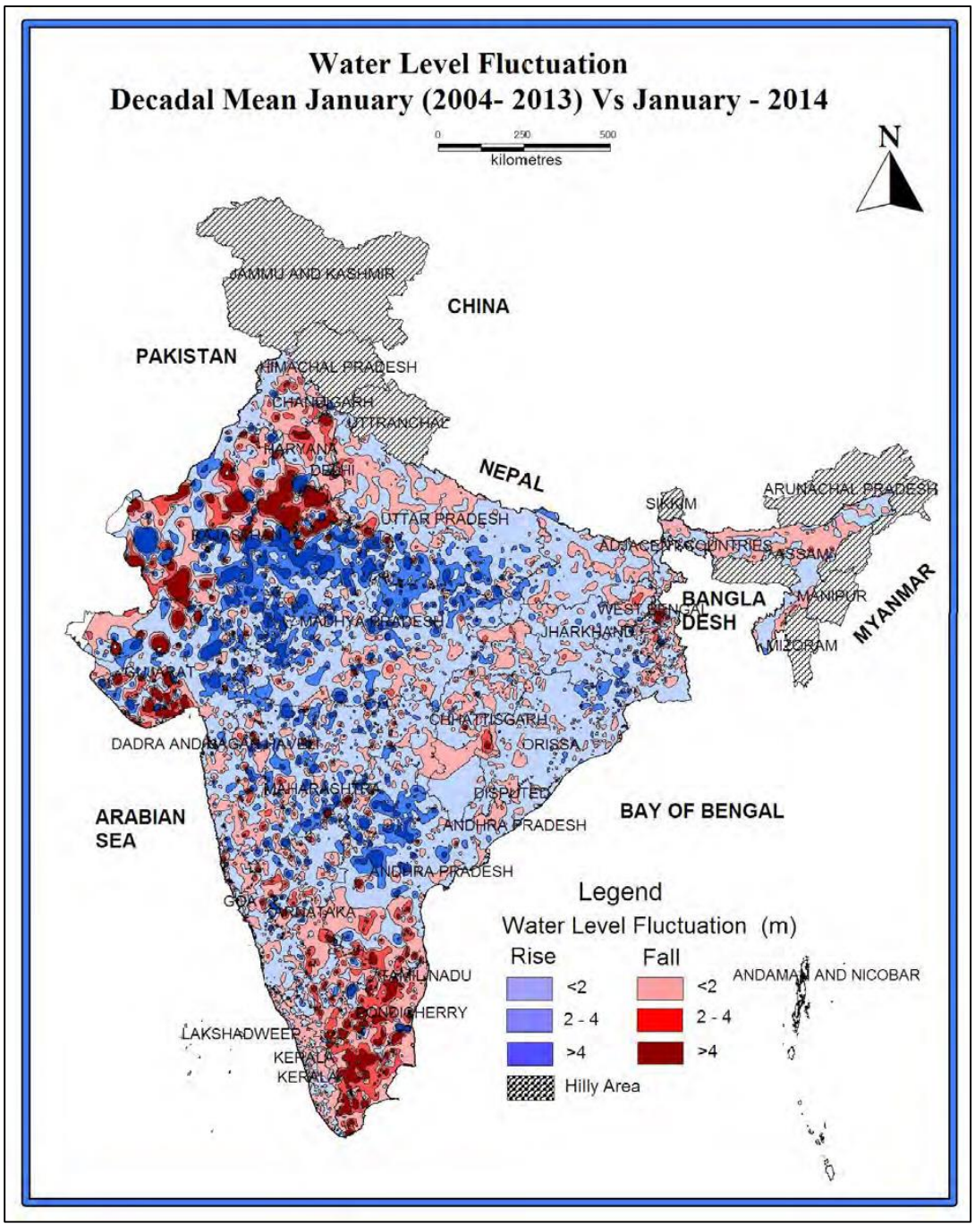
All the samples were drawn from the wells which included hand pumps, tube wells, bore wells supply schemes and analyzed for heavy metal parameters. From the analysis it has been estimated that the groundwater quality of study area is declining very frequently and the level of water table is also depleting at a very fast rate. In the study area a fall of 2m in water level has been noticed from January 2004 to January 2013. In this study, we have also analysed 4 elements (Zn,Pb,Cr^{6} and Fe)) in the water samples because from the research carried out by various researchers and also from the groundwater report of Ghaziabad, it has been estimated that the groundwater of this area is severely affected by only these four metals.

