A

Project Report

On

SPATIAL HYDROCHEMICAL CHARACTERIZATION OF GROUNDWATER IN MEWAT

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BY

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CERTIFICATE

This is to certify that the work embodied in this dissertation entitled ***"SPATIAL HYDROCHEMICAL CHARACTERIZATION OF GROUNDWATER IN MEWAT" by*** **Vikas Saini** in the partial fulfillment of degree in Master of Technology (Applied Geology) to the Department of Geology, Kurukshetra University, Kurukshetra is original and carried out at National Institute of Hydrology, Roorkee during the period from Jan, 2016 to June, 2016 under my supervision and guidance. The matter presented in this dissertation has not been submitted to any other University/Institute for the award of any other degree or diploma.

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VIKAS SAINI

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SUMMARY

The present study was aimed at spatial hydro-chemical characterization of the quality of water resource degradation in Mewat district, Haryana. A total of 13 samples were collected in the month of March, 2016 from canal, open wells, handpumps and borewells situated in Chokha, Lahbas, Ghagas, Ulhetha, Naseerbad, Jhirkhola, Kotla, Palla, Tauru. The samples were analysed for Electrical Conductivity (EC), pH, Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Bicarbonate (HCO_3^- Sulphate (SO_4^{2-}), Nitrate (NO_3^-),Chloride (Cl^-), Iron (Fe), Zinc (Zn), Manganese (Mn) and Copper (Cu). The results indicated variations in physico-chemical parameters as EC (759– 32300 μS/cm) average value 6394.91, pH (7.3 – 8.4) average value 7.8, Hardness (813.8-26156.32 mg/l) average value 5609.21, Na^+(30-4850 mg/l) average value 887.91, K^+ (6.2-50.6 mg/l) average value 13.8, Ca^{2+} (107-3980 mg/l) average value 789.83, Mg^{2+} (94.22-395.3 mg/l) average value 886.5, SO_4^{2-} (194-645 mg/l) average value 341.66, NO_3^- (0.5- 48.8 mg/l) average value 11.6, Cl^- (199.98-8397.4 mg/l) average value 2040.83, Fe(164.4-727.1 μg/l) average value 417.08, Zn (8.32-425.5 μg/l) average value 51.8, Cu (0.7-51.51 μg/l) average value 8.50 and Mn (0.19-89.68 μg/l) average value 14.97. The results have been compared with the drinking water standard prescribed by Bureau of Indian Standard (BIS) and has been found out the values of EC, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, F^-, Fe in most of the samples are above permissible and desirable limits. On the basis of water quality parameters analysed, the water quality is found good in the foot hills of Aravalli hills with higher ground gradients but it is problematic in low lying areas. A strong correlation of EC with Na^+, Ca^+, Mg^+, Cl^- indicated that these parameters are the cause of salinity in the area. However, a detailed investigation is required to ascertain the cause of the salinity and its remediation.

CHAPTER 1

INTRODUCTION

Groundwater is a vital element to sustain life and the rapid growth of population, urbanization and agricultural activities leading to depletion in groundwater level and deterioration in its quality due to geogenic and anthropogenic activities in the northwest-region on India (CGWB, 2011; Chopra and Krishan, 2014a, b; Krishan and Chopra, 2014; Krishan et al. 2013a,b,c; 2014 a, b, Krishan et al., 2015a-c; Lohani and Krishan, 2015). According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its restoration to actual condition requires prolonged time and decontamination is not possible by just stopping the ingress of pollutants from the source. The groundwater quality is important to the community, therefore to ensure its. The groundwater quality may be affected naturally or due to geogenic reasons activities like: excessive use of fertilizers and pesticides in agricultural areas; introduction of untreated/partially treated waste water to the environment and excessive pumping and improper management of aquifers. Contamination of groundwater by domestic, industrial effluents and agricultural activity is a serious problem faced by developing countries. The industrial waste water, sewage sludge and solid waste materials are currently being discharged into the environment indiscriminately. These materials enter subsurface aquifers resulting in the pollution of irrigation and drinking water (Girija et al., 2007). High rates of mortality and morbidity due to water borne diseases are well known in India. Access to safe drinking water remains an urgent necessity, as 30% of urban and 90% of rural households still depend completely on untreated surface or groundwater (Palanisamy et al. 2007). The quality of water is defined in terms of its physical, chemical and biological parameters. Its development and management plays a vital role in agriculture production, poverty reduction, environmental sustenance and sustainable economic development. Assessing risk involves identifying the hazard associated with a particular occurrence, action, or circumstance and determining the probability of that hazard occurring. Hence, evaluation of groundwater quantity and quality is important for the development of further civilization and to establish database for planning future water resources development strategies. The quality of water may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of the dissolved salts depending upon source of the salt and soil, subsurface environment.

Monitoring of ground water regime is an effort to obtain information on ground water levels and chemical quality through representative sampling. In India, most of the population is dependent on groundwater as the only source of drinking water supply. The groundwater is believed to be comparatively much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage and solid waste dumping results in pollution of groundwater and health problems. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water. As per the latest estimate of Central Pollution Control Board, about 29,000 million litre/day of wastewater generated from class-I cities and class-II towns out of which about 45% is generated from 35 metro-cities alone (Mangukiya et.al, 2012).

In India, 5.5 million ha area is saline soil and saline zones can increase over time . Groundwater salinization can be caused by saltwater intrusion resulting from aquifer drawdown or by agricultural intensification. It has been estimated that 20% of the world's irrigated areas are affected by secondary salinization,

In this study, the groundwater quality study of Mewat was carried out where groundwater salinization issues have been emerged. Mewat region is located in Haryana state of India. The area is devoid of perennial surface water sources making availability of groundwater the critical factor in defining the sustainability of the agro-ecosystem. Groundwater is the only source of drinking water in this area. The work was carried out with the following objectives:

- Hydro-chemical characterization of groundwater in Mewat district, Haryana.
- To map spatial variation of physic-chemical parameters (Electrical Conductivity(EC), pH, Sodium(Na^+), Potassium(K^+), Calcium(Ca^{2+}), Magnesium(Mg^{2+}), Bicarbonate(HCO_3^- Sulphate (SO_4^{2-}), Nitrate (NO_3^-),Chloride (Cl^-), Iron (Fe), Zinc (Zn), Manganese (Mn) and Copper (Cu) in the groundwater in Mewat district, Haryana.

1.1 Study Area:

Mewat district officially known as Nuh district. Recently the name of Mewat district has changed to Nuh on 13 April, 2016. Nuh is the headquarters of Mewat which covers an area of 1,859.61 square kilometers. The district has 512 villages and 365 panchayats.

Mewat is located at 27° 39' and 28° 20' North latitude and 76° 51' and 77° 20' East longitudes (Fig. 1.1). Mewat district is bounded Guru Gram in the north, Rewari in the west, Faridabad and Palwal in the east. Mewat is most backward state of Haryana. The district has a population of 10,89,263 (Census, 2011). Mewat has a high poverty of incidence where 62% of rural household below poverty line.

1.1.1 Hydro-geology

The soil of Mewat is particularly sandy, sandy loam and clay loam. The upper hills are mostly barren. The district area is mainly underlain by alluvium of Quaternary age which forms the principal groundwater reservoir. Some amount of groundwater also occurs in fractures, joints and crevices of hard rocks found as strike ridge in the district. The ground water in the upper zone is 70 m depth. The aquifers that occur at deeper levels are confined to semi-confined. Alluvium thickness varies from almost insignificant near to hill ranges to above 291meters in the area (CGWB, 2012). The depth to water table is between 2-32 mbgl. In central part it is between 2 to 10 m bgl. In Tauru block the depth to water varies from 12 to 32 mbgl. The shallowest water table is recorded to be 0.53 m bgl at Nuh Block. Water logging and shallow water conditions occur in a large area in the central and south eastern parts of the district covering blocks like Nuh, Nagina and Punhana with water level ranging between 3 – 5 mbgl (CGWB, 2012).

The area shows a seasonal rise in water levels between 1 to 4 metres, except small patches in parts of Punhana, Nuh, Nagina and Firozpur–Jhirka where the rise in water levels less than 1 metre is recorded. Maximum rise was recorded (3-5 m) in isolated patches of the southern parts of the district area. On a long term basis most parts of the district show rising trend of water levels from 0.20 to 4 m over the period of 10 years. Quality of ground water is a major factor in the district for rising or stagnant water level trends. The area is having saline ground water even at shallow depth. Therefore the withdrawal of ground water is negligible in the area causing water logging at places (CGWB, 2012).

However, the Southern part of the district shows declining trend from 0.50 to 3.45 m bgl covering Ferozepur Jhirka block. Taoru block registers maximum declining trend in last 10 year ranging from 1.25 to 11.60 mbgl. Water table slopes north to south and south to north indicating natural trough in Nuh block. The ridge trending NNE-SSW direction, act as a ground water divide between the western and eastern part of area as indicated by the configuration of the water table on either side of the ridge (CGWB, 2012).

1.1.2 Climate and rainfall:

Mewat falls under the Sub-Tropical, Semi-arid climatic zone with extremely hot temperature in summer. May and June are the hottest months of the year with the temperature ranging from 30°C to 48°C. January is the coldest months of the year with the temperature ranging from 2°C to 25°C. The humidity is considerably low during the greater part of the year. The Mewat experience high humidity during the monsoon period. The maximum rainfall occurs during the monsoon season and the average rainfall varies from 336 mm to 440 mm in the district. The normal annual rainfall in Mewat district is 594mm (CGWB, 2012).

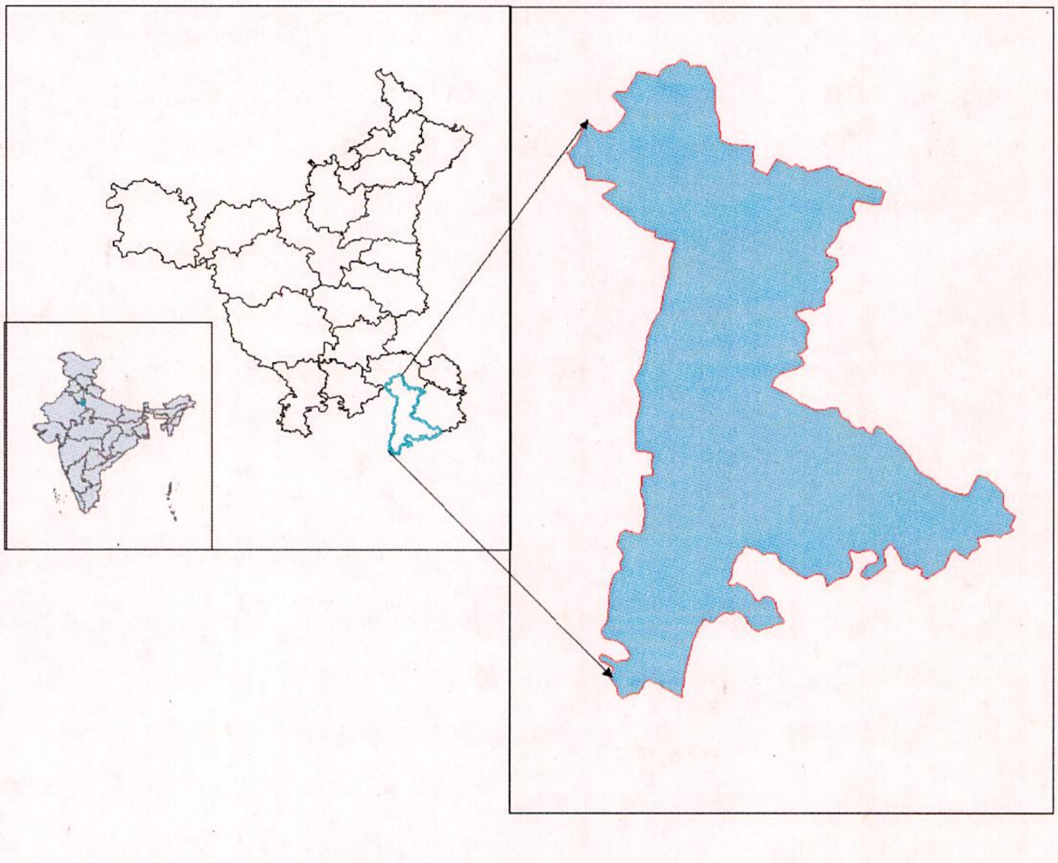


Fig: 1.1.2 Location of Mewat District in India Map

CHAPTER 2

REVIEW OF LITRATURE

Requirement for freshwater will continue to rise significantly over the coming decades to meet the needs of increasing populations, growing economies, changing lifestyles and evolving consumption patterns. This will greatly amplify the pressure on limited natural resources and ecosystems. Unsafe water and sanitation account for almost one tenth of the global burden of disease (Fewtrell et al., 2007). Total 768 million and 2.5 billion people in the world are living without access to clean water and proper sanitation, respectively (WHO, 2002). International development agencies are often urging the developing countries devote more attention to protecting and improving water quality. The developed world also must spend more and do more to clean up degraded waterways, or economic development will stall and the quality of life will fall (Falkenmark and Lindh, 1993). In every country, where agricultural fertilizers and pesticides are used, there are reports of contaminations of groundwater aquifers as well as surface waters. Europe and America confront enormous water pollution. Over 90% of Europe's rivers have high nitrate concentrations, mostly from agrochemicals, and 5% of them have concentrations at least 200 times greater than nitrate levels that occur in unpolluted rivers (WHO, 1999). Although mineral salts of low pollution relevance are the most common constituents found in groundwater, some serious pollutants and pollution levels also can be detected. UNEP (1998) reported that 79% of groundwater samples in Sri Lanka contains nitrate levels above the drinking water standard of 10 mg/l. The primary source of NO_3-N in ground water is leaching from soils. Shrivastva et al, (1988) and Olaniya and Saxena (1 977) have reported the leaching of nitrate ions from the soil into ground water. Nitrate itself is relatively nontoxic but when ingested with food or water it may be reduced to nitrite ($N0_2^-$) by bacteria present in mouth and gut. If nitrite containing water is utilized for drinking purposes (Qian-Feng et al, 1983) it can react with secondary arnines present in the human body, and may form carcinogenic nitrosamines.

Hydro-chemical studies become unavoidable since its poor quality may badly affect it users (Prasanna et al. 2010) and various studies on groundwater quality focused on drinking and irrigation carried out in various parts of India; Punjab (Chopra and Krishan, 2014b; Krishan et al., 2013b); Gharana wetland Jammu (Krishan et al., 2013d); N. Delhi Andhra Pradesh , Jharkhand (Singh et al., 2012); Pondicherry (Thilagavathi et al, 2012);

Groundwater can be contaminated by recharge through contaminated surface water and by liquid hazardous substances (or solids that can dissolve in water) that filter through the soil into groundwater, radioactive materials through rocks to aquifers (Krishan et al, 2015; 2014c), by salt water moving in from the ocean, or by minerals that are naturally present in the area. The water quality may be affected by natural processes like evaporation (Krishan et al, 2013c) and weathering and or anthropogenic like agricultural activities, domestic- industrial effluents and minor amount of atmospheric fallout. Bishnoi and Malik (2008) studied the quality of groundwater in the environmentally degraded localities of Paniput city in Haryana. They attribute the high levels of chemical constituents to geological factors, poor sewage and indiscriminate dumping of solid wastes.

Correlation coefficient analysis showed a positive and significant correlation of electrical conductivity with total dissolved salts, total hardness, sulphate and total alkalinity. Total hardness was positively and significantly correlated with magnesium and sulphate. Further, total alkalinity was found to be positively and significantly correlated with bicarbonate. Fluoride was higher than permissible limits in most of the samples. Ground water samples were collected by Gupta (2009) from different locations in the radius of 25 km. of Kaithal city, Haryana (India), were analyzed for their physicochemical characteristics. On comparing the result s against drinking water quality standards laid by ICMR and WHO, it is found that some of the water samples are non-potable for human being due to high concentration of one or the other parameter.

The presence of fluoride in water cannot be detected without the help of water quality testing equipment. High fluoride content is often detected from such symptoms on human beings as yellowing of teeth, damaged joints and bone deformities, which occur from long years of exposure to fluoride containing water. Due to this reason, by the time the community realises the “menace”, a large section of the population is already affected. A recent survey by the International Water Management Institute (IWMI) in north Gujarat showed 42 per cent of the people covered in the sample survey (28,425) were affected; while 25.7 per cent were affected by dental fluorosis, 6.2 per cent were affected by muscular skeletal fluorosis and 10 per cent by both.

The incidence of fluoride above permissible levels of 1.5 ppm occur in 14 Indian states, namely, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal affecting a total of 69 districts, according to some estimates. Some other estimates find that 65 per cent of India's villages are exposed to fluoride risk.

High levels of salinity are reported from all these states except West Bengal and also the NCT of Delhi, and affects 73 districts and three blocks of Delhi. Iron content above permissible level of 0.3 ppm is found in 23 districts from 4 states, namely, Bihar, Rajasthan, Tripura and West Bengal and coastal Orissa and parts of Agartala valley in Tripura. Pollution of groundwater due to industrial effluents and municipal waste in water bodies is another major concern in many cities and industrial clusters in India. A 1995 survey undertaken by Central Pollution Control Board identified 22 sites in 16 states of India as critical for groundwater pollution, the primary cause being industrial effluents. A recent survey undertaken by Centre for Science and Environment from eight places in Gujarat, Andhra Pradesh and Haryana reported traces of heavy metals such as lead, cadmium, zinc and mercury. Shallow aquifer in Ludhiana city, the only source of its drinking water, is polluted by a stream which receives effluents from 1300 industries. Excessive withdrawal of groundwater from coastal aquifers has led to induced pollution in the form of seawater intrusion in Kachchh and Saurashtra in Gujarat, Chennai in Tamil Nadu and Calicut in Kerala.

CHAPTER 3

MATERIALS AND METHODS

3.1 METHODOLOGY

12 water samples were collected from open well, submersible pump, hand pump and 1 sample from canal during 12-13 March 2016 for the analysis of cations -Sodium(Na^+), Potassium(K^+), Calcium(Ca^{2+}), Magnesium(Mg^{2+}), anions -Bicarbonate(HCO_3^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Chloride (Cl^-) and trace metals- Iron (Fe), Zinc (Zn), Manganese (Mn) and Copper (Cu). The canal sample was collected to see its impact on nearby groundwater sample. The physical parameters such as pH and electrical conductivity etc. were determined in the field using portable instrument (Hach, HQ30d portable meter). The analysis was performed as per standard method (APHA, 2012; Jain and Bhatia, 1988). The details of analytical methods and equipment used in the study are described in the table 3.1

Table 3.1: Details of the analytical methods and equipments used in the study

S. No.	Parameter	Method	Equipment
A.	PHYSICO – CHEMICAL ANALYSIS		
1.	pH	Electrometric	pH Meter
2.	Conductivity	Electrometric	Conductivity meter
4.	Calcium	Titration by EDTA	Digital Burette
5.	Magnesium	Titration by EDTA	-
6.	Sodium	Flame emission	Flame photometer
7.	Bicarbonate	Titration by H_2SO_4	-
8.	Sulphate	Turbidimetric	Turbidity Meter
9.	Chloride	Titration by $AgNO_3$	Digital Burette
10.	Fluoride	SPANDS	UV –VIS Spectrophotometer
11.	Nitrate	Chromatography	Ion Chromatograph
12.	Zinc	Chromatography	Ion Chromatograph
13.	Iron	Chromatography	Ion chromatograph
14.	Mn	Chromatography	Ion Chromatograph
15.	Cu	Chromatography	Ion Chromatograph

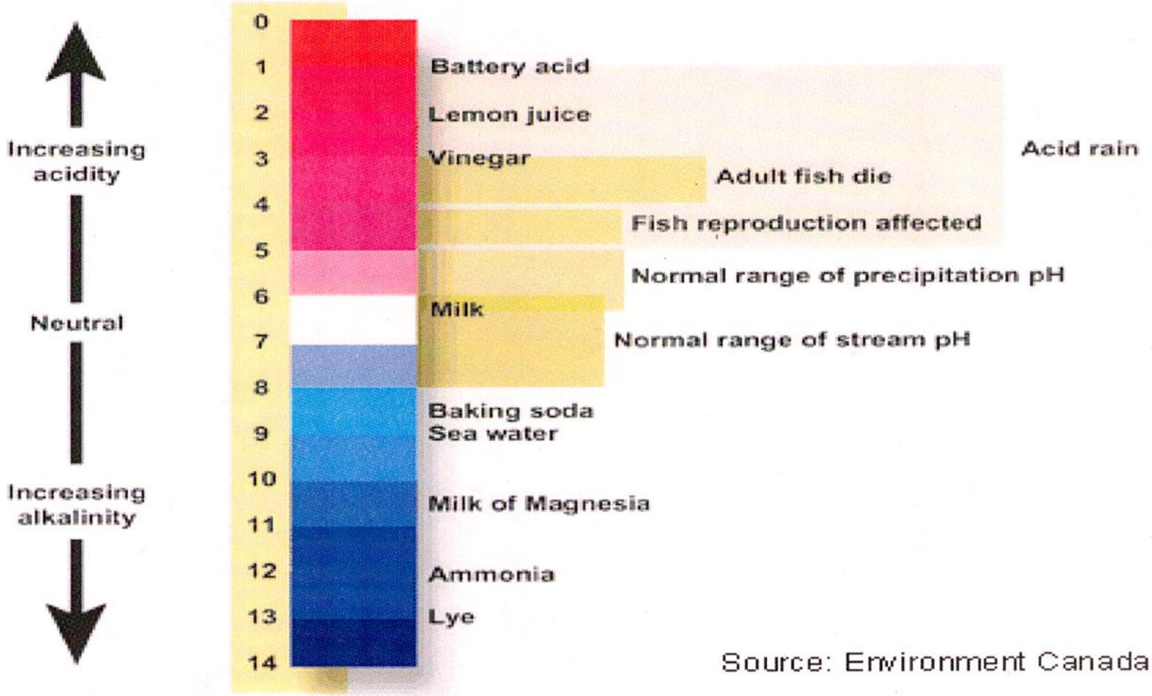
3.2 HYDROCHEMISTRY (Water Quality parameters studied)

3.2.1 pH

pH: pH mean potential of hydrogen ion in water and is measured in logarithmic unit to indicate acidity or alkalininity and is denoted as:

$$pH = -\log(H^{+})$$

More free hydrogen ion in water indicates acidity while more free hydroxyl ion indicated basicity.



