Spatial Distribution Of Groundwater Quality In Killai Taluk, Cuddalore District, Tamil Nadu

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Abstract: The present investigation reports the results of a monitoring study focusing on groundwater quality of killai taluk, Cuddalore District of Tamil Nadu. Since, remediation of groundwater is very difficult, knowledge of the existing nature, magnitude, and sources of the various pollution loads is a prerequisite to assessing groundwater quality. 18 groundwater samples were collected randomly from Bore wells and analyzed for various chemical parameters. Geologically, the study area comprises Quaternary alluvium. An attempt has been made to study on the quality of ground water for the Villages falling in the killai taluk to interpolate major ions concentration in groundwater. Highest concentration of hardness in groundwater is observed in S and E part of the study area. Abundance of Ca and HCO_3 hardness may be attributed due to dissolution of aragonite bearing minerals by the way of pedological differenceaction in the preceding sedimentary cycle of deposition. Maximum concentration of NO_3 concentration is higher in central part of the study area. which comprises of recent alluvium. Above zones were found to put for maximum agricultural operation by applying Verm icomposit for crop production in the study area.

Keywords: Spatial distribution, Alluvium, groundwater quality, Major ions,

I. INTRODUCTION

Groundwater is one of the most important sources of water for various human activities. With deteriorating surface water quality, there is an increasing reliance on groundwater resources in urban and rural areas. Thus, groundwater quality and quantity are continuously under threat due to abuse of resources. Problems of falling groundwater table and deteriorating groundwater quality have become a common problem throughout the world. According to State of India's Environment's (2015) report, India is one of the largest consumers of groundwater resources, distributed unevenly in the country. In India, there is lack of scientific data due to incomplete understanding in recharge and discharge processes of underground water and are mostly approximated. The number of groundwater withdrawal structures has increased rapidly leading to overexploitation and depletion of the resource (Singh & Singh, 2002). Das (2011) reported that the uneven alluvium region The vast population and ever increasing industrial activities in India, makes its water resources more vulnerable to water quality deterioration. The groundwater resources are at higher risk as its remediation is very difficult. The major anthropogenic activities (Anandhan 2016, Chidambaram 2013,2014, Srinivasamoorthy 2011, 2013) for continuous groundwater quality deterioration are urbanization, industrialization, and agriculture run off. Also the problem of drinking water contamination, water conservation, and water quality management has assumed a very important role for sustainable development of countries, such as India (Shankar 2011,Prashant et al., 2010). GIS based spatial distribution mapping groundwater suitability evaluation

of groundwater quality for domestic and agricultural purposes were carried out Sanjay Kumar et.al. 2010.
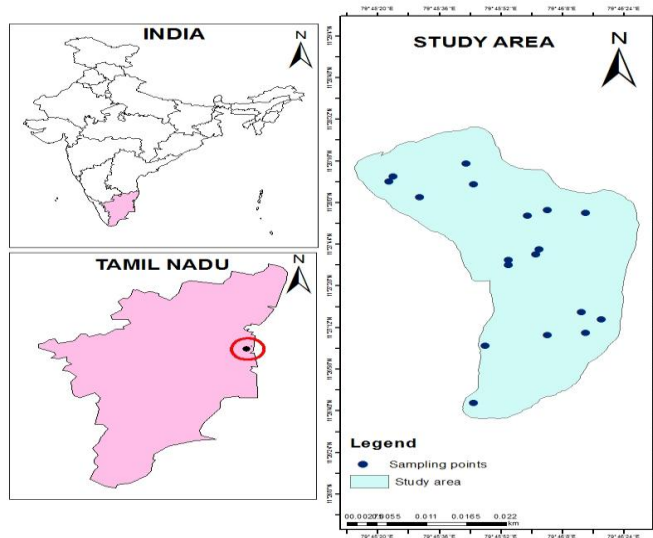