4.1 GROUNDWATER LEVEL DEPLETION

As per the recent well census, the amount of groundwater abstraction structures have been increased around 21 million in previous two decades with an estimated with drawl of about 22100 million cubic metre(MCM) annually from groundwater.

In the last few decades, rapid development has been noticed in the water resource sectors, resulting in several undesirable environmental impacts. A large number of bore wells are getting dried in some areas of Country due to decreasing groundwater level have had an immediate impact on water supply for domestic, irrigation and industrial purposes. As per the data given in Central groundwater year book when January 2014 data of water level was compared with previous year data of January 2013.This analysis estimates a fall of water level in around 22% wells, Out of which 19% of wells have shown fall in the range of 0-2m and the maximum fall is 15.10 m in the groundwater level in that particular State. While When the fluctuation of groundwater level in January 2014 compared with decadal mean fluctuation (January 2004-2013), shows that there is a normal fall in the groundwater level in Uttar Pradesh. About 30% of the analysed wells have estimated a fall

in water level. Out of which 26% of the wells have shown 0-2 m fall while 4% of them have shown more than 2 m fall **(Groundwater Year Book 2013-14)[8] .**



Source-Central groundwater board annual report

Figure4.1 DECADAL WATER LEVEL FLUCTUATION MAP

4.2 ANALYSIS OF HEAVY METALS

TABLE 1.6 RESULTS

S.No	Parameter	Permissible Limit(mg/l)	SAMPLES															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Zn	5.0	.02	.02	.03	.002	5.7	5.2	5.3	5.8	.01	.01	5.1	4.9	4.3	4.2	5.1	6.1
2	Pb	0.1	0.7	.01	.02	.01	0.2	0.2	0.3	0.3	0.2	0.2	0.4	0.4	0.3	0.3	0.4	0.5
3	Cr^6	0.05	.02	.02	.03	.02	1.3	1.2	1.1	1.5	.03	.02	1.6	1.7	1.1	1.8	1.7	2.3
4	Fe	0.3	.03	.03	.07	.01	0.3	0.3	0.4	0.4	0.1	.06	0.8	0.8	0.7	0.3	0.4	0.7

4.2.1 ZINC:

Zinc is an essential trace element found in all food and potable water in the form of salts or organic complexes.