Source: Environment Canada

Fig: 3.2.1 Limit of pH

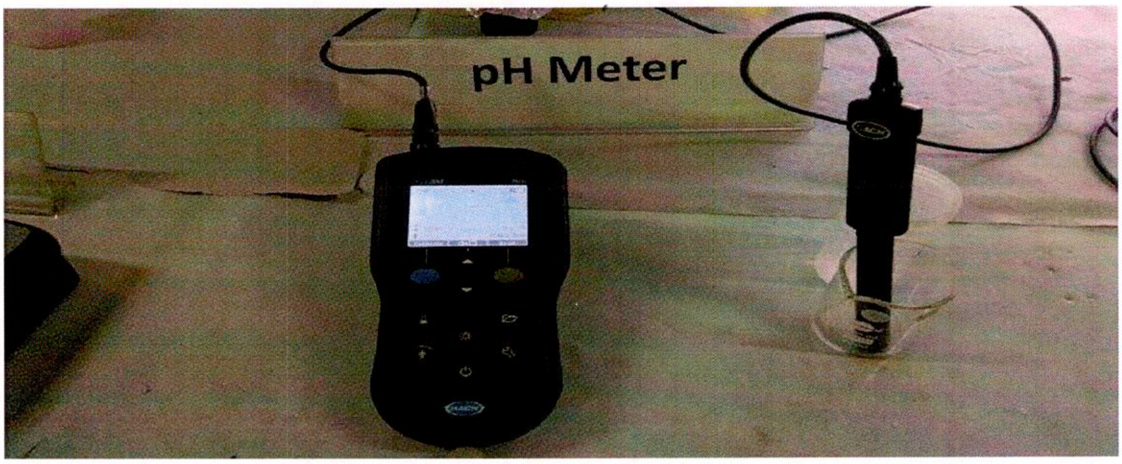


Fig: 3.2.2 pH meter

Procedure:

The pH was measured by a pH meter. Firstly, the electrode or probe was rinse with distilled water; cleaned with tissue paper. Electrode or probe first calibrated against pH 4,7 and 10 at a temperature of 25 °C. After calibration the electrode or probe is rinsed the distilled water, clean with tissue paper and immersed in pH 4 if the value indicates 4 instruments is calibrated. The electrode or probe was then immersed in the sample and stirred gently and stopped. After that take observation one by one.

Significance of pH:

1. The pH water determines the solubility (amount that can be dissolved in water).
2. pH also measure the what foam of phosphorous is most important in water.
3. pH also determine whether aquatic life can use it.
4. The degree to which they are soluble determine their toxicity.
5. Metal tends to more toxic at lower pH because they are soluble.

Note: Sometimes litmus paper is used for simply indication whether solution is acidic or basic.Blue litmus paper terns red under acid condition and Red litmus paper under turns blue under alkaline conditions.

3.2.2 Electrical conductivity (EC):

The electrical conductivity of water estimates the total amount of solids dissolved in water -TDS, which stands for Total Dissolved Solids. TDS is measured in ppm (parts per million) or in mg/l

Units Used for Analytical Results: µS/cm

Normal Method(s) of Analysis: Electrometric.

Occurrence/Origin: Reflects mineral salt content of water.

Health/Sanitary Significance: No direct significance.

The conductivity of water is an expression of its ability to conduct an electric current. As this property is related to the ionic content of the sample which is in turn a function of the dissolved (ionisable) solids concentration, the relevance of easily performed conductivity measurements is apparent. In itself conductivity is a property of little interest to a water analyst but it is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solids content of the water. While a certain proportion of the dissolved solids (for example, those which are of vegetable origin) will not be ionised (and hence will not be reflected in the conductivity figures) for many surface waters the following approximation will apply:

Conductivity (µS/cm) x 2/3 = Total Dissolved Solids (mg/l).

Conductivity: Recommended or Mandatory Limit Value

Table: 3.2.2 Limits of electrical conductivity with water

SR. NO.	Electrical Conductivity micro mhos/cm at 25° C	Types of water
1.	Up to 250	Low Conductivity Water
2.	250 to 750	Medium Conductivity Water
3.	750 to 2250	High Conductivity Water
4.	Above 2250	Very High Conductivity Water

Procedure:

The conductivity was determined by means of a conductivity meter. The conductivity probe was rinse with distilled water, clean with tissue paper and immerse in NaCl solution. The instruments was show until the value is indicating 1413 µS/cm. then instruments is calibrated. After calibrated the probe was rinse with distilled water, clean with tissue paper. Then the probe is immersed in the sample one by one and take reading

3.2.3 Calcium (Ca)

Calcium occurs in water naturally. Seawater contains approximately 400 ppm calcium. One of the main reasons for the abundance of calcium in water is its natural occurrence in the earth's crust. Calcium is also a constituent of coral. Rivers generally contain 1-2 ppm calcium, but in lime Areas Rivers may contains calcium concentrations as high as 100 ppm.

Calcium is an important determination of water hardness, and it is also function as a pH stabilizer, because of its buffering qualities. Calcium gives water as a better taste.

Apparatus required: Burette, pipette, conical flask, beakers and dropper.

Reagents: Dry powder, Sodium hydroxide 2N

Procedure:

Two milliliters (2.0 mL) of 1 M NaOH was added to 50 ml of sample. The mixture was stirred and 0.1g of murex indicator was added to it. Titration was done immediately after the addition of the indicator.EDTA Titrant was slowly added with continuous stirring until the colour changed from pink colour to orchid purple.

Reaction with water

Calcium reacts with water at room temperature, according to the following reaction mechanism:

$Ca\ (s) + 2H_2O\ (g) -> Ca(OH)_2\ (aq) + H_2\ (g)$

This reaction forms calcium hydroxide that dissolves in water as a soda, and hydrogen gas.

Solubility of calcium and calcium compound

Elementary calcium reacts with water. Calcium compounds are more or less water soluble. Calcium carbonate has a solubility of 14 mg/l, which is multiplied by a factor five in presence of carbon dioxide. Calcium phosphate solubility is 20 mg/l, and that of calcium fluoride is 16 mg/l. Calcium chromate solubility is 170 g/l, and at $0^{o}C$ calcium hypo chlorate solubility is 218 g/l. Solubility of other calcium compounds lies between the levels of these examples, for example calcium arsenate 140 mg/l, calcium hydroxide 1.3 g/l and calcium sulphate 2.7-8.8 g/l.

Presence in Water

Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness, because it can be found in water as Ca^{2+}ions. Magnesium is the other hardness determinant.

Health effect of Calcium in water

Calcium is a dietary mineral that is present in the human body in amounts of about 1.2 kg. No other element is more abundant in the body. Calcium phosphate is a supporting substance, and it causes bone and tooth growth, together with vitamin D. Calcium is also present in muscle tissue and in the blood. It is required for cell membrane development and cell division, and it is partially responsible for muscle contractions and blood clotting. Calcium regulates membrane activity, it assists nerve impulse transfer and hormone release, stabilizes the pH of the body, and is an essential part of conception. In order to stimulate these body functions a daily intake of about 1000 mg of calcium is recommended for adults.

Environmental effects of calcium in water

Calcium is a dietary requirement for all organisms apart from some insects and bacteria. Calcium carbonate is a building stone of skeletons of most marine organisms, and eye lenses. Calcium phosphate is required for bone structure and teeth structure of terrestrial organisms. Plants mainly contain calcium oxalate. Calcium storage in plants is about 1% of dry mass.Calcium is largely responsible for water hardness, and may negatively influence toxicity of other compounds.

Elements such as copper, lead and zinc are much more toxic in soft water. In limed soils calcium may immobilize iron. This may cause iron shortages, even when plenty of iron is present in the soil.

Method to remove calcium from water

Removing calcium and magnesium ions from water is carried out by water softeners. These are ion exchangers that usually contain Na^{+} ions, which are released and substituted by $\mathbf{Ca}^{2+}$ and Mg^{2+} ions.

Calcium compounds may be applied for wastewater treatment. Drinking water pH and hardness may be altered by means of calcium carbonate and calcium hydroxide.

Calculation:

Calcium hardness (mg/l) = Total hardness- Magnesium hardness

3.2.4 Magnesium (Mg)

Magnesium is present in seawater in amounts of about 1300 ppm. After sodium, it is the most commonly found cation in oceans. Rivers contains approximately 4 ppm of magnesium, marine algae 6000-20000 ppm and oysters 1200 ppm. Dutch drinking water contains between 1 and 5 mg of magnesium per liter. Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water, and water containing low amounts of these ions is called soft water.

Apparatus required: Burette, pipette, conical flask, beakers and dropper.

Reagents: Dry powder, Sodium hydroxide 2N

Procedure:

Two milliliters (2.0 mL) of 1 Mol NaOH was added to 50 ml of sample. The mixture was stirred and 0.1g of murex indicator was added to it. Titration was done immediately after the addition of the indicator.EDTA. Titrant was slowly added with continuous stirring until the colour changed from pink colour to orchid purple.

Reaction with water

Magnesium metals are not affected by water at room temperature. Magnesium generally is a slow-reacting element, but reactivity increases with oxygen levels. Furthermore, magnesium reacts with water vapor to magnesium hydroxide and hydrogen gas:

$Mg (s) + 2 H_2O (g) \rightarrow Mg(OH)_2 (aq) + H_2 (g)$

Magnesium fires cannot be extinguished by water. Magnesium continues to burn after oxygen is depleted. It than reacts with nitrogen from air to form magnesium nitride (Mg_3N_2).

Solubility of magnesium and magnesium compound

Magnesium is mainly present as Mg^{2+} (aq) in watery solutions, but also as $MgOH^+$ (aq) and $Mg(OH)_2$ (aq). In seawater it can also be found $MgSO_4$.Water solubility of magnesium hydroxide is 12 mg/l. Other magnesium compounds are clearly more water soluble, for example magnesium carbonate (600 mg/l). Magnesium sulphate adds a bitter flavour to water, and has a water solubility of 309 g/l at 10°C.

Presence in Water

A large number of minerals contains magnesium, for example dolomite (calcium magnesium carbonate; $CaMg(CO_3)_2$) and magnesite (magnesium carbonate; $Mg CO_3$). Magnesium is washed from rocks and subsequently ends up in water.

Environmental effects of magnesium in water

Magnesium is a dietary mineral for any organism but insects. It is a central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Magnesium cannot only be found in seawater, but also in rivers and rain water, causing it to naturally spread throughout the environment. Three magnesium isotopes occur naturally, which are all stable and consequently not radioactive. There are also eight instable isotopes.

Health effect of Magnesium in water

Human body contains about 25 g of magnesium, of which 60% is present in the bones and 40% is present in muscles and other tissue. It is a dietary mineral for humans, one of the micro elements that are responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Magnesium is an ingredient of many enzymes. Magnesium and calcium often perform the same functions within the human body and are generally antagonistic.

Purification technology to remove Magnesium from water

Magnesium compounds are usually removed from water, because of the role magnesium plays in water hardness. This is achieved by means of water softening. Magnesium hydroxide is applied as a flocculent in water purification.

Calculation

Magnesium hardness (mg/l) = Total hardness- calcium hardness

3.2.5 Sodium (Na)

Sodium is washed out from rocks and soils, ending up in oceans, where it may remain for about 50.106 years. Seawater contains approximately 11,000 ppm sodium. Rivers contain only about 9 ppm. Drinking water usually contains about 50 mg/l sodium. This value is clearly higher for mineral water. In soluble form sodium always occurs as Na^+ ions.

Apparatus Required: Flame photometer, lab glassware.

Instrument: Flame Photometer

Procedure:

Switch on compressor pressure should be 0.5 Kg/cm^2 and calibrate the instrument with the standard solution 20, 40, 60, 80 and 100 were appear for Sodium and potassium after calibration start the analysis by instrument.

Reaction with water

Sodium reacts strongly with water, according to the following reaction mechanism:

$2Na\ (s) + 2\ H_2O \rightarrow 2NaOH\ (aq) + H_2\ (g)$

A colourless solution is formed, consisting of strongly alkali sodium hydroxide (caustic soda) and hydrogen gas. This is an exothermic reaction. Sodium metal is heated and may ignite and burn with a characteristic orange flame. Hydrogen gas released during the burning process reacts strongly with oxygen in the air.

A number of sodium compounds do not react as strongly with water, but are strongly water soluble.

Solubility of Sodium and Sodium compound

A number of examples of water solubility of sodium are available. De most familiar sodium compounds is sodium chloride (NaCl), otherwise known as kitchen salt. At 20°C solubility is 359 g/l, in other words adequately water soluble. Solubility is nearly temperature independent. Sodium carbonate (Na_2CO_3) is also adequately water soluble. Solubility is 220 g/l at 20 ^{0}C.

Presence in Water

Sodium compounds naturally end up in water. As was mentioned earlier, sodium stems from rocks and soils. Not only seas, but also rivers and lakes contain significant amounts of sodium. Concentrations however are much lower, depending on geological conditions and wastewater contamination.

Sodium compounds serve many different industrial purposes, and may also end up in water from industries. They are applied in metallurgy, and as a cooling agent in nuclear reactors. Sodium nitrate is often applied as a synthetic fertilizer.

Environmental effects of Sodium in water

Sodium is attributed water hazard class 2, in other words it is a risk when present in water. Sodium chloride however is not a risk and is attributed water hazard class 1.Sodium is a dietary mineral for animals. Plants however hardly contain any sodium. The LC 50 value for gold fish is 157 mg/l. Sodium hypo chlorite from sanitary cleansers may contribute to chlorinated hydrocarbon formation, and may therefore heavily charge wastewater. Only one sodium isotope occurs naturally, namely the stable 23 Na. There are 13 instable sodium isotopes, which are mildly radioactive.

Health effect of Sodium in water

Sodium is present in the human body in amounts of about 100 g. It is a dietary mineral, partially responsible for nerve functions. Blood serum contains 3.3 g/l sodium. It regulates extra cellular fluids, acid-base balance and membrane potential, partially together with potassium.

One may overdose on sodium from kitchen salt. This causes increased blood pressure, arteriosclerosis, oedema, hyperosmolarity, confusion and increased risk of infection from excessive Na^+ intake. Sodium shortages may lead to dehydration, convulsion, muscle paralysis, decreased growth and general numbness. Generally, humans require about 300 mg sodium chloride per day to warrant a balanced sodium level. People that have diarrhea or other health effects that increase salt requirements need a higher dietary amount of sodium than usual. Adult intake of kitchen salt is on average 9 g per day, which translates to approximately 4 g of sodium. People with heart and kidney disease are recommended a sodium poor diet. Kitchen salt solution was applied as vomiting provoker in the old days. Caustic soda can deeply affect tissues.

Purification technology to remove Sodium from water

To remove sodium chloride from water, one may apply reverse osmosis, electro dialysis, distillation techniques or ion exchange. Reverse osmosis is most economical considering energy and money requirements. Sodium is applied in water purification. It may function as a counter ion of calcium and magnesium in water softeners.

Calculation:

Values of Na shown on monitor is in mg/l

3.2.6 Potassium (K)

Seawater contains about 400 ppm potassium. It tends to settle, and consequently ends up in sediment mostly. Rivers generally contains about 2-3 ppm potassium. This difference is mainly caused by a large potassium concentration in oceanic basalts. Calcium rich granite contains up to 2.5% potassium. In water this element is mainly present as K^+ (aq) ions. 40K is a naturally abundant radioactive potassium isotope. Seawater contains a natural concentration of about 4.5 - 10-5 g/l.

Apparatus required: Flame photometer, lab glassware.

Instrument: Flame Photometer

Procedure:

Firstly switch on compressor pressure should be 0.5 Kg/cm^2 and calibrate the instrument with the standard solution 20, 40, 60, 80 and 100 were appear for Sodium and potassium after calibration start the analysis by instrument.

Reaction with water

Potassium reacts rapidly and intensely with water, forming a colorless basic potassium hydroxide solution and hydrogen gas, according to the following reaction mechanism:

$2K\ (s) + 2H_2O\ (l) -> 2KOH\ (aq) + H_2\ (g)$

This is an exothermal reaction and potassium is heated to such an extend that it burns a purple flame. Additionally, hydrogen released during the reaction strongly reacts with oxygen and ignites. Potassium reacts with water more slowly than does rubidium, which is placed under potassium in the periodic chart. It reacts with water more rapidly than does sodium, which is placed higher in the periodic chart.

Solubility of Potassium and Potassium compound

Potassium is non-water soluble, but it does react with water as was explained earlier. Potassium compounds may be water soluble. Examples are potassium dichromate with a water solubility of 115 g/l, potassium permanganate with a water solubility of 76 g/l, potassium iodide with a water solubility of 92 g/l, and potassium iodide, of which even up to 1480 g may be dissolved in one liter of water.

Presence in water

Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Examples are feldspars (orthoclase and microcline), which are however not very significant for potassium compounds production, and chlorine minerals carnalite which are most favourable for production purposes. Some clay minerals contain potassium. It ends up in seawater through natural processes, where it mainly settles in sediments.

Elementary potassium is extracted from potassium chloride, but does not serve many purposes because of its extensive reactive power.

Environmental effects of Potassium in water

Potassium is an dietary requirement for nearly any organism but a number of bacteria, because it plays an important role in nerve functions.

Potassium plays a central role in plant growth, and it often limits it. Potassium from dead plant and animal material is often bound to clay minerals in soils, before it dissolves in water. Consequently, it is readily taken up by plants again. Ploughing may disturb this natural process. Consequently, potassium fertilizer are often added to agricultural soils. Plants contain about 2% potassium (dry mass) on average, but values may vary from 0.1-6.8%. Mosquito larvae contain between 0.5 and 0.6% potassium, and beetles contain between 0.6 and 0.9% potassium (dry mass). Potassium salts may kill plant cells because of high osmotic activity.

Health effect of Potassium in water

Potassium is a dietary requirement for us, and we take up about 1-6 g per day at a requirement of 2-3.5 g per day. The total potassium amount in the human body lies somewhere between 110 and 140 g and mainly depends upon muscle mass. The muscles contain most potassium after red blood cells and brain tissue.

Whereas its opponent sodium is present in intracellular fluids, potassium is mainly present within cells. It preserves osmotic pressure. The relation of potassium in cells to potassium in plasma is 27:1, and is regulated by means of sodium-potassium pumps.

Method to remove Potassium from water

Potassium may be removed from water by means of reverse osmosis. Potassium is applied in water purification. For example, potassium permanganate is applicable for oxidation of waterborne compounds, such as for iron or manganese removal, and disinfection. This is however not generally recommended. Potassium permanganate application makes it possible to determine the oxidative capacity of organic matter in water. Generally this exceeds BOD. Potassium dichromate is applied for COD determination.

Calculation:

Values of K shown on monitor is in mg/l

3.2.7 Bicarbonate (HCO_3^-)

Bicarbonate is an intermediate form in the deprotonation of carbonic acid. It is a polytomic anion with the chemical formula H_2CO_3

- Bicarbonate (HCO_3-) is alkaline, and a vital component of the pH buffering system of the human body (maintaining acid-base homeostasis). 70–75% of CO_2 in the body is converted into carbonic acid (H_2CO_3), which can quickly turn into bicarbonate.

- With carbonic acid as the central intermediate species, bicarbonate – in conjunction with water, hydrogen ions, and carbon dioxide – forms this buffering system, which is maintained at the volatile equilibrium required to provide prompt resistance to drastic pH changes in both the acidic and basic directions. This is especially important for protecting tissues of the central nervous system, where pH changes too far outside of the normal range in either direction could prove disastrous.

Apparatus required: Burette with Burette stand, pipettes with elongated tips, pipette bulb, conical flask, 250 mL measuring cylinders, standard flask, wash bottle, beakers.