Figure 1: Location map of the study area

II. STUDY AREA

The Study area lies in between 11°23' to 11°28' N in latitude and 79°44' to 79°48' E in longitude and it is located at NE part of Chidambaram Non Municipal. The total geographical area of this area is about 290.09 hectares. The study area consists of quartenary Alluvium (Fig 2). The Alluvium of the Vellar river partially overlies the cretaceous and the cuddalores. The tidal mud flats are present along the Bay of Bengal. These mud flats are associated with marshy swamps and lagoons consisting of mangrove forests. The slope is from west to east. There are no hills or mountains in the area. The main source of irrigation is old Coleroon river, which has got a perennial flow and Vellar river, which has got only a seasonal flow during monsoon rains.
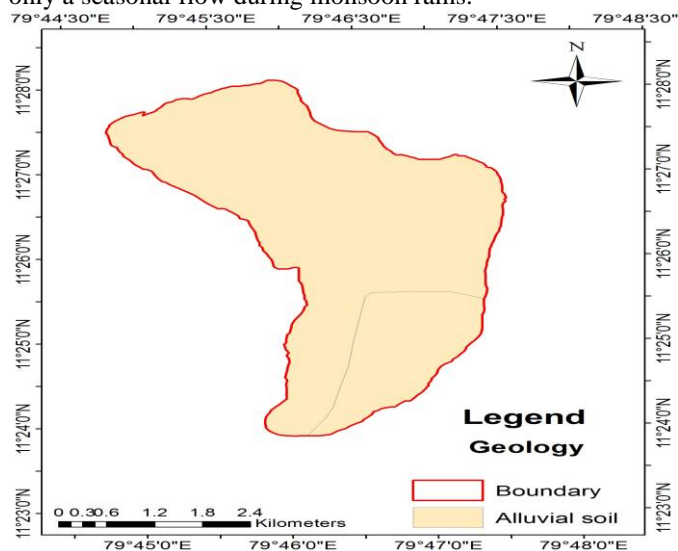

Figure 2: Geology Map of the Study area

	PH	EC	Cl	Ca	Mg	HCO$_3$	Na	K	SiO$_4$	NO$_3$	PO$_4$	SO$_4$	TDS
MAX	8.33	6600	1790.2	156	112.8	567.3	83.7	82.7	50	1194.82	13.25	72.5	2651.77
MIN	5.75	701	168.38	36	7.2	195.2	10.5	6.7	8.5	39.12	0.25	4.5	686.60
AVG	6.43	2929.4	812.03	88.4	35.3	292.12	41.6	28.2	38.3	252.4	1.944	16.8	1607.26

Table 1: Max, Min and Average ions present in the ground water of the study area

III. MATERIALS AND METHODS

Sample analysis and Analytical techniques Major Elements were analyzed from 18 groundwater samples collected during the season from bore wells of killai region (Figure 1). Samples were collected using polythene bottles washed with clear acid and standard procedures (Ramesh and Anbu1996)were used for analysis parameter, such as Temperature, pH, EC (Electrical Conductivity) and TDS (Total Dissolved Solids were analyzed in Thermo Orion ion electrode probe Portable kit) were measured in the field. Ca^{2+}, Mg^{2+}, HCO_3 titrimetric Methods15. Na, K determined by using Flamephotometer, SO_4^{-2}, PO_4, NO_3 determined by using UV Spectrophotometer HACH 6000 Instrument. The analytical precision for the measurements of ions was determined by calculating the ionic balance error, which is generally within ±5 %.

IV. RESULTS AND DISCUSSION

PH AND EC

The ground water in the study area is colourless and odourless in most of the places. The pH refers to the activity of hydrogen ions expressed in logarithmic units (negative base 10 log of the hydrogen ion activity in moles/ litre). The hydrogen ion activity is controlled by chemical reaction that produces or consumes hydrogen ions. Hence pH is an index for knowing the equilibrium reaction in the water. pH in the study area varies from 5.75 to 8.34 (Table 1). The pH average concentration in the region is 6.44. EC is the ability of a substance to conduct electric current. The measure of conductivity is directly proportional to the strength of the water. The EC for purest water is 0.05 $\mu s/cm^2$ (Hem, 1991). In the study area EC varies from 701$\mu s/cm^2$ to 6600 $\mu s/cm^2$. On an average 2929 $\mu s/cm^2$ is observed in the region. The spatial distribution diagram pH and EC shows that (Fig 3 and 4) the higher concentration EC shows in NW and SE part of the study area. pH higher value absorbed in NW and Central part of the study area.
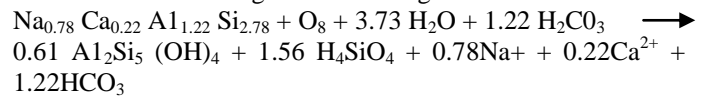
CHLORIDE (CL)