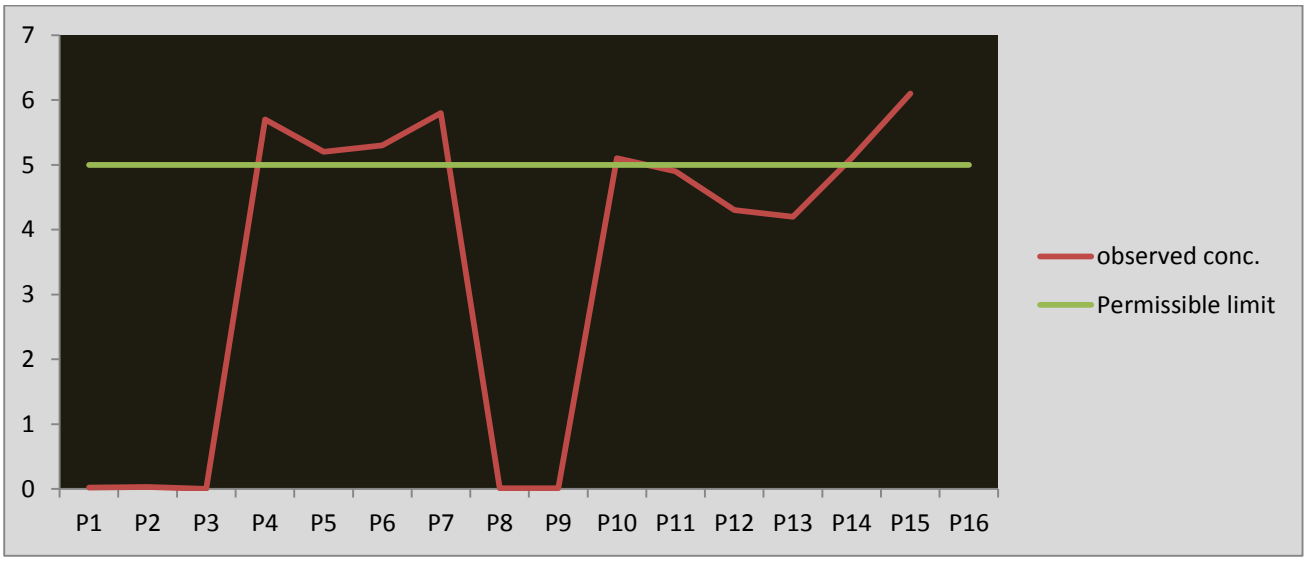


Figure 4.2 LINE DIAGRAM OF ZINC

Zinc causes disease include pulmonary distress, chills, fever and gastroenteritis **(Balakrishnan A et al.,2014)** [2] .Concentration of zinc estimated in this study, range

from .002 to 6.1ppm. From this analysis, it has been observed that the concentration of zinc lies within permissible limit except few places.

4.2.2 LEAD:

Lead is a dangerous element; it is harmful even in small amount. Lead is toxic to many organs and tissues including heart, intestines, bones, kidneys, reproductive system etc **Patil et al,2013** [18].The concentration of lead obtained in this study, range from 0.01 to 0.7 ppm. From this analysis, it has been determined that the concentration of lead is increasing at a very fast rate towards Sahibabad industrial area.