Reagent : Methyl Orange , Phenolphthalein indicator

Procedure:

In this test firstly check pH. If the value exceeds 8.3 then the titration is done by the only phenolphthalein indicator. Take 50ml sample in a conical flask and add 2-3 drops of phenolphthalein and swirl to mix. If the colour develops titrated the sample with sulfuric acid 0.02N standard solution.The solution change from pink to colorless. Note the volume of sulfuric acid required. Add 2-3 drops methyl orange indicator to the titrated solution and swirl to mix. Continue titration with sulfuric acid standard solution, to a pink colour. Note the volume of sulfuric acid used.

Importance to human health

Bicarbonate is a major element in our body. Secreted by the stomach, it is necessary for digestion. When ingested, for example, with mineral water, it helps buffer lactic acid generated during exercise and also reduces the acidity of dietary components. Finally, it has a prevention effect on dental cavities. Bicarbonate is present in all body fluids (see table) and organs and plays a major role in the acid-base balances in the human body. The first organ where food, beverages and water stay in our body is the stomach. The mucus membrane of the human stomach has 30 million glands which produce gastric juice containing not only acids, but also bicarbonate. The flow of bicarbonate in the stomach amounts from 400 μmol per hour (24.4 mg/h) for a basal output to 1,200 μmol per hour (73.2 mg/h) for a maximal output. Thus at least half a gram of bicarbonate is secreted daily in our stomach. This rate of gastric bicarbonate secretion is 2-10% of the maximum rate of acid secretion. In the stomach, bicarbonate participates in a mucus-bicarbonate barrier regarded as the first line of the protective and repair mechanisms. On neutralization by acid, carbon dioxide is produced from bicarbonate. A study has underlined that a dose of 6.17 g of sodium bicarbonate rapidly leaves the stomach with the liquid phase of the meal.

Effects of Bicarbonates

For digestion, bicarbonate is naturally produced by the gastric membrane in the stomach. This production will be low in alkaline conditions and will rise in response to acidity. In healthy individuals this adaptive mechanism will control the pH perfectly. To modify this pH with exogenous doses of bicarbonate, some clinical experiments have been conducted with sodium bicarbonate loads as high as 6 g. Only a transient effect on pH has been obtained. It is quite possible that bicarbonate in water may play a buffering role in the case of people sensitive to gastric acidity. Thus bicarbonate may be helpful for digestion.

The most important effect of bicarbonate ingestion is the change in acid-base balance as well as blood pH and bicarbonate concentration in biological fluids. It has been studied particularly in physically active people. Among the types of acid produced, lactic acid generated during exercise is buffered by bicarbonate. In a study on sports, a dose of 0.3 g per kg of body weight of sodium bicarbonate was given (15.25 g bicarbonate for a man of 70 kg) to subjects before performing 30 minutes cycling. While blood pH was increased and then maintained constant with this bicarbonate load due to the changes in blood bicarbonate concentrations, increased acidity and decreased bicarbonate blood concentration were observed in controlled subjects. Mineral water which contains bicarbonate (>600 mg/l) may have an effect on acid-base balance.

Acid-base balance

The pH is a parameter expressing the acidity of a solution. Neutral pH is 7. For example, the pH of blood is normally 7.4 and that of muscle is 7.0. pH under 7 is acid, that is the case of vinegar (pH =3), orange juice (pH =3.7) or cola-drinks (pH =2.4).pH over 7 is basic or alkaline. Some mineral waters are alkaline, such as Abatilles (pH = 8.2).

Physical exercise can imply the production of lactic acid, leading to the acidification of pH in blood and muscle. In order to buffer this accumulation of lactic acid and to regulate the acid-base balance, the body uses biological buffers, especially the bicarbonate buffer system.

Calculation:

$$\text{Total alkalinity, (mg/l CaCO3)} = \frac{(A+B) \times 1000}{\text{Vol. of Sample, (ml)}}$$

Note: **Bicarbonate** = Alkalinity x 1.22

3.2.8 Sulphate (SO_4^{2-})

Sulphate can be found in almost all natural water. The origin of most sulfate compounds is the oxidation of sulfite ores, the presence of shale or the industrial wastes. Sulfate is one of the major dissolved components of rain. High concentrations of sulfate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. Bacteria, which attack and reduce sulfates, form hydrogen sulfide gas (H_2S).

Apparatus required: Nephelometer, magnetic stirrer, nesslers tube and lab glassware.

Reagent: Buffer solution, Barium chloride crystal

Procedure:

Take 100ml of the sample is filtered into a Nessler's tube containing 5ml of conditioning reagent. About 0.2g of barium chloride crystals is added with continued stirring. A working standard is prepared by taking 1ml of conditioning reagent and made up to 100ml, to give 100 NTU. The turbidity developed by the sample and the standards are measured using a nephelometer and the results are tabulated.

Sulphate in water

Soils and rocks contain sulfate minerals. As groundwater moves through these, some of the sulfate is dissolved into the water. Some minerals that contain sulfate are sodium sulfate (Glauber's salt), magnesium sulfate (Epsom salt), and calcium sulfate (gypsum).

Effect on health

People not used to drinking water with high levels of sulfate can experience dehydration and diarrhea. Kids are often more sensitive to sulfate than adults. As a safety measure, water with a sulfate level exceeding 400 mg/l should not be used in the preparation of baby food. Sulfate gives a bitter or medicinal taste to water if it exceeds a concentration of 250 mg/l. This may make it unpleasant to drink the water.

High sulfate levels may also be corrosive for plumbing, particularly copper piping. In areas with high sulfate levels, it is common to use corrosion resistant plumbing materials, such as plastic pipe.

How to remove sulphate from water

There are three types of treatment systems that will remove sulfate from your drinking water: reverse osmosis, distillation, or ion exchange. Carbon filters, water softeners and sediment filters will not remove sulfate. Water softeners exclusively change magnesium or calcium sulfate into sodium sulfate, which is more laxative.

- Reverse osmosis (RO) is a water treatment system that eliminates most dissolved elements and chemicals, such as sulfate, from water by pushing the water through a plastic surface similar to cellophane known as a "semipermeable membrane." Generally, it can eliminate between 93 and 99 % of the sulfate in drinking water. This depends on the type of unit.

- Distillation is a water treatment system in which water is boiled, and then the steam is cooled until it condenses into a separate container. The dissolved substances, such as sulfate, remain in the boiling pot.
- If operated properly, distillation units can remove nearly 100% of sulfate. Distillation units need about four hours to produce 3.8 liters of water, so this type of treatment uses a substantial amount of energy in its operation.
- Ion Exchange is the most known method of eliminating big quantities of sulfate from water for public, livestock, and commercial supplies, but is not generally used for individual household water treatment. It is a process where one element or chemical is replaced for another.

Calculation:

Sulphate = (nephlometric reading) (0.4) xdilution Factor

3.2.9 Nitrate (NO_3^-)

Nitrate is an inorganic compound composed of one atom of nitrogen (N) and three atoms of oxygen (O); the chemical symbol for nitrate is NO_3^- . Nitrate is not normally dangerous for the health unless it is reduced to nitrite (NO_3^-).

- Chemical Name: Nitrate
- Regulatory name: Nitrate
- Molecular formula: NO3-
- Molecular weight: 62 g/mol

Appartus: Spectrophotometer

Reagent: NitraVer 5 Nitrate Reagent Powder Pillow and lab glassware.

Procedure:

This test was done by the DR 2800 Spectrophotometer, firstly stored programme and selects the test. Take a dry square sample cell and fill 10 mL sample by a pipet. Take another dry square sample cell and fill 10 mL deionized water by a pipet. Then taken NitraVer 5 Nitrate Reagent Powder Pillow reagent and mix each square cell. The insert the deionized water sample and press zero when the zero is display. Then exit the square cell and insert the square sample cell and press the read.

Nitrate drinking water standards

Nitrate in drinking water is measured either in terms of the amount of nitrogen present or in terms of both nitrogen and oxygen. The federal standard for nitrate in drinking water is 10 mg/l nitrate-N, or 50 mg/l nitrate- NO_3^-, when the oxygen is measured as well as the nitrogen. Unless otherwise specified, nitrate levels usually refer only to the amount of nitrogen present, and the usual standard, therefore, is 10 mg/l.

Effect on health

Methaemoglobinaemia is a disease caused by nitrate excess. Nitrate needs to be regulated in drinking water basically because excess levels can cause methaemoglobinaemia or "blue baby" disease. Although nitrate levels that affect babies are not dangerous for older children and adults, they do indicate the possible presence of other more serious residential or agricultural pollutants, such as bacteria or pesticides.

Symptoms of nitrate

A typically greyish cyanosis can be observed when the level of methaemoglobin exceeds 1.5 g/dL, which is about 10% of the total methaemoglobin in a normal individual. At this level, the patient may not notice any symptoms yet. The symptoms of methaemoglobinaemia are usually those related to impaired oxygen delivery (headache, weakness, tachycardia and breathlessness) and develop gradually as concentrations of methaemoglobin rise above 20%.Concentrations higher than 50% result in severe hypoxaemia and central nervous system depression. Concentrations higher than 70% may cause death.

Elimination of nitrate from water

The solution to eliminate the nitrites in the water is to oxidize them to nitrates (as we said before, nitrates are much less toxic than nitrites). This can be done by injecting ozone in the water. Ozone is a very oxidizing chemical that would oxidize all the nitrites into nitrates, thus eliminating the toxicity caused by nitrites.

Calculation: Nitrate = NO_3^-- N x 4.4

3.2.10 Chloride (Cl^-)

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$).

Physicochemical properties

Table 3.2.10 Solubility of Chloride in water

Salt	Solubility in cold water(g/lit)	Solubility in hot water (g/lit)
Sodium chloride	357	391
Potassium chloride	344	567
Calcium chloride	745	1590

Apparatus: lab glassware

Reagents: Potassium Chromate Indicator, N/35.5 silver Nitrate Solution

Procedure:

Fifty milliliters (50ml) of sample was taken and one milliliter (1ml) of $K_2Cr_2O_4$ indicator solution was added and titration and titrated with standard Ag NO_3. Reagents blank value was established by titrating fifty milliliters (50ml) of distilled water with 1 ml of K_2CrO_4 dropped in it, against standard $AgNO_3$

Major Uses

Sodium chloride is widely used in the production of industrial chemicals such as caustic soda, chlorine, sodium chlorite, and sodium hypochlorite. Sodium chloride, calcium chloride, and magnesium chloride are extensively used in snow and ice control. Potassium chloride is used in the production of fertilizers.

Environmental fate

Chlorides are leached from various rocks into soil and water by weathering. The chloride ion is highly mobile and is transported to closed basins or oceans.

Analytical method

A number of suitable analytical techniques are available for chloride in water, including silver nitrate titration with chromate indicator (5), mercury (II) nitrate titration with diphenyl carbazone indicator, potentiometric titration with silver nitrate, automated iron(III) mercury(II) thiocyanate colorimetry, chloride ion-selective electrode, silver colorimetry, and ion chromatography. Limits of detection range from 50 g/litre for calorimetry to 5 mg/litre for titration (6).

Chloride in water

Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. Evidence of a general increase in chloride concentrations in groundwater and drinking-water has been found.

Effect on health

A normal adult human body contains approximately 81.7 g chloride. On the basis of a total obligatory loss of chloride of approximately 530 mg/day, a dietary intake for adults of 9 mg of chloride per kg of body weight has been recommended (equivalent to slightly more than 1 g of table salt per person per day). For children up to 18 years of age, a daily dietary intake of 45 mg of chloride should be sufficient . A dose of 1 g of sodium chloride per kg of body weight was reported to have been lethal in a 9-week-old child . Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water. Little is known about the effect of prolonged intake of large amounts of chloride in the diet. As in experimental animals, hypertension associated with sodium chloride intake appears to be related to the sodium rather than the chloride ion.

3.2.11 Fluoride (F^-)

Water fluoridation is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing cavities; this can occur naturally or by adding fluoride. Fluoridated water operates on tooth surfaces: in the mouth it creates low levels of fluoride in saliva, which reduces the rate at which tooth enamel de mineralizes and increases the rate at which it re mineralizes in the early stages of cavities.

Fig. 3.2.11 A cavity start in tooth

Occurrences

Fluoride naturally occurring in water can be above, at, or below recommended levels. Rivers and lakes generally contain fluoride levels less than 0.5 mg/l, but groundwater, particularly in volcanic or mountainous areas, can contain as much as 50 mg/l. Higher concentrations of fluorine are found in alkaline volcanic, hydrothermal, sedimentary, and other rocks derived from highly evolved magmas and hydrothermal solutions, and this fluorine dissolves into nearby water as fluoride. In most drinking waters, over 95% of total fluoride is the F^- ion, with the magnesium–fluoride complex (MgF^+) being the next most common. Because fluoride levels in water are usually controlled by the solubility of fluorite (CaF_2), high natural fluoride levels are associated with calcium-deficient, alkaline, and soft waters.

Apparatus and reagent: Spectrophotometer and lab glassware, Standard fluoride solution

Procedure:

This test was done by the Dr2800 Spectrophotometer firstly stored program and selects the test. Take a dry square sample cell and fill 10 mL sample by a pipet. Take another dry square sample cell and fill 10 mL deionized water by a pipet. Then taken SPADNS reagent 2.0 mL by pipet and mix each square cell. The insert the deionized water sample cell and press the read.

Implementation

Fluoridation does not affect the appearance, taste, or smell of drinking water. It is normally accomplished by adding one of three compounds to the water: sodium fluoride, fluorosilicic acid, or sodium fluorosilicate.

- Sodium fluoride (NaF) was the first compound used and is the reference standard. It is a white, odorless powder or crystal; the crystalline form is preferred if manual handling is used, as it minimizes dust. It is more expensive than the other compounds, but is easily handled and is usually used by smaller utility companies. It is toxic in gram quantities by ingestion or inhalation.
- Fluorosilicic acid (H_2SiF_6) is the most commonly used additive for water fluoridation in the United States. It is an inexpensive liquidby-product of phosphate fertilizer manufacture. It comes in varying strengths, typically 23–25%; because it contains so much water, shipping can be expensive. It is also known as hexafluorosilicic, hexafluosilicic, hydrofluosilicic, and silicofluoric acid.
- Sodium fluorosilicate (Na_2SiF_6) is the sodium salt of fluorosilicic acid. It is a powder or very fine crystal that is easier to ship than fluorosilicic acid. It is also known as sodium silicofluoride.

Usage

As of November 2012, a total of about 378 million people worldwide received artificially fluoridated water. The majority of those were in the United States. About 40 million worldwide received water that was naturally fluoridated to recommended levels.

3.2.12 Zinc (Zn)

Zinc is naturally present in water. The average zinc concentration in seawater is 0.6-5 ppb. Rivers generally contain between 5 and 10 ppb zinc. Algae contain 20-700 ppm, sea fish and shells contain 3-25 ppm, oysters contain 100-900 ppm and lobsters contain 7-50 ppm.

The World Health Organization stated a legal limit of 5 mg Zn^{2+}/L.

Reaction With Water

Elementary zinc does not react with water molecules. The ion does form a protective, water insoluble zinc hydroxide ($Zn(OH)_2$) layer with dissolved hydroxide ions, according to the following reaction mechanism:

$Zn^{+2} + 2OH^{-} -> Z_n(OH)_2$ (s)

Zinc reacts with H+ ions, according to the following reaction mechanism:

Zn (s) + 2H+ - > Zn^{+2} (aq) + H_2 (g)

This reaction releases hydrogen, which reacts with oxygen explosively. Zinc salts cause a milky turbidity in water in higher concentrations. Additionally, zinc may add an unwanted flavor to water. This occurs at concentrations of about 2 mg Zn^{+2} / L.

Solubility of zinc and zinc compounds

The solubility of zinc depends on temperature and pH of the water in question. When the pH is fairly neutral, zinc in water insoluble. Solubility increases with increasing acidity. Above pH 11, solubility also increases. Zinc dissolves in water as ZnOH+ (aq) or (aq). Zn^{+2}. Anionic $ZnCO_3$ has a solubility of 0.21 g/l. Examples of solubility of zinc compounds are: zinc chloride ($ZnCl_2$) 4320 g/l, and zinc oxide (ZnO) or zinc vitriol (Zn SO_4 .7H2O) 580 g/l.

Presence in water

The most significant zinc ores include sphalerite (ZnS) and smithsonite ($ZnCO_3$). These compounds end up in water on locations where zinc ores are found. About three-quarters of the total zinc supply is used in metal form.

The remainder is applied as various zinc compounds in various industries. Industrial wastewaters containing zinc stem from galvanic industries, battery production, etc. Zinc compounds are applied for many different purposes. Zinc chloride is applied for parchment production, zinc oxide is a constituent of salves, paints and catalysers, zinc vitriol is applied as a fertilizer, and zinc bacitracine is applied as a growth stimulant in animal husbandry.

Environmental effect of zinc in water

Some zinc compounds, such as zinc arsenate and zinc cyanide, may be extremely hazardous. Zinc is a dietary mineral for humans and animals. Still, overdoses may negatively influence human and animal health and over a certain boundary concentration, zinc may even be toxic. Toxicity is low for humans and animals, but phytotoxicity may not be underestimated.

Sludge from wastewater treatment is applied in agriculture, horticulture and forestry, and zinc concentrations may therefore not exceed the 3 g/ kg boundary.

Health effect of zinc in water

The human body contains approximately 2.3 g zinc, and zinc has a dietary value as a trace element. Its functions involve mainly enzymatic processes and DNA replication. The human hormone insulin contains zinc, and it plays an important role in sexual development. Minimum daily intake is 2-3 g, this prevents deficiencies. The human body only absorbs 20-40% of zinc present in food, consequently many people drink mineral water rich in zinc. Symptoms of zinc deficiencies are tastelessness and loss of appetite. Children's immune systems and enzyme systems may be affected.

Purification technique to remove zinc from water

Zinc may be removed from water by different methods. To achieve a level that meets legal standards, one may apply such techniques as coagulation, ion exchange and active carbon. Sand filtration is perceived and excellent solution.

3.2.13 Manganese (Mn)

Manganese is a pinkinsh-gray, chemically active element. It is a hard metal and is very brittle. It is hard to melt, but easily oxidized. Manganese is reactive when pure, and as a powder it will burn in oxygen, it reacts with water (it rusts like iron) and dissolves in dilute acids.

Effect on Health

Exposure to high concentrations of manganese over the course of years has been associated with toxicity to the nervous system, producing a syndrome that resembles Parkinsonism. This type of effect may be more likely to occur in the elderly. The new manganese AL is set low enough to ensure that the potential nervous system effect will not occur, even in those who may be more sensitive. Manganese is unlikely to produce other types of toxicity such as cancer or reproductive damage.

Standard for Manganese in drinking water

There are no enforceable federal drinking water standards for manganese. The US Environmental Protection Agency has a secondary standard of 0.05 mg/l, which is intended to let the public know that manganese can affect water quality at this level.

This secondary standard is not health-based and is not enforceable. In the absence of a federal standard, the CT DPH has developed the following:

Removal of Manganese

For manganese removal only, Manganese dioxide (MnO_2) is used as an adsorbent according to the following reaction:

$Mn + MnO_2 (s) \text{--} > 2 MnO (s)$

Manganese oxides are then adsorbed on MnO_2 grains. When all MnO_2 has been consumed, it can be regenerated by sodium hypochlorite. Manganese removal by physical-chemical way (aeration and sand filtration) can also be used but manganese oxidation kinetics are too slow at $pH< 9$.

Calculation: Values of F-shown on monitor is in mg/l.

3.2.14 Copper (Cu)

Copper is a transition metal that is stable in its metallic state and forms mono valent (cuprous) and divalent (cupric) cations.

common copper compound

Copper(II)Acetate monohydrate [$Cu(CH_3COO)_2 \cdot H_2O$],

Copper(II)Chloride [$CuCl_2$]

Copper(II) Nitrate trihydrate [$Cu(NO_3)_2 \cdot 3H_2O$],

Copper(II) CuO

Copper(II) sulfate pentahydrate [$CuSO_4 \cdot 5H_2O$]

Table: 3.2.14 Solubility of these compound in water

Compound	Density (g/cm^3)	Water solubility (g/litre)
Copper(II) acetate monohydrate	1.88	72
Copper(II) chloride	3.39	706
Copper(II) Nitrate trihydrate	2.32	1378
Copper(II) Cuo	6.32	Insoluble

Organoleptic properties

Dissolved copper can sometimes impart a light blue or blue-green colour and an unpleasant metallic, bitter taste to drinking-water. The concentration at which 50% of 61 volunteers could detect the taste of copper (i.e., taste threshold) as the sulfate or chloride salt in tap or demineralized water ranged from 2.4 to 2.6 mg/l. The taste threshold increased in the presence of other solutes. Blue to green staining of porcelain sinks and plumbing fixtures occurs from copper dissolved in tap water.

Copper in drinking water

surface water for the control of algae. Copper sulfate was once prescribed as an emetic, but this use has been discontinued owing to adverse health effects. Copper is found in surface water, groundwater, seawater and drinking-water, but it is primarily present in complexes or as particulate matter. Copper concentrations in surface waters ranged from 0.0005 to 1 mg/l in several studies in the USA; the median value was 0.01 mg/l.