Chloride in excess of 100 mg/l imparts a salty taste. Concentrations greatly in excess of 100 mg/l may cause physiological damage. Food processing industries usually require less than 250 mg/l. Some industries-textile processing., paper manufacturing, and synthetic rubber manufacturing desire less than 100 mg/l. Commonly less than 10 mg/l in humid regions but up to 1000 mg/l in more arid regions.

About 19,300 mg/l in sea water; and as much as 200,000 mg/l in brines. Chief source is sedimentary rock (evaporates); minor sources are igneous rocks. It

Figure 3: spatial distribution diagram for pH

Figure 4: spatial distribution diagram for EC

Ranges from 168.39 – 1790.23 mg/l (Table 1). The average concentration in the region is 812.03 mg/l. The spatial distribution diagram (Fig.5) shows Cl concentration is higher in Esteran part of the study area.

Figure 5: spatial distribution diagram for Cl.

CALCIUM (CA)

Main sources for calcium are amphiboles, feldspars, gypsum pyroxenes, aragonite, calcite, dolomite and clay minerals. It ranges from 36 -156 mg/l. The average (table 1) concentration in the region is 88.45 mg/l.

$$Na_{0.78} Ca_{0.22} Al_{1.22} Si_{2.78} + O_8 + 3.73 H_2O + 1.22 H_2C0_3 \longrightarrow 0.61 Al_2Si_5 (OH)_4 + 1.56 H_4SiO_4 + 0.78Na+ + 0.22Ca^{2+} + 1.22HCO_3$$

Generally, it is less than 100 mg/l in water. Sometimes brines may contain as much as 75,000 mg/l. The tank water is used for various domestic and irrigation purpose. The spatial distribution diagram (fig 6) shows Ca concentration is higher in E and crntral part of the study area.

MAGNESIUM (MG)