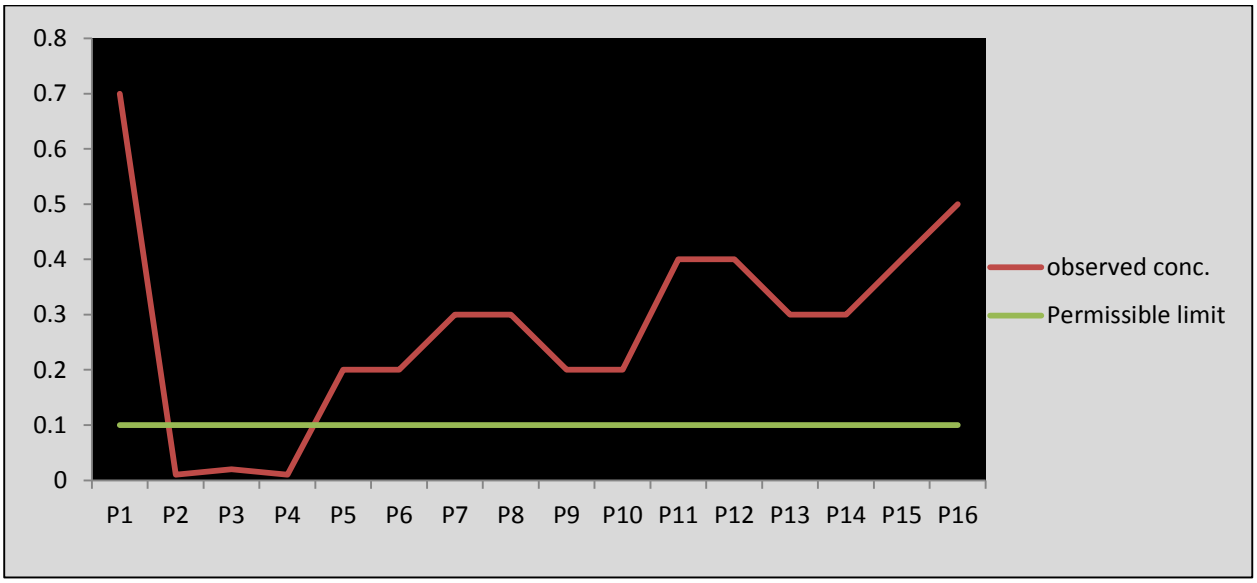


Figure 4.3 LINE DIAGRAM OF LEAD

4.2.3 CHROMIUM:

Chromium is a naturally occurring element which is essential to animal and human. Chromium in excess amount can be toxic especially the hexavalent form of chromium (Cr6). Chromium causes damage to kidney circulatory and nerve tissues; skin irritation, liver etc. In this present study area, the concentration of chromium in ground water varies from .02 to 2.3 ppm. From this analysis it has been estimated that the concentration of hexavalent chromium is increasing at a very fast rate towards Anand industrial area of Ghaziabad near Hindon river.