Health Effect

Copper is a reddish metal that occurs naturally in rock, soil, water, sediment, and air. It has many practical uses in our society and is commonly found in coins, electrical wiring, and pipes. It is an essential element for living organisms, including humans, and in small amounts necessary in our diet to ensure good health. However, too much copper can cause adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease.

How to reduce copper effect

Hot water dissolves copper more quickly than cold water; as a result, water to be used for drinking or cooking should not be drawn from the hot water tap. If you need hot water for cooking or drinking, take water from the cold tap and heat it. It is especially important not to use the hot water for making baby formula.

3.2.15 Iron (Fe)

Seawater contains approximately 1-3 ppb of iron. The amount varies strongly, and is different in the Atlantic and the Pacific Ocean. Rivers contain approximately 0.5-1 ppm of iron, and groundwater contains 100 ppm. Drinking water may not contain more than 200 ppb of iron.

Most algae contain between 20 and 200 ppm of iron, and some brown algae may accumulate up to 4000 ppm. The bio concentration factor of algae in seawater is approximately 10^4 - 10^5. Sea fish contain approximately 10-90 ppm and oyster tissue contains approximately 195 ppm of iron (all are dry mass).Dissolved iron is mainly present as $Fe(OH)_2^+$ (aq) under acidic and neutral, oxygen-rich conditions. Under oxygen-poor conditions it mainly occurs as binary iron. Iron is part of many organic and inorganic chelation complexes that are generally water soluble.

Apparatus and reagents: DR 2800 Spectrophotometer, FerroVer iron Reagent Powder Pillow and lab glassware.

Procedure

This test was done by the DR 2800 Spectrophotometer, firstly stored programme and selects the test. Take a dry square sample cell and fill 10 mL sample by a pipet. Take another dry square sample cell and fill 10 mL deionized water by a pipet. Then take iron Reagent Powder Pillow reagent and mix each square cell and give three minute timer. After that insert the deionized water sample and press zero when the zero is display. Then exit the square cell and insert the square sample cell and press read and take reading one by one samples.

Reaction with water

Iron does not clearly alter in pure water or in dry air, but when both water and oxygen are present (moist air), iron corrodes. Its silvery colour changes to a reddish-brown, because hydrated oxides are formed. Dissolved electrolytes accelerate the reaction mechanism, which is as follows.

$4\ Fe + 3\ O_2 + 6\ H_2O \rightarrow 4\ Fe^{3+} + 12\ OH^- \rightarrow 4\ Fe(OH)_3$ or $4\ FeO(OH) + 4\ H_2O$

Solubility of iron compound

Elementary iron dissolves in water under normal conditions. Many iron compounds share this characteristic. Naturally occurring iron oxide, iron hydroxide, iron carbide and iron penta carbonyl are water insoluble.The water solubility of some iron compounds increases at lower pH values. Other iron compounds may be more water soluble than the examples mentioned above. Iron carbonate has a water solubility of 60 mg/l, iron sulphide of 6 mg/l, and iron vitriol even of 295 g/l.

Presence in water

The main naturally occurring iron minerals are magnetite, hematite, goethite and siderite. Weathering processes release the element into waters. Both mineral water and drinking water contain iron carbonate. In deep sea areas the water often contains iron fragments the size of a fist, manganese and small amounts of lime, silicon dioxide and organic compounds.

Health effects of iron in water

The total amount of iron in the human body is approximately 4 g, of which 70% is present in red blood colouring agents. Iron is a dietary requirement for humans, just as it is for many other organisms. Men require approximately 7 mg iron on a daily basis, whereas women require 11 mg. The difference is determined by menstrual cycles. When people feed normally these amounts can be obtained rapidly. The body absorbs approximately 25% of all iron present in food. When someone is iron deficit feed iron intake may be increased by means of vitamin C tablets, because this vitamin reduces tertiary iron to binary iron. Phosphates and phytates decrease the amount of binary iron. In food iron is present as binary iron bound to haemoglobin and myoglobin, or as tertiary iron. The body may particularly absorb the binary form of iron.

How to remove iron from water

Iron removal from water is mostly carried out in drinking water preparation, because mineral water contains high amounts of iron ions. These influence water colour, odour and turbidity. Iron is present in all wastewaters. Iron removal from wastewater may be achieved by oxidation of binary iron to tertiary iron. Hydrolysis subsequently causes flake formation, and flakes can be removed by sand filtration. Oxidation may be achieved by adding oxygen or other oxidants, such as chlorine or potassium permanganate. The reaction rate depends upon pH values, and is slower under acidic than under alkalic conditions. To speed up the reaction under acidic conditions, the water may be aerated for carbon dioxide removal and pH recovery. The total reaction causes acid formation and thereby diminishes itself. Iron is often reduced together with manganese. Applying ion exchangers for iron trace removal from drinking water and process water is another option, but this is not very suitable for removing high iron concentrations. Iron compounds are applied in wastewater treatment.

3.1.16 Hardness

The hardness of water is defined in terms of ability to precipitate soap. The degree of hardness of drinking water has been classified in terms of its equivalent CaCO3 concentration. There are two types of water hardness. Temporary and permanent hardness. This calculator determines the permanent total hardness.

Total permanent hardness = Calcium hardness + Magnesium hardness

The calcium and magnesium hardness is the concentration of calcium and magnesium ions expressed as equivalent of calcium carbonate. The molar mass of $CaCO_3$, Ca^{2+} and Mg^{2+} are respectively 100 g/mol, 40.1 g/mol and 24,3 g/mol.

3.3 Pearson Scatter plot

A scatter plot is a graph that is used to plot the data points for two variables. Each scatter plot has a horizontal axis (*x*-axis) and a vertical axis (*y*-axis). Scatter plots provide a visual representation of the correlation, or relationship between the two variables. All correlations have two properties: strength and direction. The strength of a correlation is determined by its numerical value. The direction of the correlation is determined by whether the correlation is positive or negative.

Positive correlation: Both variables move in the same direction. In other words, as one variable increases, the other variable also increases. As one variable decreases, the other variable also decreases.

Negative correlation: The variables move in opposite directions. As one variable increases, the other variable decreases. As one variable decreases, the other variable increases.

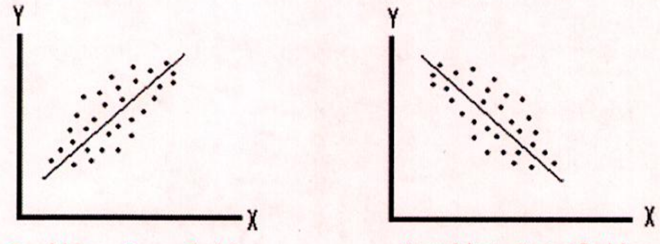
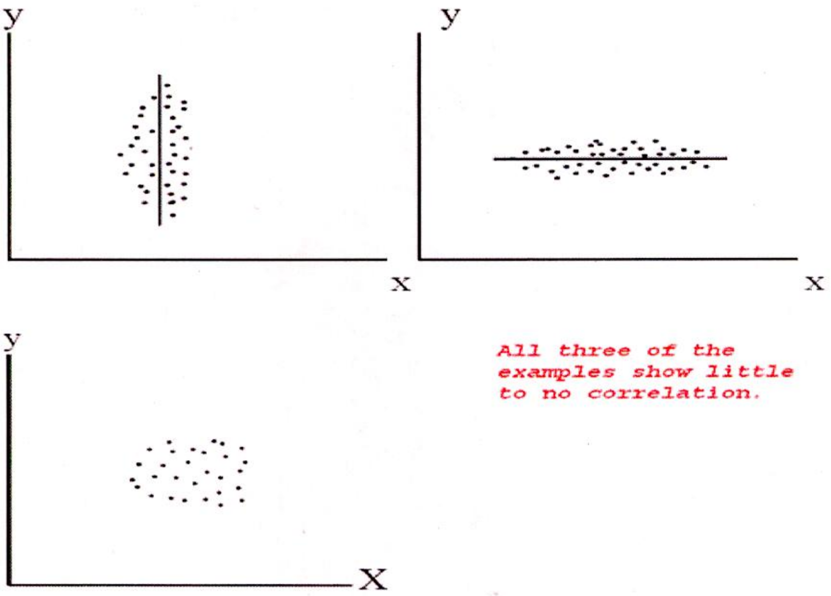


Fig: 3.3 Correlation between plots

Strength of correlation

The strength of a correlation indicates how strong the relationship is between the two variables. The strength is determined by the numerical value of the correlation. A correlation of 1, whether it is +1 or -1, is a perfect correlation. In perfect correlations, the data points lie directly on the line of fit. The further the data are from the line of fit, the weaker the correlation. A correlation of *0* indicates that there is no correlation. The following should be considered when determining the strength of a correlation:

- The closer a positive correlation lies to +1, the stronger it is.
    - i.e., a correlation of +.87 is stronger than a correlation of +.42.
- The closer a negative correlation is to -1, the stronger it is.
    - i.e., a correlation of -.84 is stronger than a correlation of -.31.
- When comparing a positive correlation to a negative correlation, only look at the numerical value. Do not consider whether or not the correlation is positive or negative. The correlation with the highest numerical value is the strongest.
    - i.e., a correlation of -.80 is stronger than a correlation of +.55.
- If the numerical values of a correlation are the same, then they have the same strength no matter if the correlation is positive or negative.
    - i.e., a correlation of -.80 has the same strength as a correlation of +.80.



All three of the examples show little to no correlation.

Fig: 3.3.1 Correlation between parameters

CHAPTER 4

RESULTS AND DISCUSSION

A total of 13 water samples were collected from different locations as shown in Fig 4.1 and were analysed for various physico- chemical parameters viz. pH, electrical conductivity (EC), total hardness as $CaCO_3$, Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Bicarbonate (HCO_3^{-}), Total dissolved solids (TDS), Chloride (Cl^{-}), Sulphate (SO_4^{2-}), Nitrite (NO_2^{-}), Fluoride (F^{-}), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn).

4.1 **Results**

The statistical summary of the result of these water samples have been shown in Table 4.1

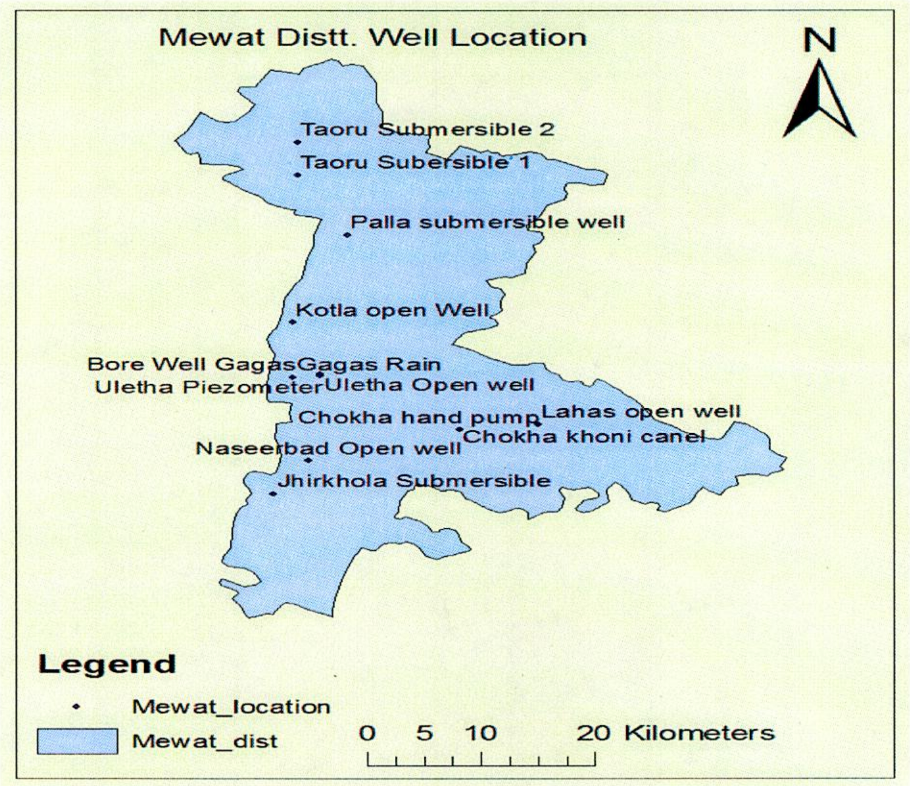


Fig: 4.1 Sampling location in study area

4.1.1 pH

The pH varies in the range of 7.3-8.4 with an average value of 7.8. The maximum value is 8.4 observed at two places Uletha Piezometer and Naseerbad open well while the minimum was found that 7.3 at Chokha hand pump. All the water samples were found within the permissible limit in study area. (Fig: 4.1.1)

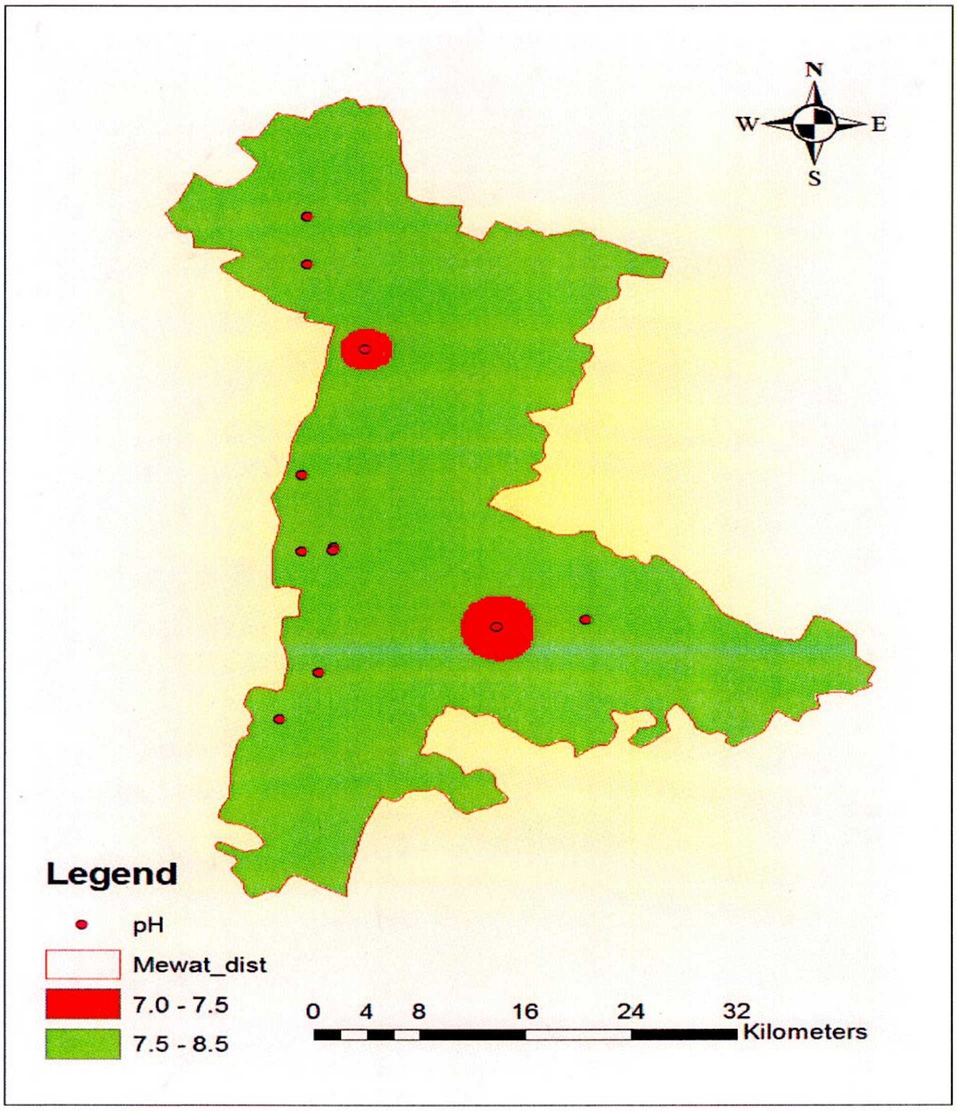


Fig: 4.1.1 Spatial variation in pH in Mewat District

Table 4.1 Satistical summary of the physico-chemical parameters in Mewat, Haryana

SR No.	Parameter	Maximum	Minimum	Average	IS(10500-2012) Acceptable limit	IS(10500-2012) Permissible limit
1	pH	8.4	7.3	7.8	6.5 – 8.5	No relaxation
2	EC µS/cm	32300	759	6394.91	500	2000
3	$Ca2+$ (mg/l)	3980	107	789.83	75	200
4	Mg^{2+} (mg/l)	395.3	94.22	886.5	30	100
5	Na^{+} (mg/l)	4850	30	887.91	200	200
6	K^{+} (mg/l)	50.6	6.2	13.8	10	10
7	Hardness (mg/l)	26156.32	813.8	5609.21	200	600
8	HCO_3^- (mg/l)	600	120	323.33	200	600
9	$SO4^{2-}$ (mg/l)	645	194	341.66	200	400
10	NO_3^- mg/l	48.8	0.5	11.6	45	No relaxation
11	Cl^- (mg/l)	8397.4	199.98	2040.83	250	1000
12	F- mg/l	5.22	0.6	1.82	1.0	1.5
13	Fe (µg/l)	727.1	164.4	417.08	100	300
14	Zn (µg/l)	425.5	8.32	51.8	8000	15000
15	Mn (µg/l)	89.68	0.19	14.97	100	300
16	Cu (µg/l)	51.51	0.7	8.50	50	1500

4.1.2 Electrical Conductivity

The EC of water samples varies in the range of 759-32300 µS/cm. with an average value of 6394.91. The maximum value is 32300 µS/cm observed at Uletha open well while the minimum was found that 759 µS/cm at Jhirkhola submersible well. About 75% of samples was found above the permissible limit in study area except the places and most of the sampling point are in north-western part of the district Jhirkhola submersible well, Kotla, Tauru submersible 1, Tauru submersible 2. (Fig: 4.1.2)

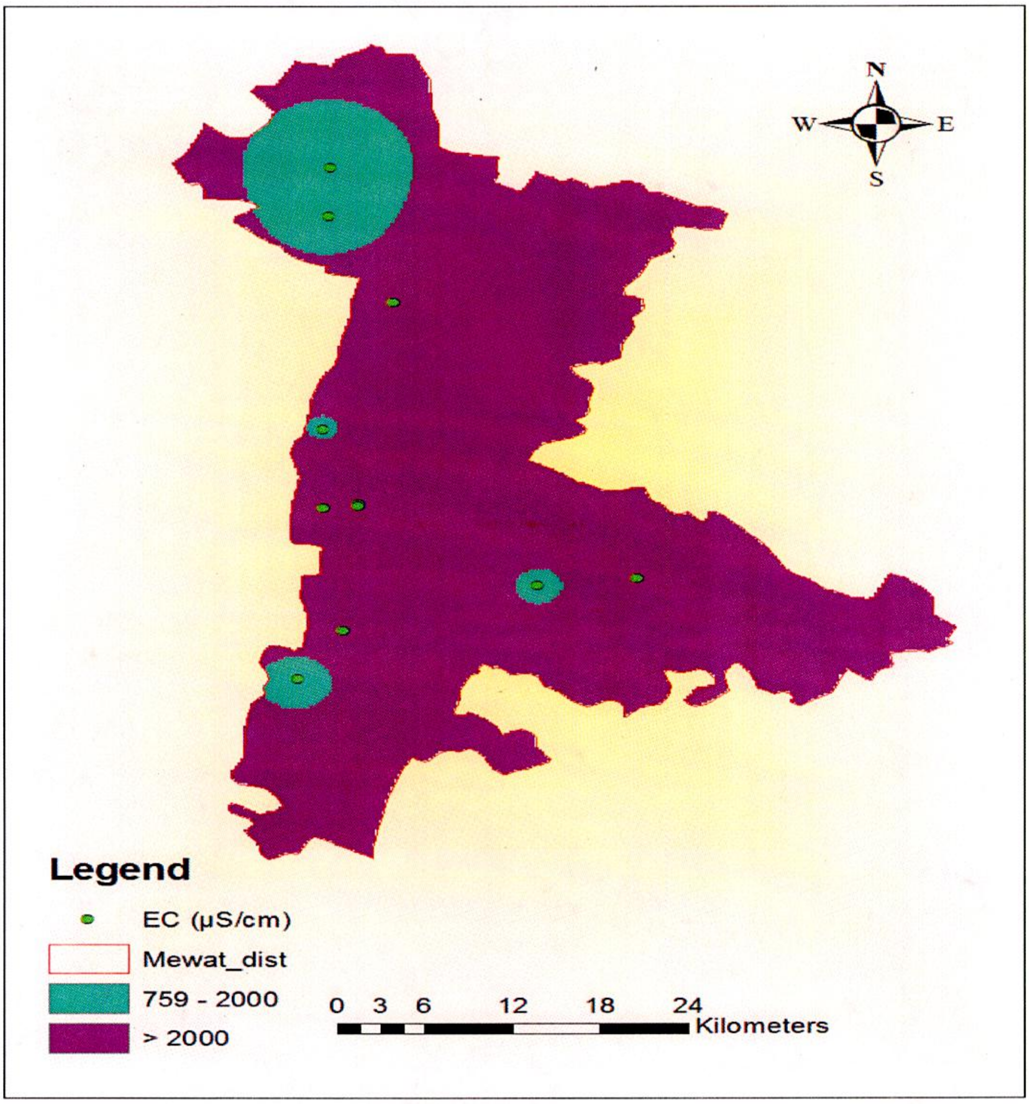


Fig: 4.1.2 spatial variation in Electrical conductivity in Mewat District

4.1.3 Calcium

The Calcium varies in the range of 107-3980 mg/l with an average value of 789.83 mg/l. The maximum value 3980 mg/l is observed at Uletha open well while the minimum was found that 107 mg/l at Tauru submersible 1. About 33.3% of samples was found above the permissible limit in study area except the samples at places Chokha khoni canal, chokha hand pump, Jhirkhola submersible well, Kotla open well, Tauru submersible 1 and Tauru submersible 2. (Fig: 4.1.3)