Generally less they are than 50 mg/l in continental waters. Ocean water contains more than 1000 mg/l. The main sources are Amphiboles, Olivine, Pyroxenes, Dolomite, Magnesite and clay minerals. It ranges from 7.2 to 113.8 mg/l. The average concentration in the region is 35.33 mg/l. The Mg concentration is higher at some places because the residence time over the clay or because of the domestic waste like soap waters.
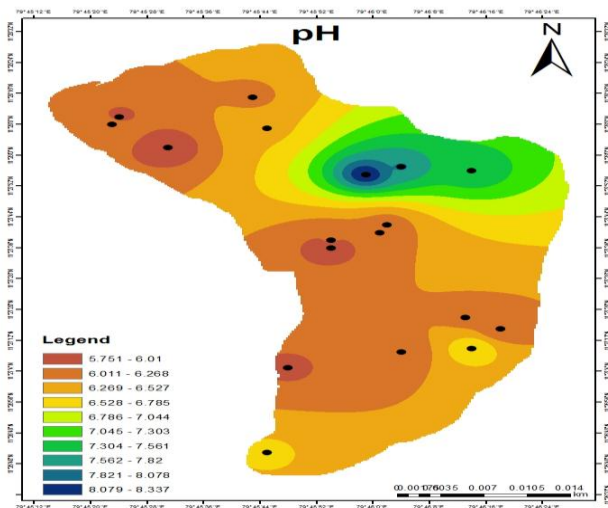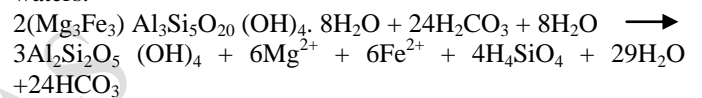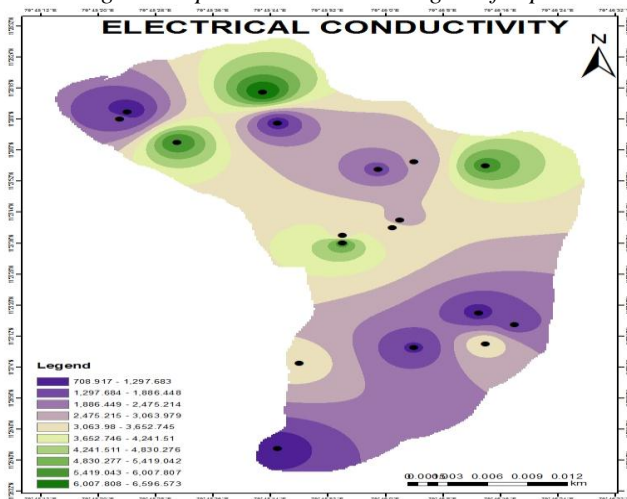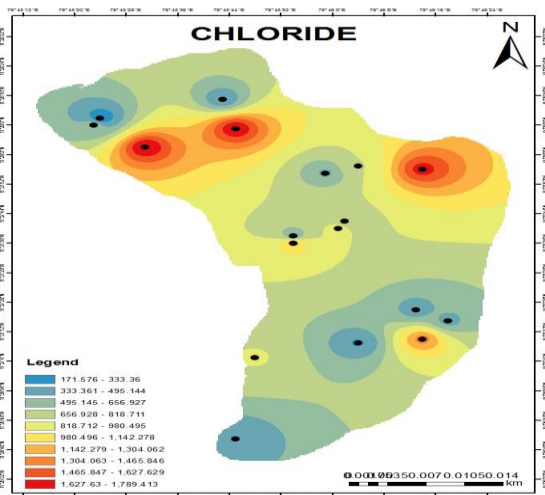
$$2(Mg_3Fe_3) Al_3Si_5O_{20} (OH)_4. 8H_2O + 24H_2CO_3 + 8H_2O \longrightarrow 3Al_2Si_2O_5 (OH)_4 + 6Mg^{2+} + 6Fe^{2+} + 4H_4SiO_4 + 29H_2O +24HCO_3$$
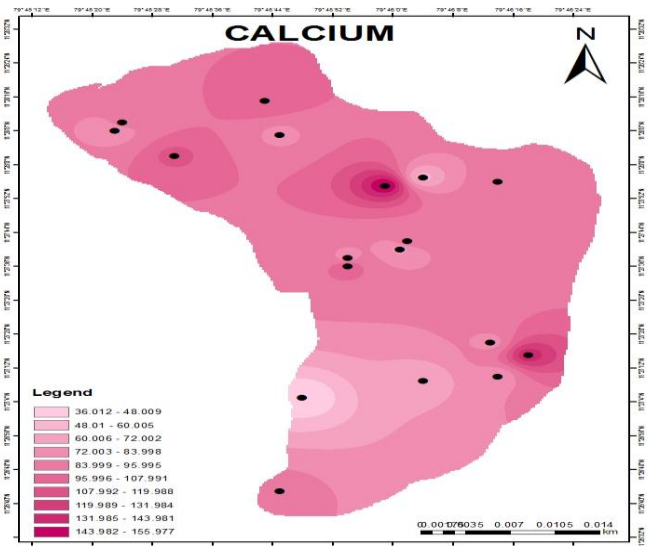

Figure 6: spatial distribution diagram for Ca

Calcium and magnesium combine with bicarbonate, carbonate, sulfate and silica to form heat retarding, pipe clogging scale in boilers and in other heat-exchange equipment. Calcium and magnesium combine with ions of fatty acid in soaps to form soapsuds; the more calcium land magnesium. A high concentration of magnesium has a laxative effect, especially on new users of the supply. The spatial distribution diagram (fig 7) shows Mg concentration is higher in Eastern part of the study area.
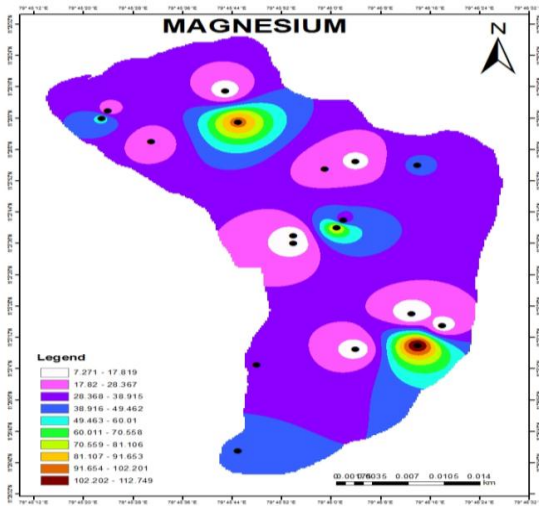
Figure 7: spatial distribution diagram for Mg