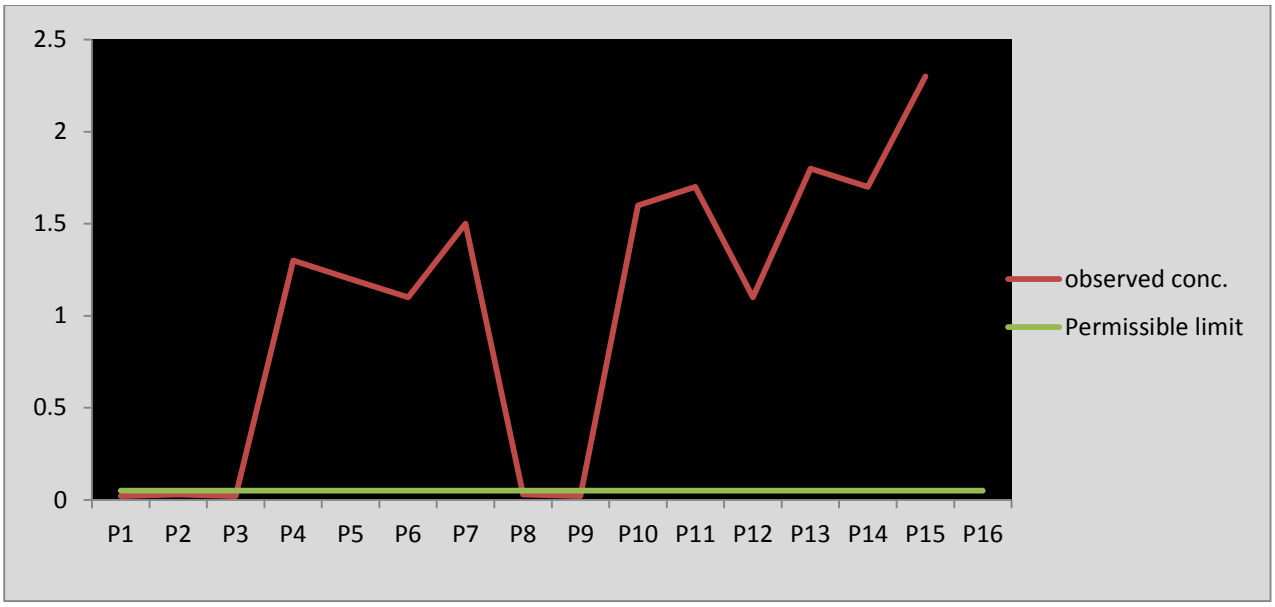


Figure 4.4 LINE DIAGRAM OF CHROMIUM

4.2.4 IRON:

Iron is an essential nutrient for health. It is a major component of haemoglobin

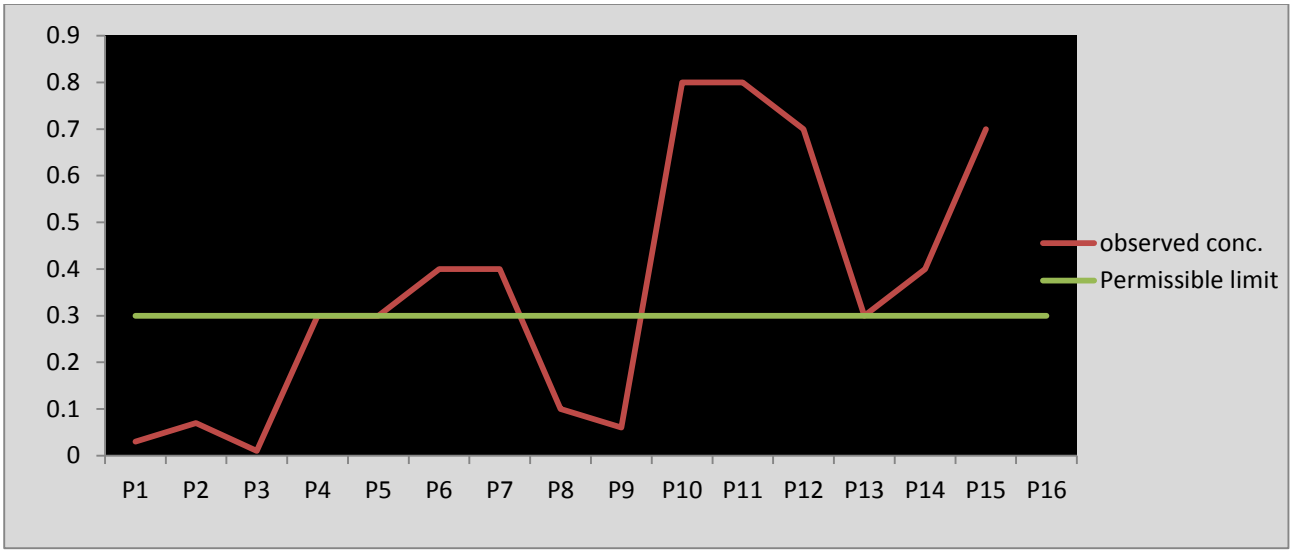


Figure 4.5 LINE DIAGRAM OF IRON

Which is used to supply oxygen and carbon dioxide in the blood. In the present study area, the concentration of iron content range in ground water from 0.01to 0.8ppm.From the analysis it has been found that the concentration of iron at some places is more than the permissible limit prescribed by BIS.

4.2.5 COMPARATIVE STUDY OF ALL ANALYSED HEAVY METALS

From the above results, it has been analysed that the trace metal, zinc has highest concentration as compare to other heavy metals. Zinc has highest concentration 6.1ppm and also having minimum concentration .002 ppm. All the trace metals have been plotted with different colours like zinc has been highlighted with blue colour, Chromium with light green colour, Lead with red colour and the last Iron with purple colour. Among all heavy metals Zinc has highest average concentration while lead has least average concentration.