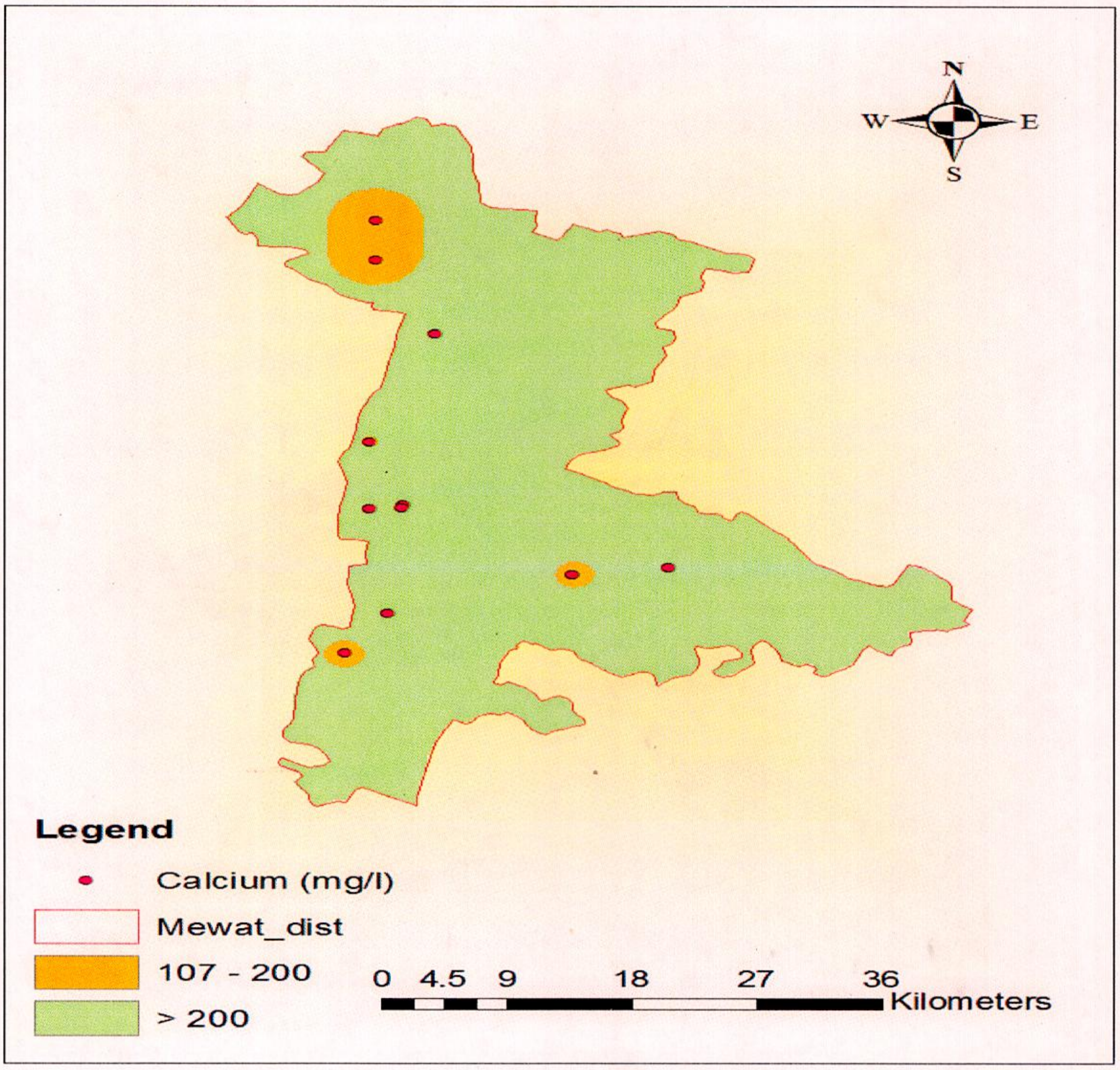


Fig: 4.1.3 spatial variation of Calcium in Mewat District

4.1.4 Magnesium

The Magnesium varies in the range of 94.22-3952.8 mg/l with an average value of 886.5 mg/l. The maximum value is 3952.8 mg/l observed at Uletha open well, however, the minimum was found that 94.22 mg/l at Chokha Khoni Canal but in groundwater samples the minimum (250.3 mg/l) value was found at Jhirkhola. All groundwater samples were found above the permissible limit (Fig: 4.1.4).

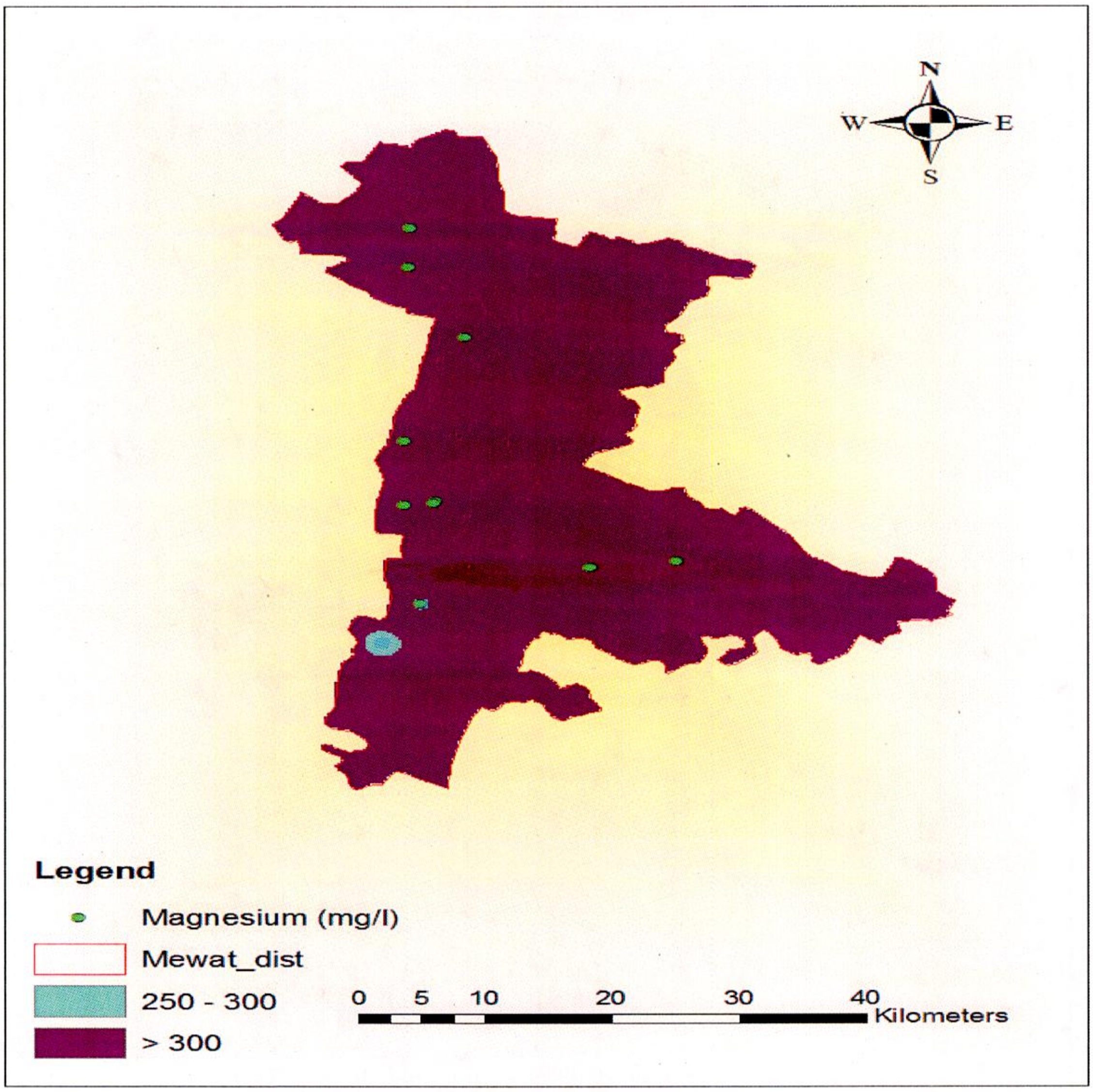


Fig: 4.1.4 Spatial variation of Magnesium in Mewat District

4.1.5 Sodium

The sodium content of water samples varies in the range of 30-4850 mg/l with an average value of 887.91 mg/l. The maximum value is 4850 mg/l observed at Uletha open well while the minimum was found that 30 mg/l at Tauru submersible 2. About 33.3% of samples was found above the permissible limit in study area except the places Chokha khoni canel chokha hand pump, lahas open well, Jhirkhola susible well, palla submersible well, Kotla submersible well, Kotla Submersible well, tauru submersible well1 tauru submersible well 2. (Fig 4.1.5)

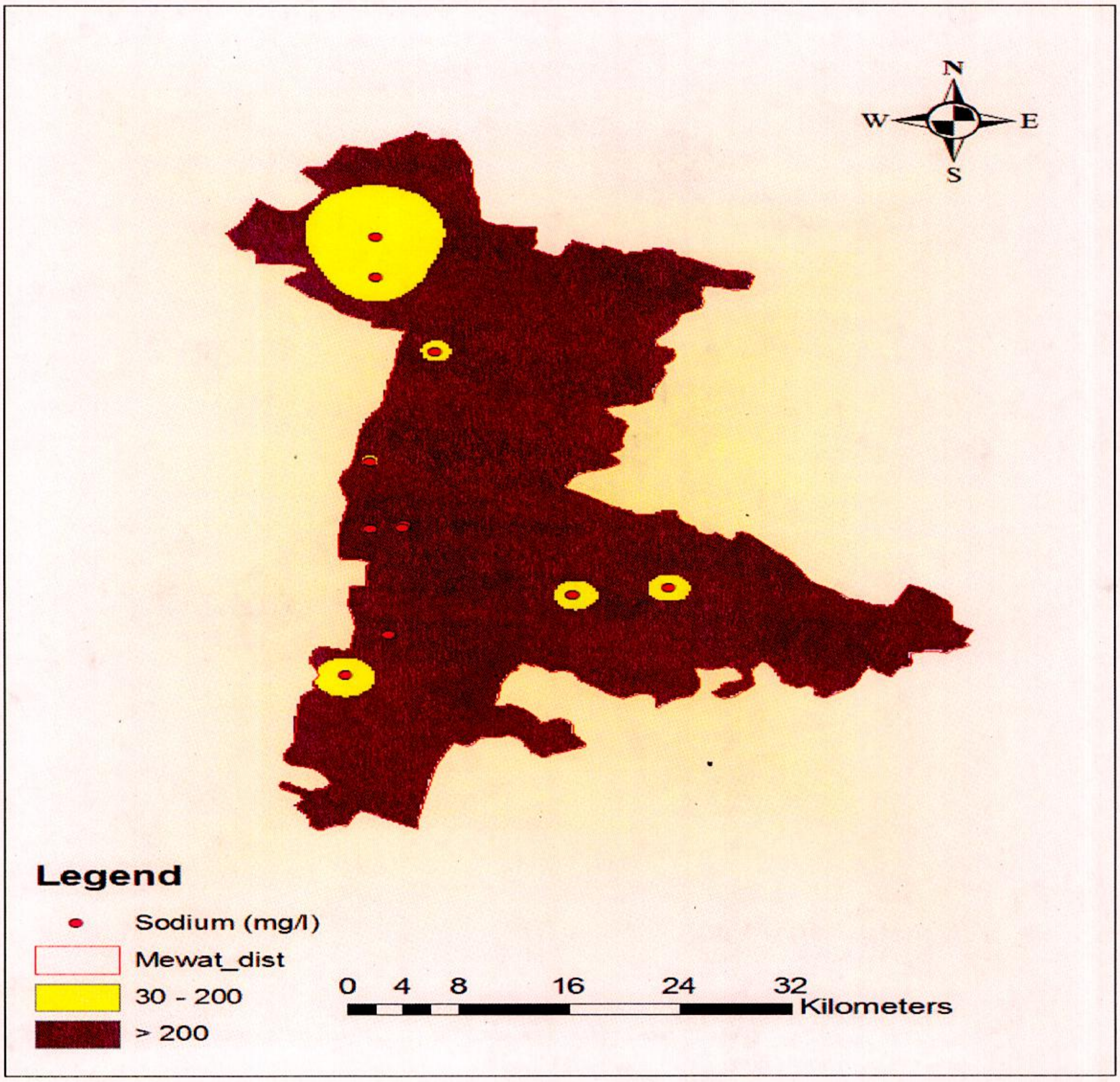


Fig: 4.1.5 Spatial variation of Sodium in Mewat District

4.1.6 Potassium

The Potassium concentration of water samples varies in the range of 6.2-50.6 mg/l with an average value of 13.8 mg/l. The maximum value is 50.6 mg/l is observed at Uletha Piezometer while the minimum was found that 6.2 mg/l at Tauru submersible well. About 50% of samples was found above the permissible limit in study area except the samples at places Chokha hand pump, Lahas open well, Bore well ghagas, Naseerbad open well, Kotla open well, Jhirkhola submersible well, Tauru submersible 1 and Tauru submersible 2. (Fig: 4.1.6)

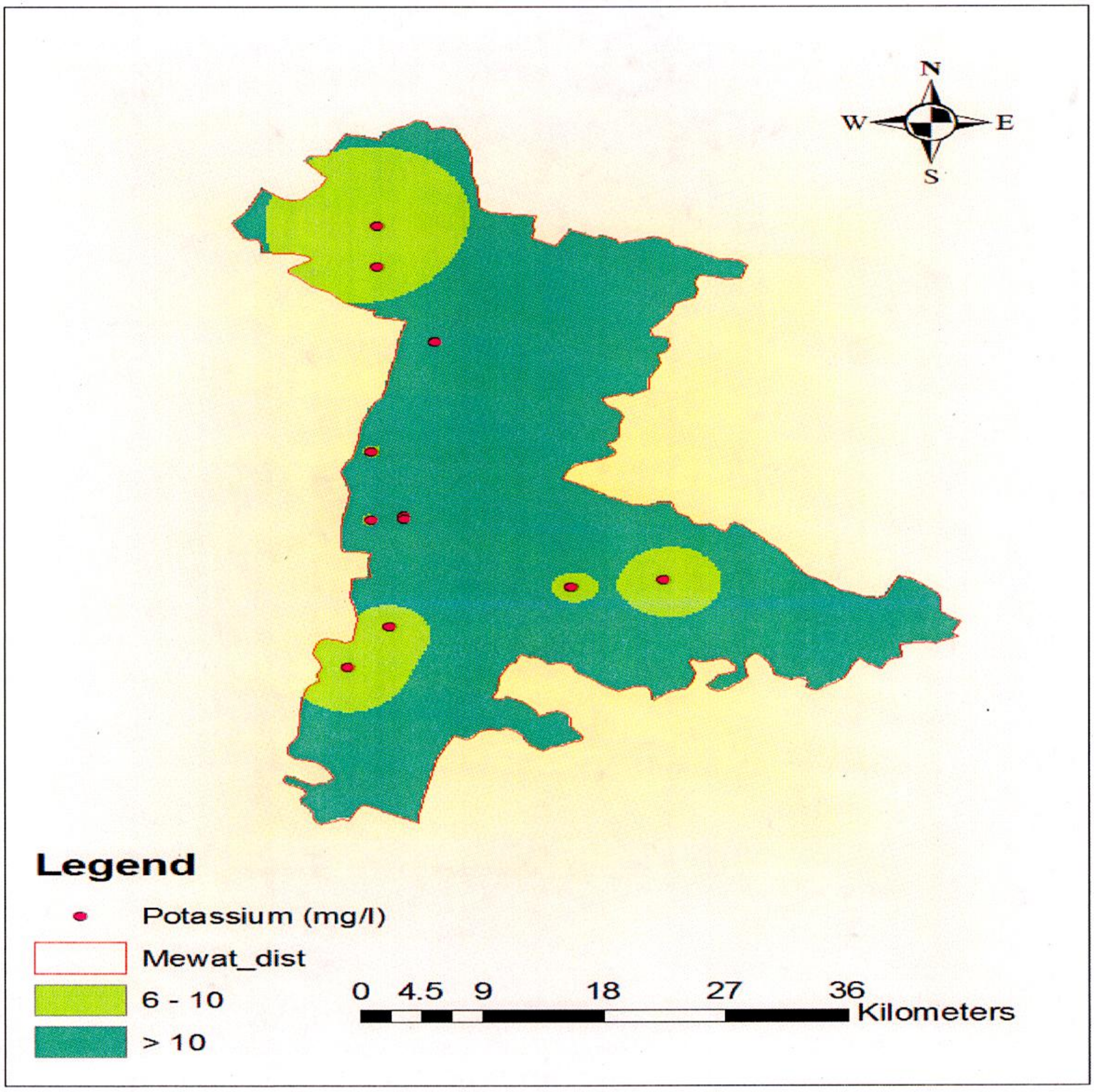


Fig: 4.1.6 Spatial variation of potassium in Mewat District

4.1.7 Bicarbonate

The Bicarbonate concentration of water samples varies in the range of 120-600 mg/l with an average value of 323.33 mg/l. The maximum value is 600 mg/l is observed at Uletha Piezometer while the minimum was found that 6.2 mg/l at Kotla open well. All the samples was found within the permissible limit in study area. (Fig: 4.1.7)

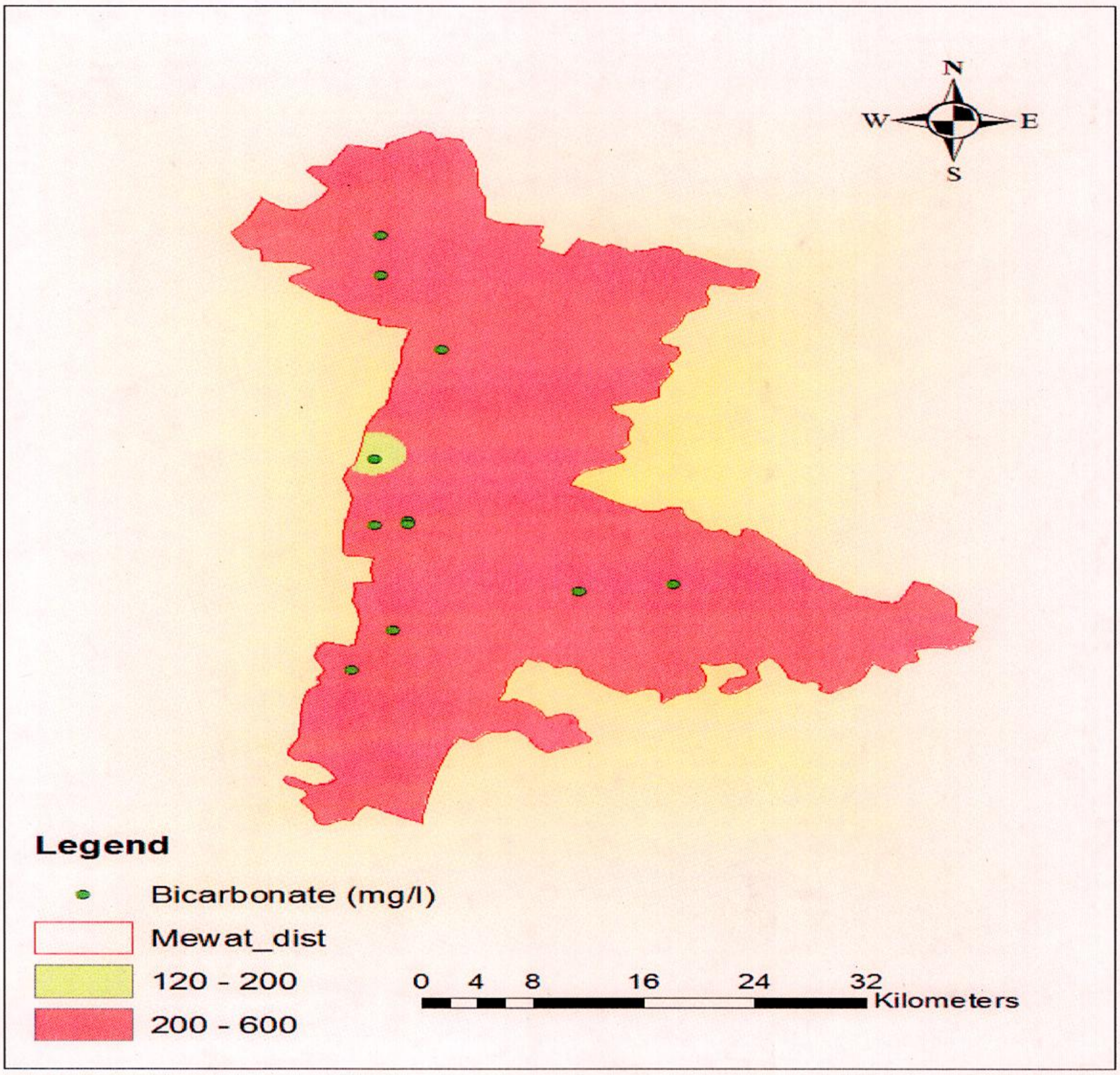


Fig: 4.1.7 Spatial variation of Bicarbonate in Mewat District

4.1.8 Sulphate

The Sulphate varies in the range of 194-645 mg/l with an average value of 341.66 mg/l. The maximum value 645 mg/l observed at Uletha Piezometer while the minimum was found that 194 mg/l at Chokha hand pump. About 25% of samples was found above the permissible limit in study area except the places Chokha hand pump, Chokha khoni canal, Lahbas open well, Jhirkhola submersible well, Palla submersible well, Tauru submersible (Fig:4.1.8).