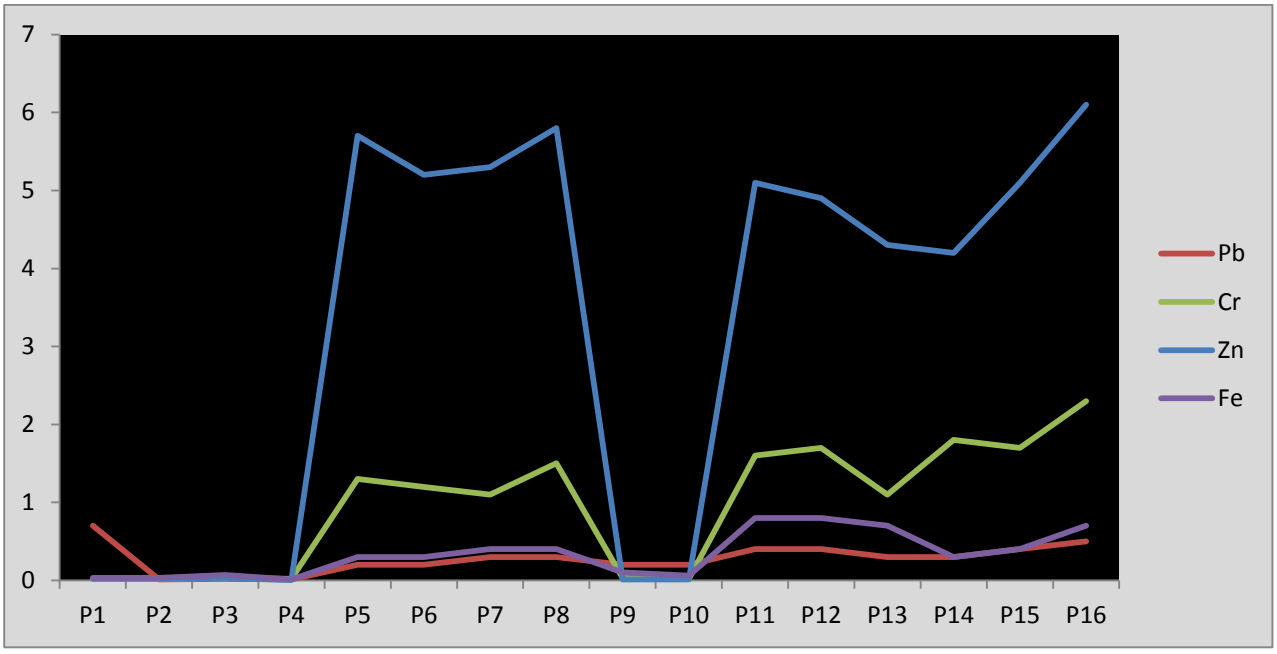


Figure 4.6 COMPARATIVE LINE DIAGRAM

From the above results, it has been observed that the groundwater is highly contaminated at all the places in the study area. In this diagram the contaminated areas are highlighted with the particular contaminants those are found in the study area. Groundwater of the

study area is contaminated with Cr6,Zn,Pb and iron heavy metals. All these metals are highly toxic to human health,they can cause severe health problems like permanent brain disorder in small kids, nervous system disorder and also responsible for different types of cancers.

Figure 4.7 STUDY AREA CONTAMINATED DUE TO HEAVY METALS

CHAPTER- 5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research has determined the significant information about the quality as well as quantity of the groundwater in Sahibabad industrial area of Ghaziabad. In the study area the level of groundwater table goes down at a very fast rate due to excessive usage of water in various sectors due to which dilution factor of water is decreasing. The concentration of minerals is increasing in groundwater, resulting declination in the self purification capacity of groundwater. High Concentration of various heavy metals such as Zinc, lead, chromium and iron etc has has been observed in the area which is diminishing the groundwater quality of that particular area. All these heavy metal contaminants estimated in groundwater comes from the effluents of many industries, domestic and agricultural because effluent may dispose without any treatment from industries into Hindon river, and after infiltration process this effluent mix into groundwater and contaminated it. The concentrations of heavy metals like Zn, Pb,Cr and Fe have been determined by using Atomic Absorption Spectrometer .Based on the Indian standards for drinking water quality, the concentration of trace metals Zn, Pb, Cr6, Fe is increasing in the study area.

On the basis of above discussion it may conclude that the underground drinking water at almost all places in study area is highly contaminated with trace metals. High amount of these parameters in groundwater may cause unpleasant taste of water and harmful effects on human health and also the groundwater level is depleting at a very fast rate. The concentration of heavy metal present in groundwater sample were compared with BIS standards and estimated that the most of the water samples are suitable for irrigation purpose but not suitable for drinking .High concentration of heavy metals in drinking water can cause severe health problems. Metals are highly toxic to many organs and tissues including heart, intestines, bones, kidneys, reproductive system etc. It interferes with the development of nervous system and is therefore toxic to children, causing permanent learning and behaviour disorders. Therefore the use of ordinary hand pump and bore well should be discouraged. People dependants on this water are often prone to health hazards due to contaminated potable water. If the situation is not control in future, it may

assume alarming situation for inhabitants. Therefore, a great attention should be given in order to reduce pollution load.

5.2 RECOMMENDATIONS

Increasing water level depletion and heavy metal contamination in groundwater is a major concern of natural resource declination. Stress on water resources has been increasing over the decades mainly due to rising water demands and per capita water consumption because of rapid population growth, and through rising water extraction for irrigation and drinking water supply. Most heavy metals are well-known poisonous and carcinogenic agents and it represents a significant threat to the human population and the fauna and flora of the receiving water bodies. Heavy metals have a great propensity to bio-accumulate and end up as permanent supplement to the environment. There are several techniques to avoid water crises and improve the quality as well as quantity of groundwater.

1. To stop the further declination of water level and improving the quality and quantity of ground water, Roof top rain water harvesting and proper practice of artificial recharge should be used particularly in urban areas.
2. Industries should have their own effluent treatment plants like MBR, SBR and comprehensive water management plant of the effluent with zero contaminant discharge. Treated water should be recycled for other uses such as irrigation purpose, cleaning and washing of equipments and also can be used in construction works.
3. Scientific perspective should be prepared while executing the ground water development plan. The water management practices should be used and make the people aware about the declination of groundwater level and also to improve the quality of ground water by using artificial recharge practices or rain water harvesting practices in problematic areas of Ghaziabad**.**
4. A mass awareness programme (MAP) for the awareness among the people of that particular area/region should be organised by the Ministry of Water Resources in the area of crises.
5. In most of the rural areas, desilting of old tanks and advancement of drainage system, direct and indirect methodologies for artificial recharge such as water diffusing through lateral ditch and furrow schemes in younger flood plain should be applied.

6. Sludge should be safely disposed on a sanitary site in order to avoid contamination of groundwater. Various methods should be used to remediate the heavy metal impurities from groundwater which are as follows.

5.6.1 PUMP AND TREAT METHOD

Pump-and-treat process has been used for a significant time to treat contaminated groundwater. Contaminated groundwater is expelled with the help of pumps from ground and sent it to the treatment plant where water can be treated or impurities can be removed by the conventional water treatment methods. After treatment the treated water can be either released into water bodies or re-injected into groundwater. The main advantage of this pump-and-treat method is a great professional experience can be gain with water treatment technology and the pumping technologies are also well efficient. Pumping and treating are conducted with significant costs over a period of time, specially where the contaminated region cannot be effectively polluted, and the incursion of new groundwater makes further accumulation of contaminants, and rising amount of water require treatment [9].

5.6.2 BIOREMEDIATION PROCESS

Bioremediation is defined as a process by which microorganisms are motivated to frequently degrade hazardous organic materials up to environmentally secure level in water, soils, and sediments. This method uses micro-organisms to decrease, remove or transform metal contaminants present in water. Bioremediation technology mainly depends on the existence of specific microorganisms in the exact amount or combination and in the suitable environmental conditions. These indigenous microbes try to use nutrients and electron acceptors present in water.

Bioremediation process includes both biotransformation and biodegradation by converting hazardous contaminants to less hazardous or non hazardous chemicals. Biodegradation is the process of breakdown of organic matters or bioaccumulation of inorganic compounds into eco-friendly compounds. The energy and carbon can be obtained through metabolism of organic matters by the microbes present in bioremediation processes**.** Thus, microbial bioremediation is a cost effective and beneficial bio resource for eliminating various hazardous contaminants from electroplating, tannery and other industrial effluent (**Singh et al,2013)[10].**

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