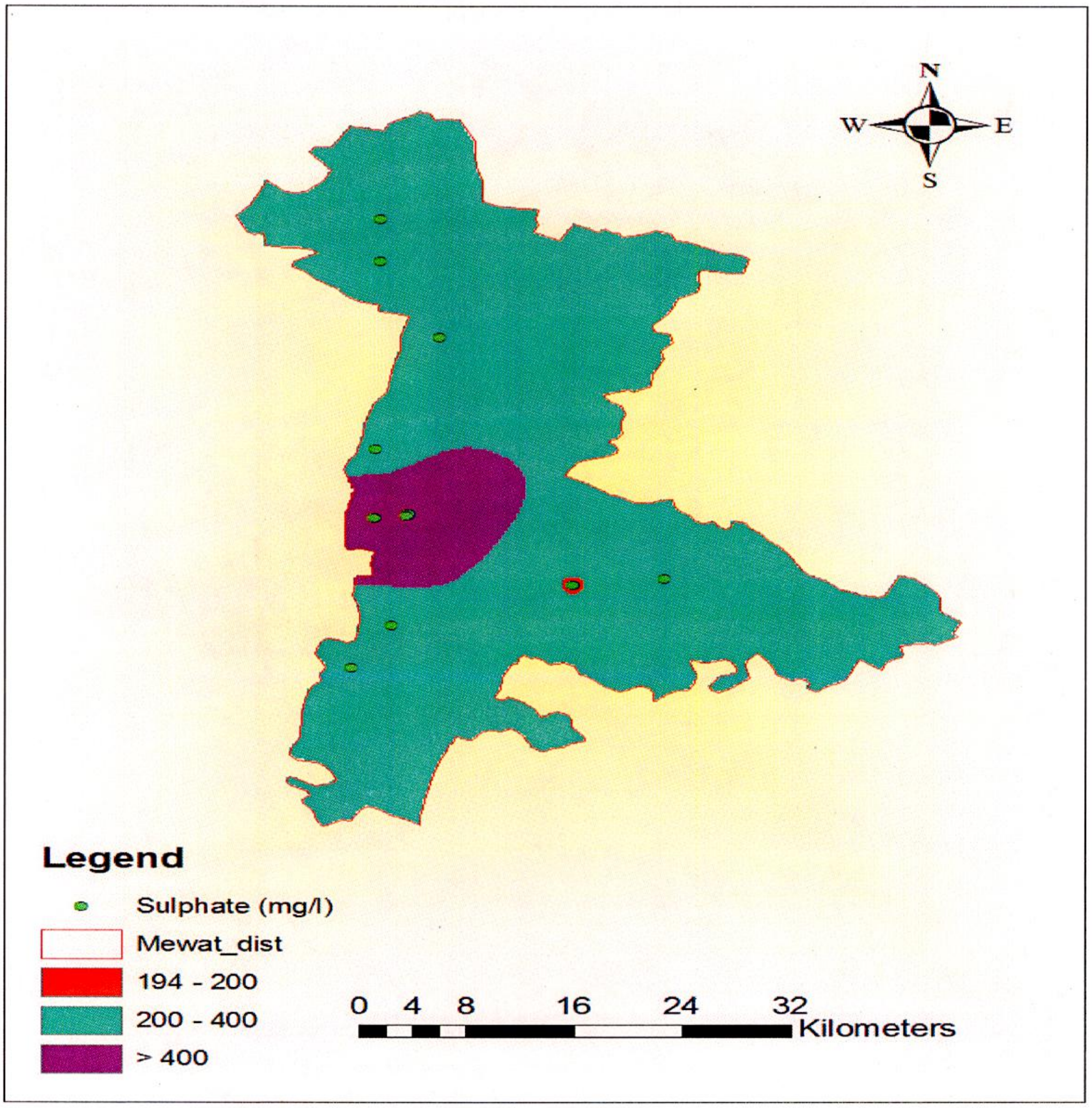


Fig: 4.1.8 Spatial variation of Sulphate in Mewat District

4.1.9 Nitrate

The Nitrate found in the range of 0.5-48.8 mg/l with an average value of 11.6 mg/l. The maximum value 48.8 mg/l observed at Bore well Ghagas while the minimum was found that 0.5 mg/l at Naseerbad open well. About 88% of samples was found within the permissible limit in study area except at Ghagas. (Fig: 4.1.9)

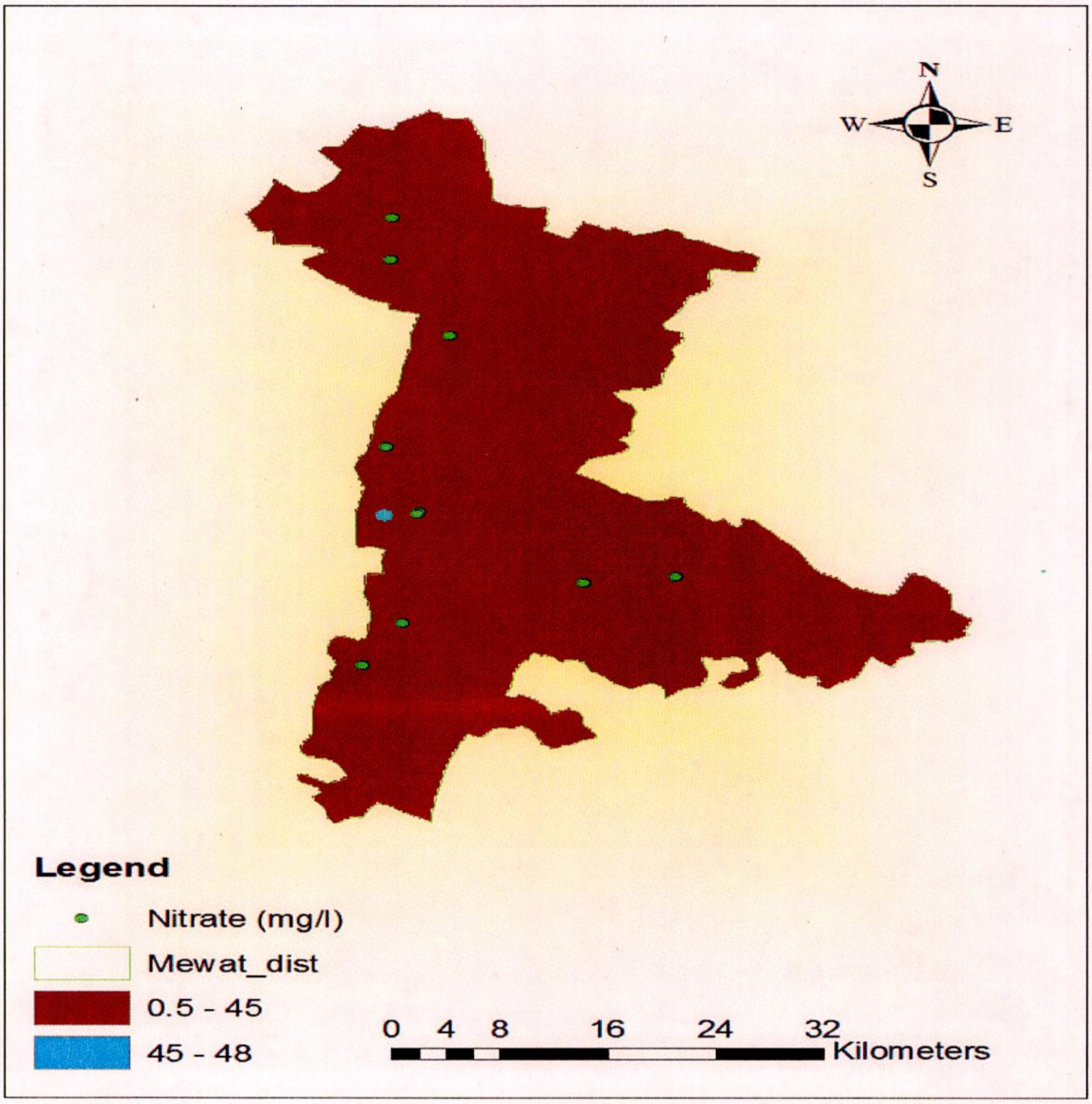


Fig: 4.1.9 Spatial variation of Nitrate in Mewat District

4.1.10 Chloride

The Chloride values of water samples vary in the range of 199.98-8397.4 mg/l with an average value of 2040.83 mg/l. The maximum value 8397.4 mg/l observed at Uletha Piezometer while the minimum was found that 199.98 mg/l at Tauru submersible 2.About 25% of samples was found above the permissible limit in study area except the places Chokha hand pump, Chokha khoni canal, Lahas open well, Nasserbad open well,Jhirkhola submersible well, Kotla open well, Palla submersible well, Tauru submersible1 and Tauru submersible 2. (Fig: 4.1.10)

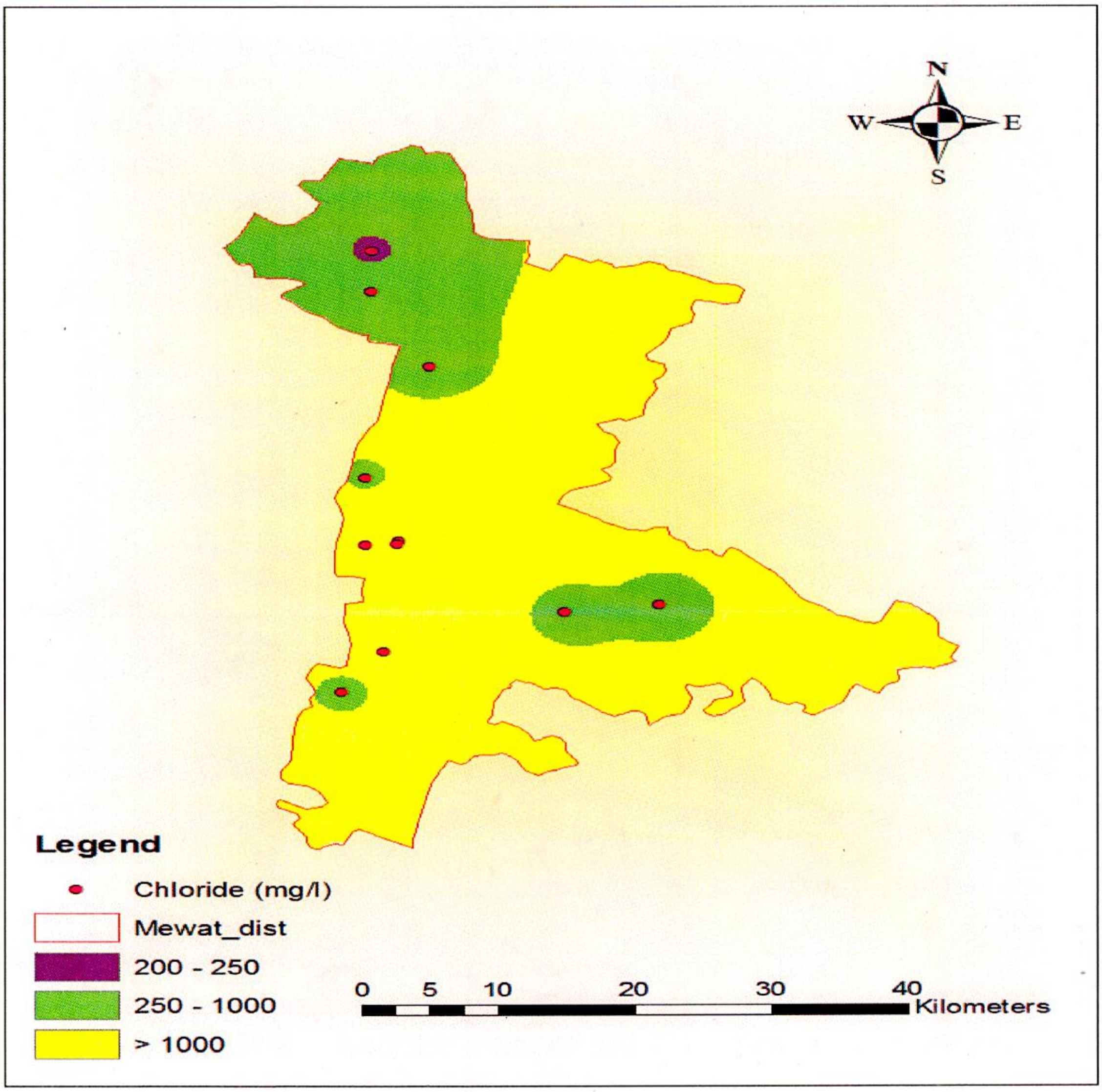


Fig: 4.1.10 Spatial variation of Chloride in Mewat District

4.1.11 Fluoride

The Flouride found in the range of 0.64-5.22 mg/l with an average value of 1.82 mg/l. The maximum value5.22 mg/l observed at Uletha Piezometer while the minimum was found that 0.64 mg/l at Tauru submersible 2. About 50% of samples were found above the permissible limit in study area except the places Lahas open well, Jhirkhola submersible, Palla submersible well, Kotla open well, Tauru submersible well 1, Tauru submersible well 2. (Fig: 4.1.11)

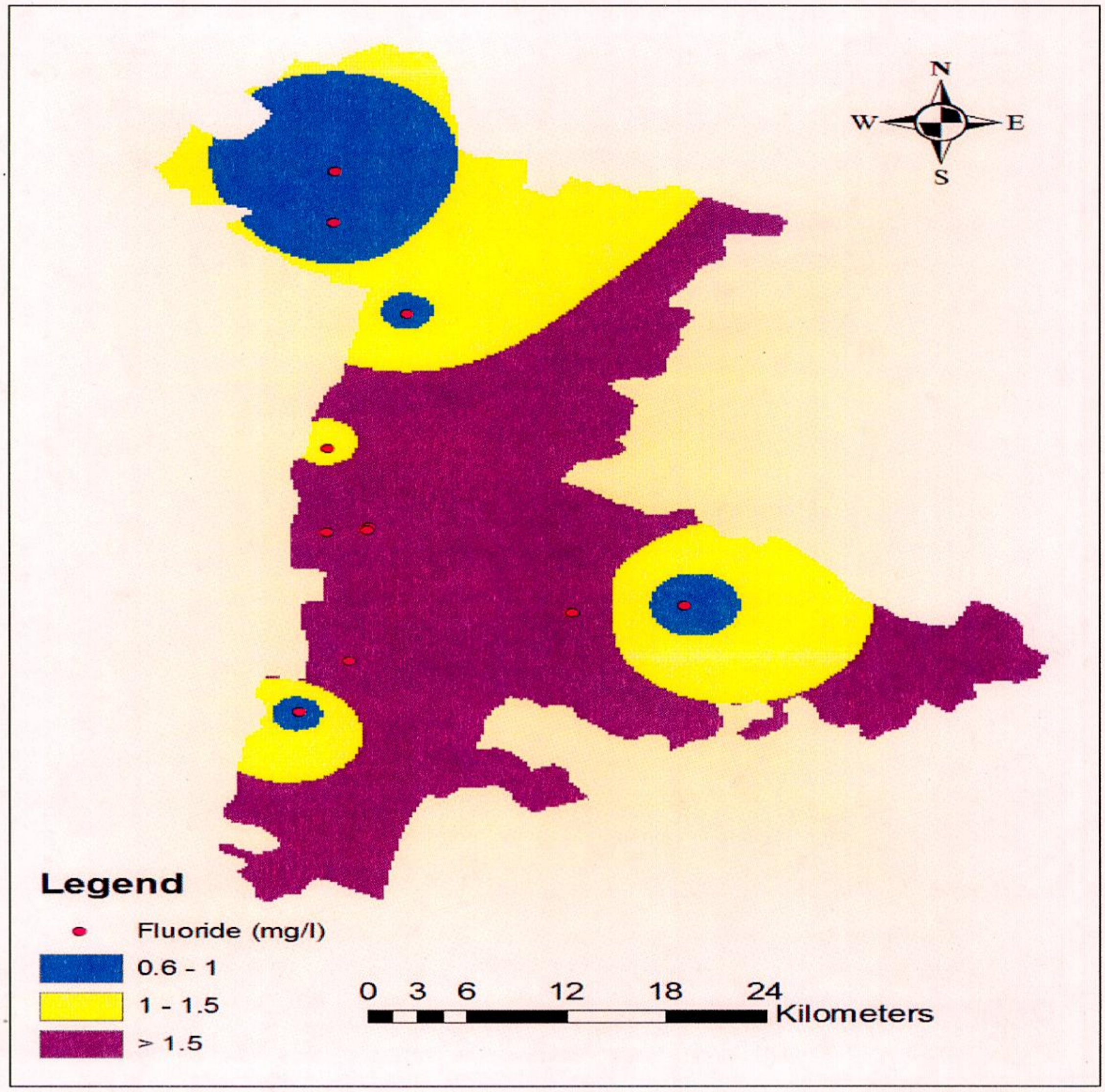


Fig: 4.1.11 Spatial variation of Flouride in Mewat District

4.1.12 Zinc

The Zinc values of water samples varies in the range of 8.32-425.5 µg/l with an average value of 51.8 µg/l. The maximum value 425.5 µg/l observed at Bore well Ghagas while the minimum was found that 8.32 µg/l at Chokha hand pump. All the water sample lies within the permissible limit in study area. (Fig: 4.1.12)

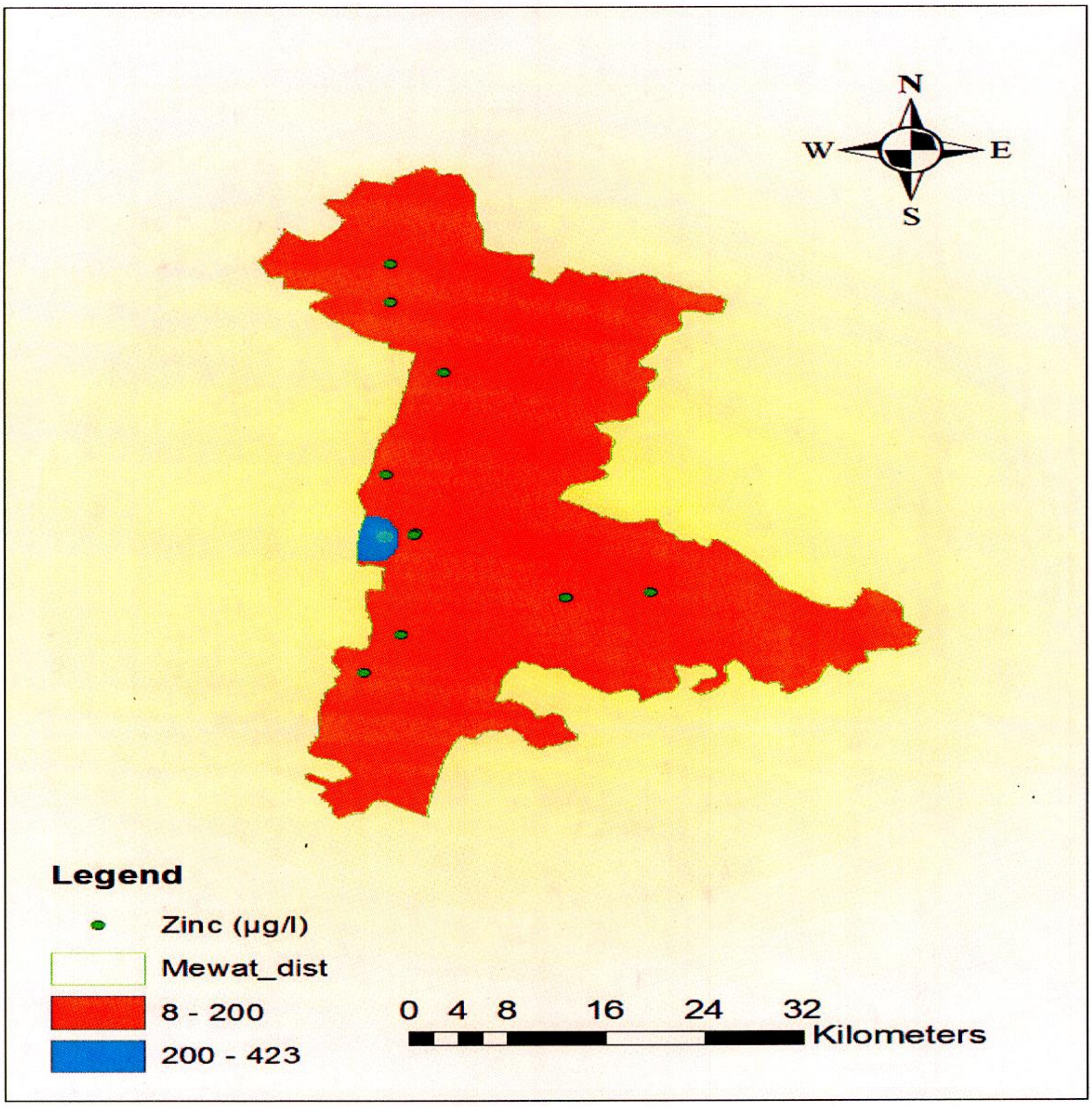


Fig: 4.1.12 Spatial variation of Zinc in Mewat District

4.1.13 Manganese

The Manganese content varies in the range of 0.19-89.68 µg/l with an average value of 14.97 µg/l. However, the maximum value 89.68 µg/l observed at Chokha khoni canal but among groundwater samples the maximum (52.69 µg/l) was found at Ulheta open well and minimum (0.19 µg/l) was found at Jhirkhola submersible well. All the samples were found within the permissible limit in study area. (Fig: 4.1.13).

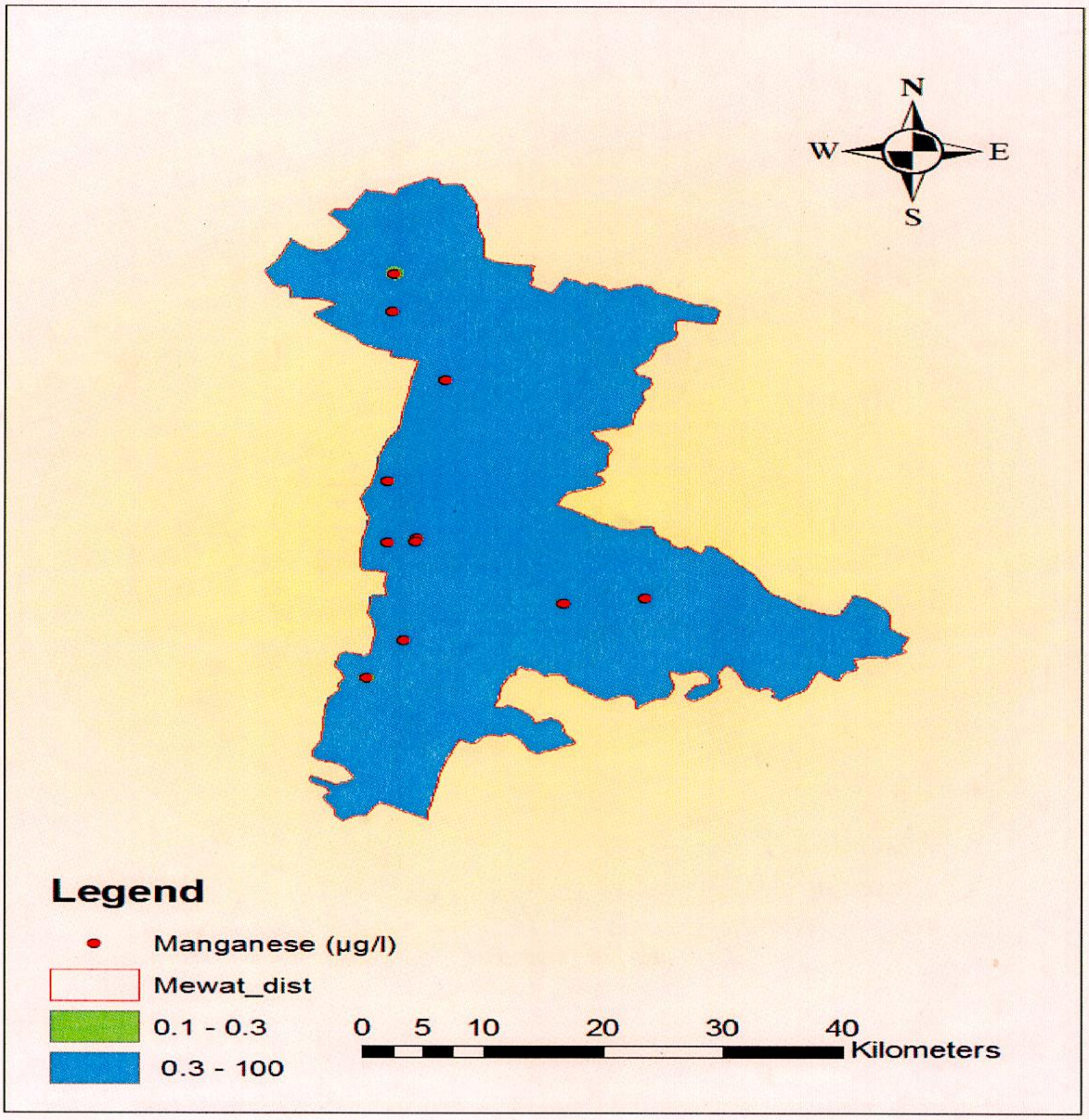


Fig: 4.1.13 Spatial variation of Manganese in Mewat District

4.1.14 Copper

The Copper varies in the range of 0.7-51.51 µg/l with an average value of 8.50 µg/l. The maximum value is 51.51 µg/l observed at Chokha khoni canel while the minimum was found that 0.7 µg/l at Jhirkhola summersible well. All the samples were found within the permissible limit. (Fig: 4.1.14)

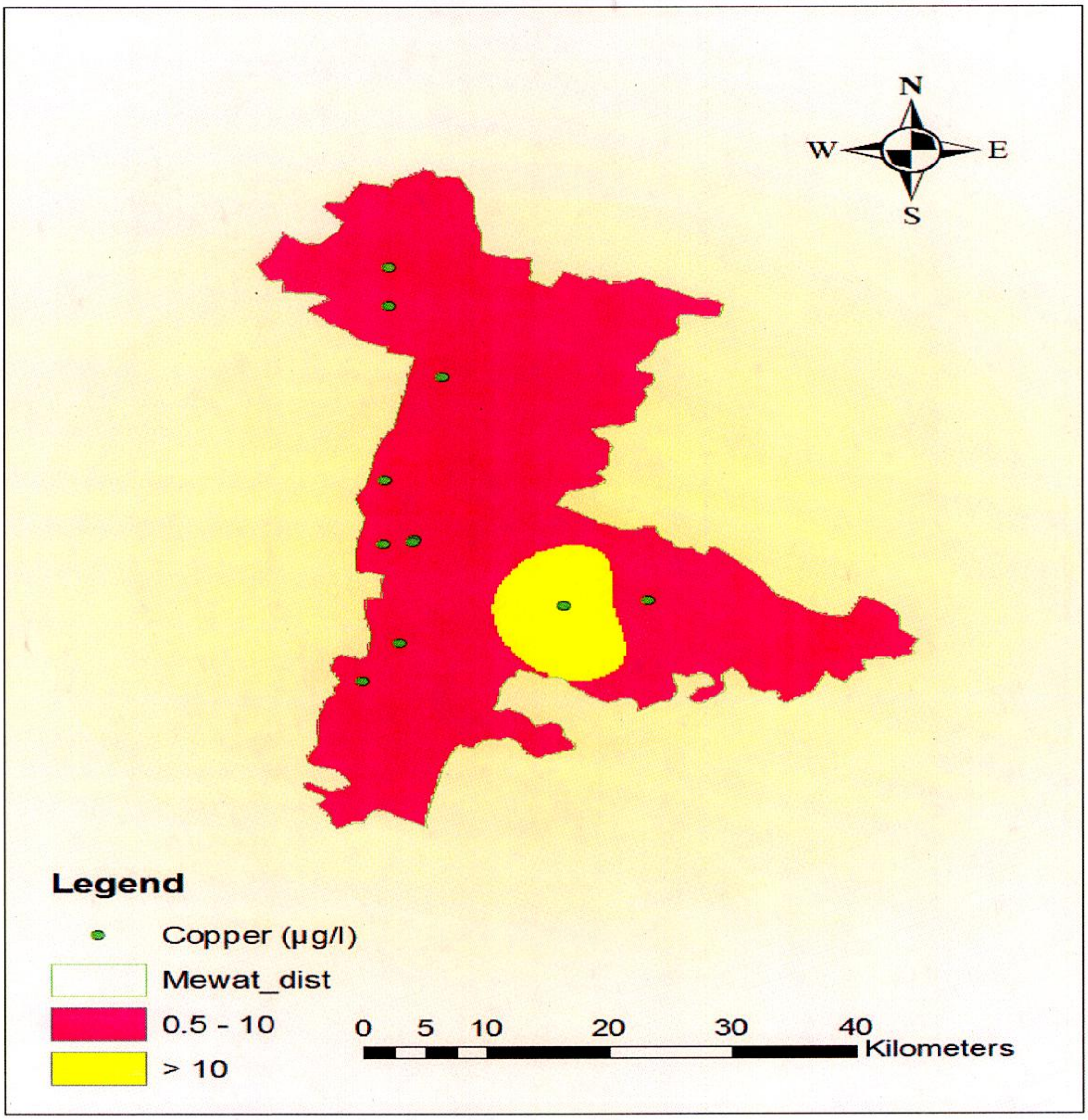


Fig: 4.1.14 Spatial variation of Copper in Mewat District

4.1.15 Iron

The Iron content varies in the range of 164.4-727.1 μg/l with an average value of 417.08 μg/l. The maximum value 727.1 μg/l observed at Uletha open well while the minimum was found that 164.4 μg/l at Tauru submersible 2. About 66.6% of samples were found above the permissible limit in study area except the places Palla submersible well, Kotla open well, Tauru submersible well 1, Tauru submersible well 2 (Fig: 4.1.15).

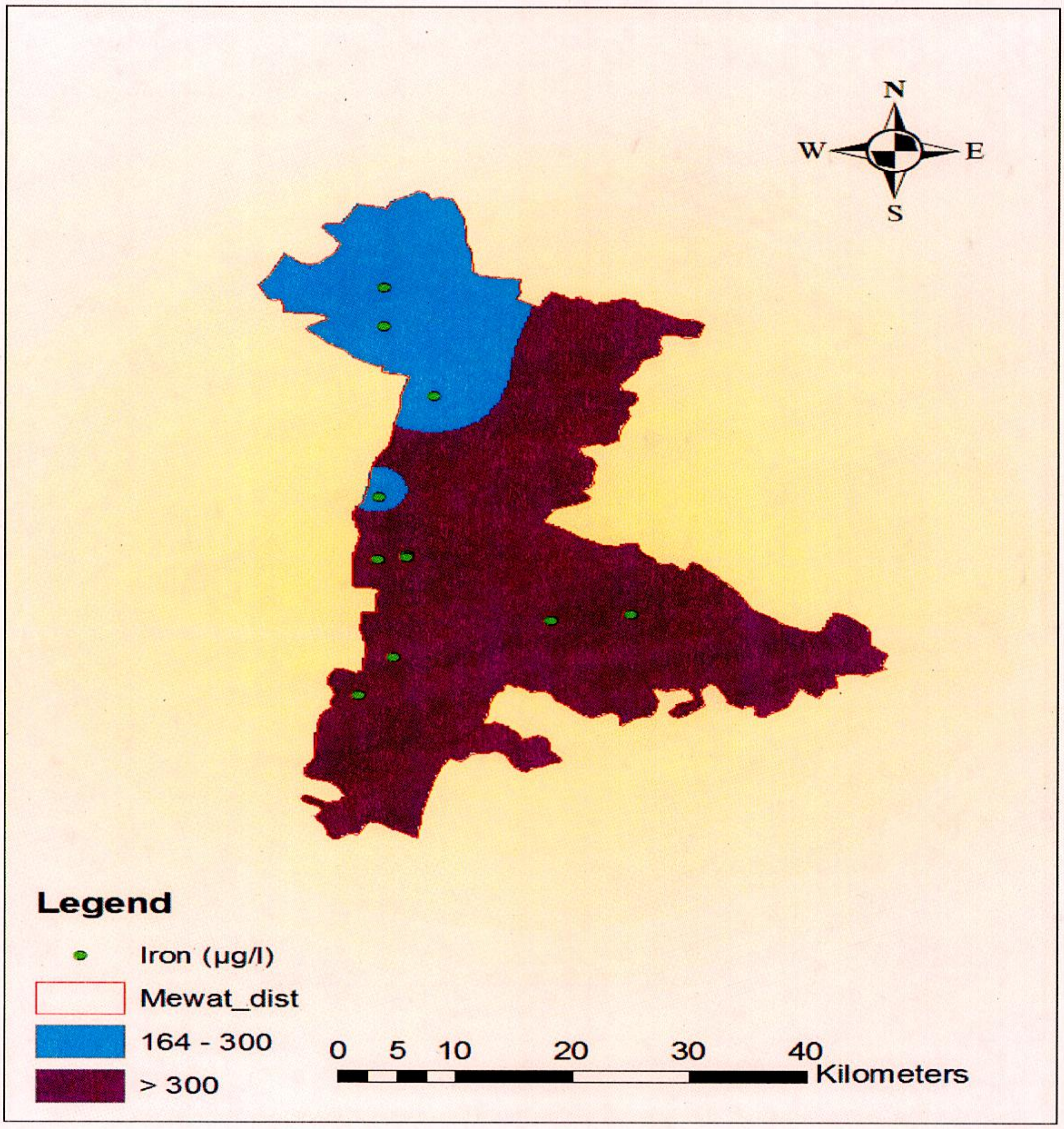


Fig: 4.1.15 Spatial variation of Iron in Mewat district

4.1.16 Hardness

The hardness values of water samples vary in the range of 813.8-26156.32 mg/l with an average value of 5609.21 mg/l. The maximum value is 26156.32 mg/l observed at Uletha open well however the minimum value was found 813.8 mg/l at Chokha khoni canal, while in groundwater samples it was found minimum (1378 mg/l) at Jhirkhola. Most of the water samples were found above the permissible limit in study area. (Fig: 4.1.16)

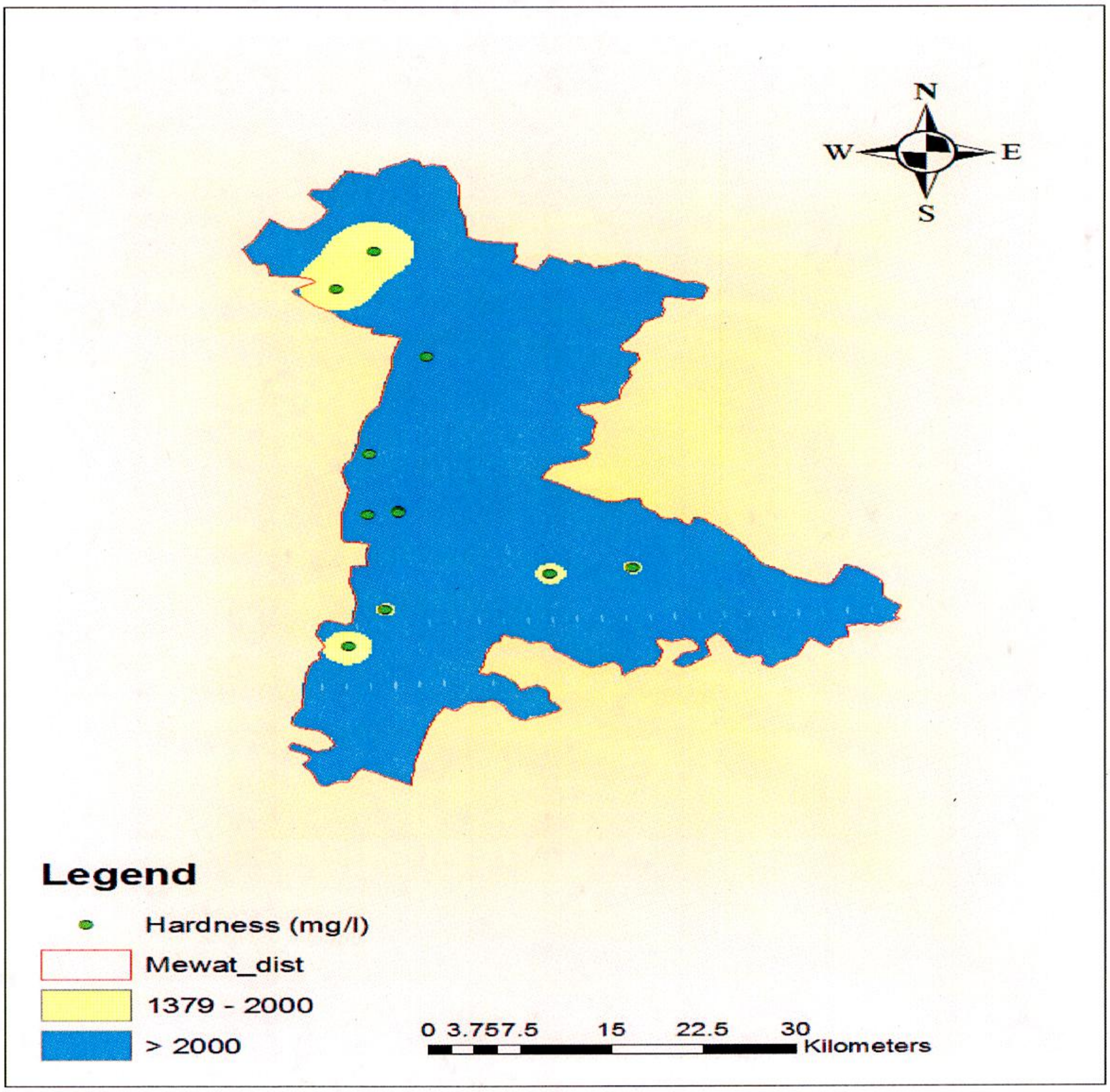


Fig: 4.1.16 Spatial variation of Hardness in Mewat District

4.2 Correlation

In all the figures correlation of sulphate and bicarbonate with Ca^+, Mg^{2+}, Na^+, K^+ shows that point representing Uletha piezometer and Uletha open well lies away from the line. Same has been observed in correlation of EC with F^-, Cl^-, SO_4^{2-}, Ca^+, Mg^{2+}, Na^+, and K^+ . A strong correlation of EC, sulphate, bicarbonate found with Ca^+, Mg^{2+}, Na^+, K^+.

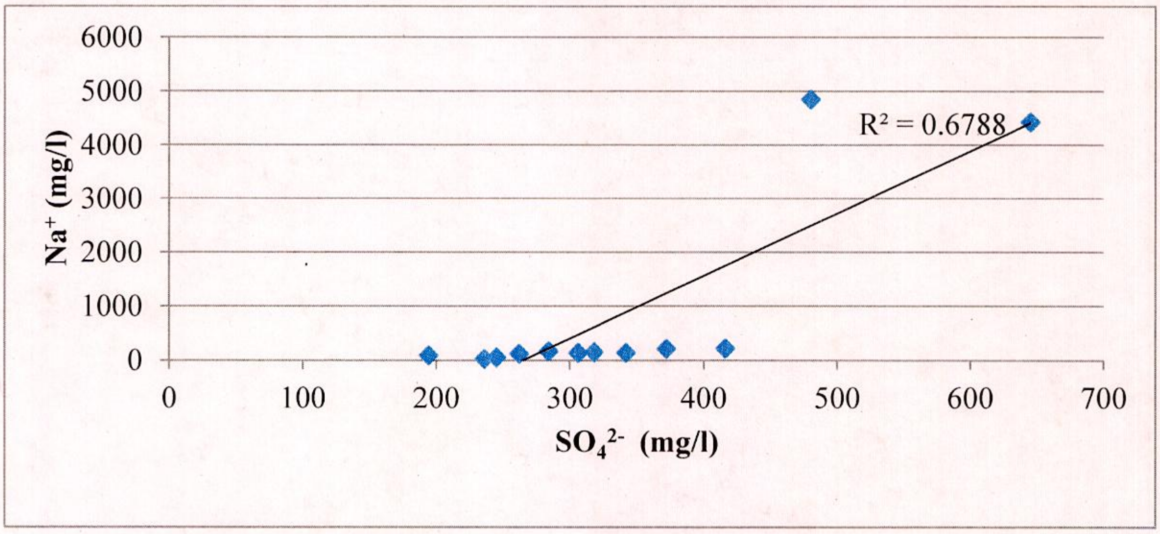


Fig: 4.2.1 Scatter plot between **Na^+** and **SO_4^{2-}**

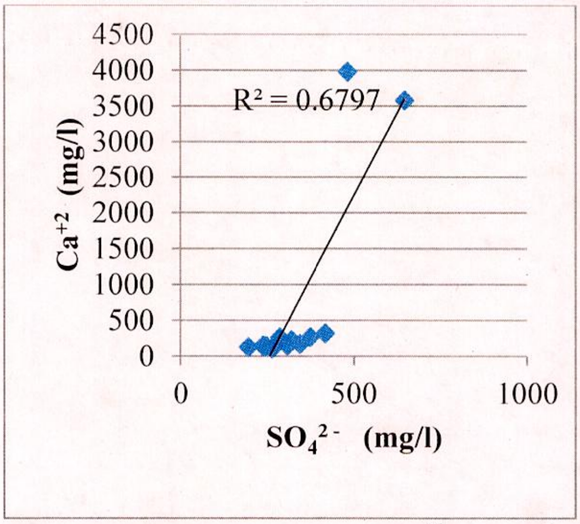


Fig: 4.2.2 Scatter plot between **Ca^{+2}** and **SO_4^{2-}**

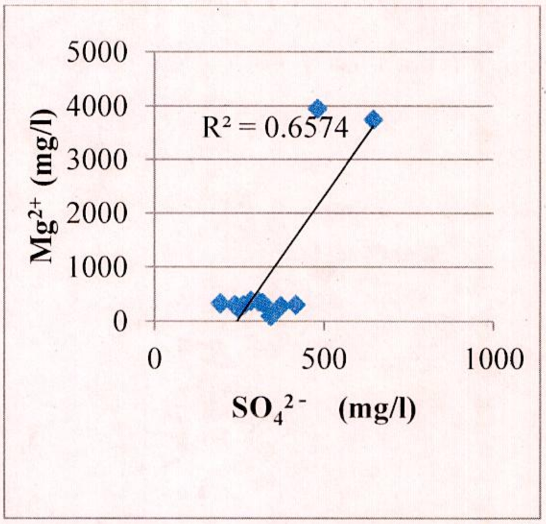
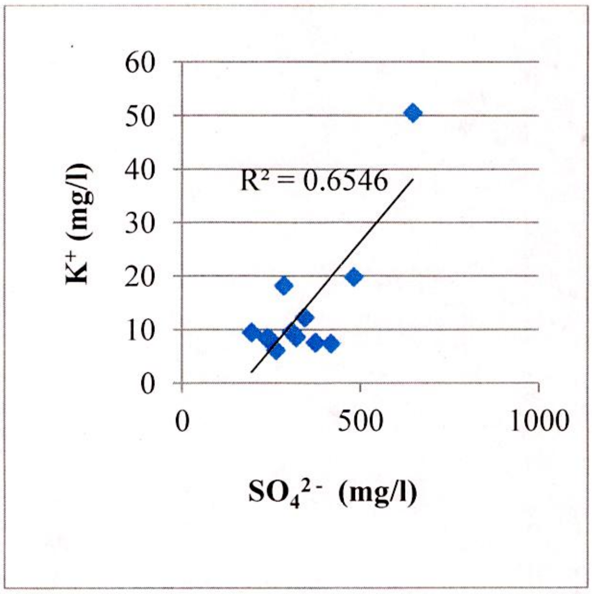


Fig: 4.2.3 Scatter plot between **SO_4^{2-} and Mg^{2+}**



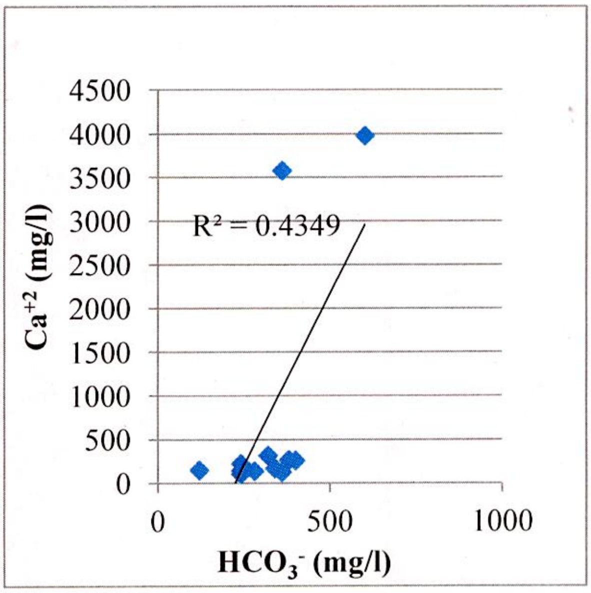
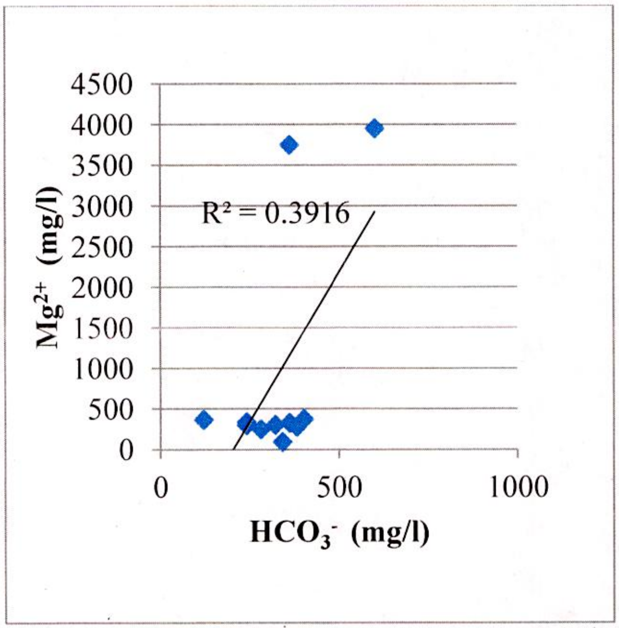


Fig: 4.2.4 Scatter plot between **K^+** and **SO_4^{2-}**

Fig: 4.2.5 Scatter plot between **Ca^{+2}** and **HCO_3^-**



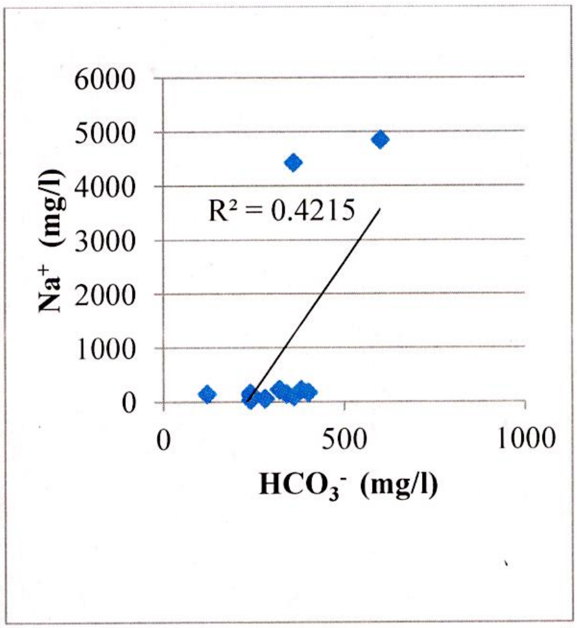


Fig: 4.2.6 Scatter plot between **HCO_3^-** and **Mg^{2+}**

Fig: 4.2.7 Scatter plot between **HCO_3^-** and **Na^+**

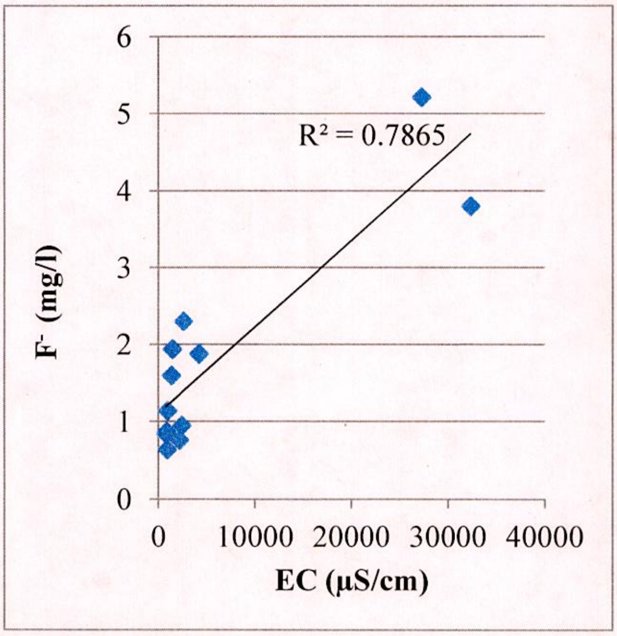


Fig: 4.2.8 Scatter plot between **EC** and **F^-**

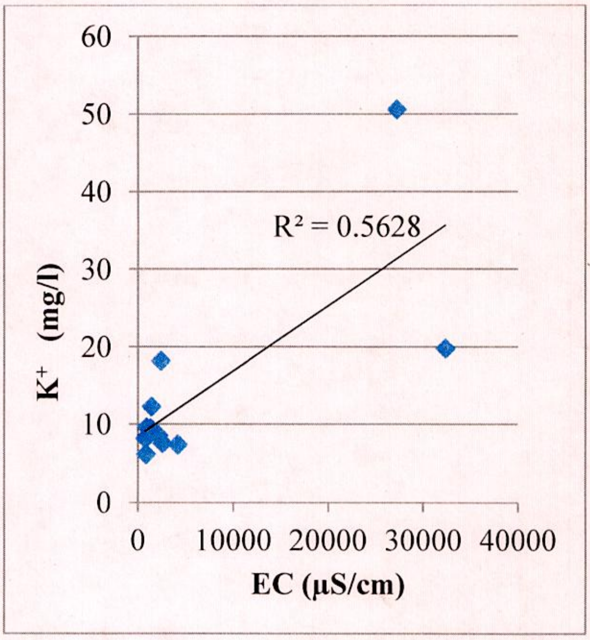


Fig: 4.2.9 Scatter plot between **EC** and **K^+**

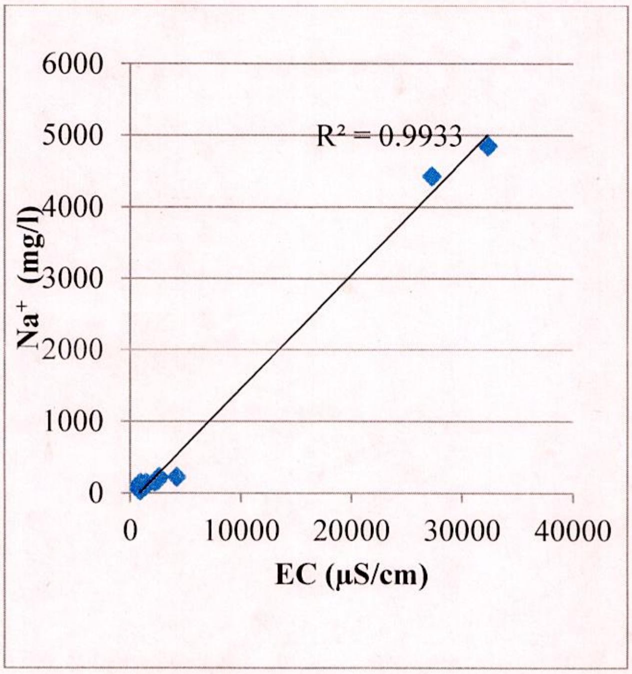


Fig: 4.2.10 Scatter plot between **Na^+** and EC

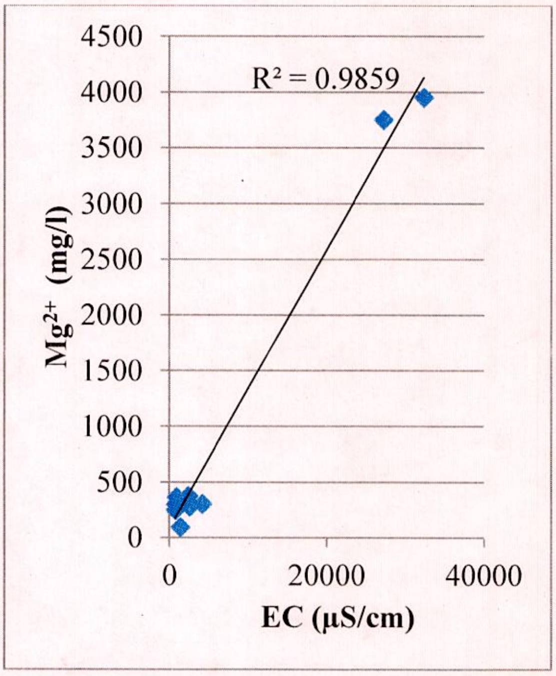


Fig: 4.2.11 Scatter plot between Mg^{2+} and EC

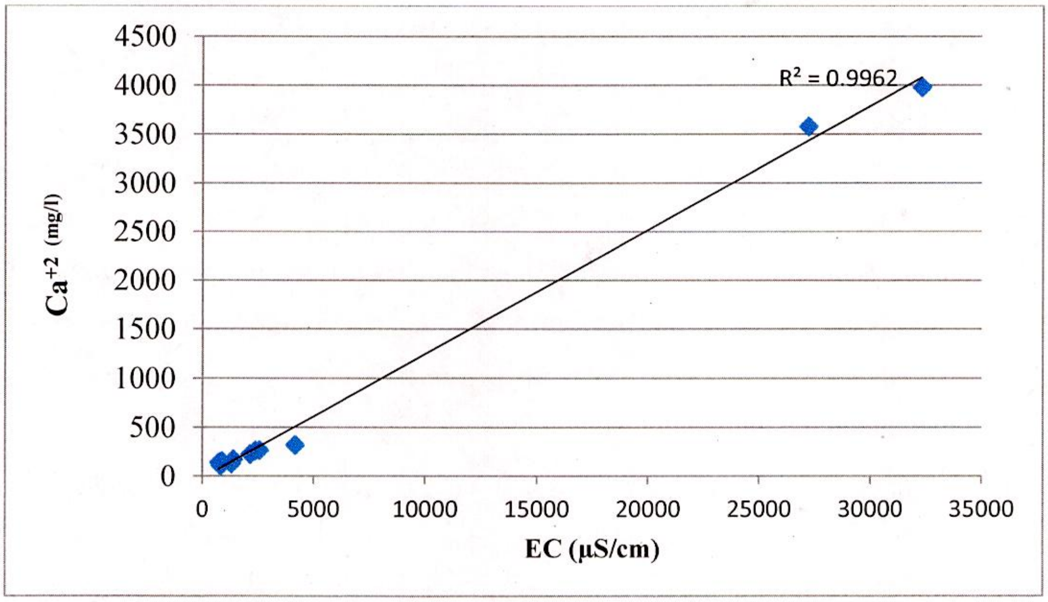


Fig: 4.2.12 Scatter plot between **Ca^{+2}** and **EC**

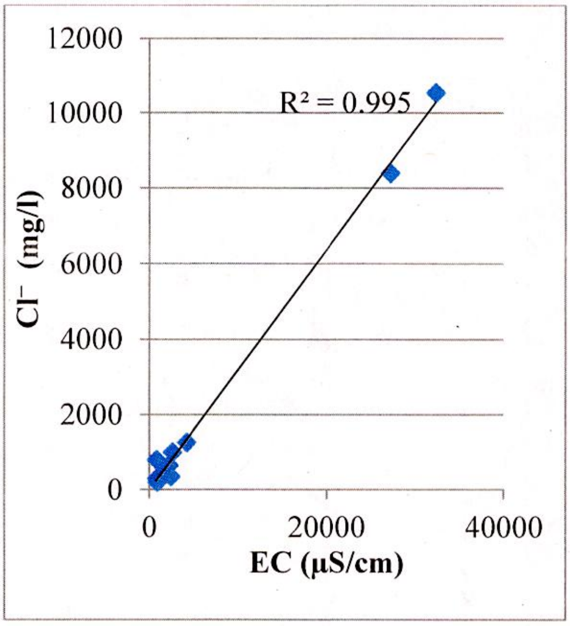


Fig: 4.2.13 Scatter plot between **EC** and **Cl^{-}**

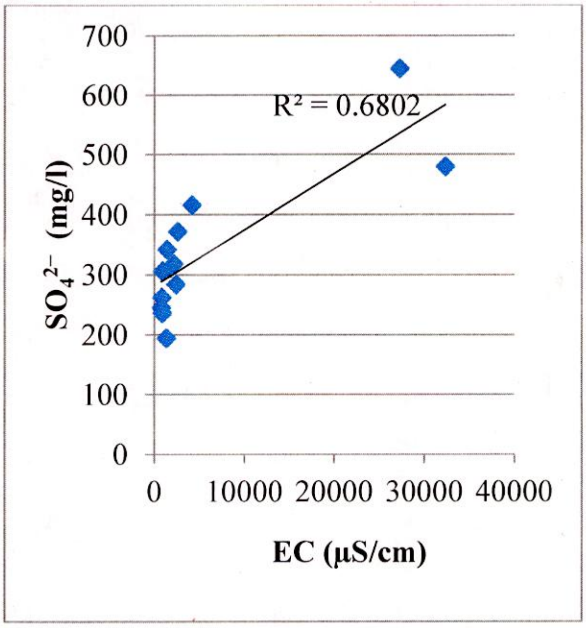


Fig: 4.2.14 Scatter plot between **SO$_4^{2-}$** and **EC**

4.3 Discussion

After studying all the parameters we found that the values of EC, Hardness, Sodium, Potassium, Calcium, Magnesium, Sulphate, Chloride, Nitrate, Fluoride and Iron are above the permissible limit in the locations Chokha khoni canel; Chokha hand pump; Chokha hand pump; Lahas open well; Bore Well Gagas; Uletha Open well; Uletha Piezometer; Naseerbad Open well; Jhirkhola Submersible; Kotla open Well; Palla submersible well; Taoru Subersible 1; Taoru Submersible 2, respectively. The canal has effect on nearby groundwater. In the hilly area Tauru, the value of EC is lie between the desirable and permissible limit. In trace metals, the concentration of iron is more as compared to zinc, manganese and copper. The Electricity conductivity of Uletha piezometer and Uletha open is very high. A strong correlation of EC with Na^+, Ca^+, Mg^+, Cl^- indicated that these parameters are the cause of salinity in the area. Correlation of sulphate and bicarbonate with calcium, magnesium, sodium, potassium shows that the point Uletha piezometer and Uletha open well are the exceptions. A strong correlation of EC, sulphate, bicarbonate found with Ca^+, Mg^{2+}, Na^+, K^+.

Hydrogeochemical processes are responsible for the chemical nature of groundwater supply in a place and variations in groundwater is due to the varied composition of infiltrating surface water, soil and rock properties, the processes like ion-commutation, dissolution, evaporation, precipitation etc. Carbonate and silicate weathering processes may be responsible for the presence of Ca, Mg, HCO_3 & SO_4 and Na, K & HCO_3 in the groundwater. The variations in hydrochemical composition may be due to the variation in mineral composition of bedrock.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The Mewat district has high saline groundwater which have been found polluted with fluoride, Zinc, chloride, calcium, sodium, potassium, magnesium and Iron. In the present study we took sample from villages namely Chokha, Lahas, Ghagas, Uletha, Naseerbad, Jhirkhola, Kotla, Palla, and Tauru and analysed for physico-chemical parameters. The result shows that values of all the parameters except pH, HCO_3^-, Zn, Mn, Cu are found above the permissible limit. In the samples where the Fluoride concentration is above permissible limit require special treatment like Reverse osmosis, Distillation etc. There exists a strong relationship of sulphate with cations and bicarbonate with anion. A very strong correlation with (R^2=0.99) of EC with Ca^+, Mg^{2+}, Na^+, K^+ F^-, Cl^-, SO_4^{2-} points towards the possible cause of high salinity due to the presence of the salts. Based on the conclusions it is recommended that:

1. Further, detailed investigation is required to ascertain the cause of salinity in the parts of Mewat district especially in the south western part and assessing the quality of water for its suitability for drinking and irrigation purposes in Mewat district, Haryana
2. There is an urgent need for regular monitoring of groundwater quality in Mewat district, Haryana.
3. Some study should be carried out to trace the recharge areas of groundwater in different zones to find out the causes of spatial variations in the concentrations of major, minor and trace elements in groundwater and the residence time of the groundwater in contact with rock materials in Mewat district, Haryana.
4. Study should also be carried out to find the ion exchange characters of groundwater of this region
5. Efforts should be made to understand the geology of the study are and its possible influence on the chemical transformation of the groundwater resources.

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