SODIUM (NA)

The main sources are Feldspars, clay minerals; evaporates and industrial wastes. The sodium ranges from 10.5 – 83.7 mg/l. The average concentration in the region is 41.68 mg/l. Here again the concentration of the Na is higher in the surface water due to three reason as it stays in the clay bed; cation exchange and due to the evaporation effect and due to domestic wastewater.

They are present in Feldspars (albite)

$$2.33\ NaAlSi_3O_8 + 8.64\ H_2O + 2CO_2 \longrightarrow Na_{0.33}\ Al_{2.33}\ Si_{3.67}\ O_{10}\ (OH)_2$$
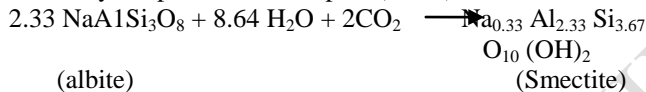
(albite)   (Smectite)

$$+ 2Na^+ + 2HCO_3^- + 3.32\ H_4SiO_4$$

The reaction should produce Na, HCO_3 and H_4SiO_4 in the ratio 1:1:1.66

More than 50 mg/l sodium and potassium in the presence of suspended matter causes foaming, which accelerates scale formation and corrosion in boilers. Sodium and potassium carbonate in recalculating cooling water can cause deterioration of wood in cooling towers. More than 65 mg/l of sodium can cause problems in the manufacture. Generally they are less than 200 mg/l, about 2000 mg/l in seawater and about 25000 mg/l in brines. The spatial distribution diagram (fig 8) shows Na concentration is higher in central part of the study area.
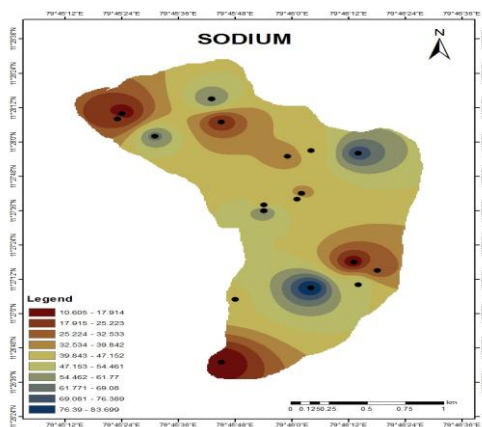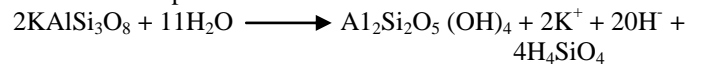

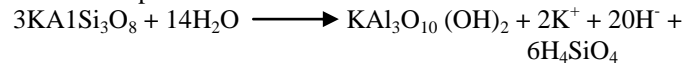*Figure 8: spatial distribution diagram for Na*

POTASSIUM (K)

The Potash feldspar would react with water, releasing other ions and H_4SiO_4 (Helgeson and others1969).The H_4SiO_4 concentration is increased and decreases if gibbsite is converted to Kaolinite. The equilibrium showing the conversion of

✓ K — feldspar to Kaolinite

$$2KAlSi_3O_8 + 11H_2O \longrightarrow Al_2Si_2O_5\ (OH)_4 + 2K^+ + 20H^- + 4H_4SiO_4$$

✓ K feldspar to Muscovite

$$3KAlSi_3O_8 + 14H_2O \longrightarrow KAl_3O_{10}\ (OH)_2 + 2K^+ + 20H^- + 6H_4SiO_4$$

In general it's below 50 mgl^{-1} with few exceptions because of it is low geochemical mobility in freshwater. K is seldom found greater or almost equal to Na. Main sources of K here is Feldspar, Mica and Felspathoid. Inspite of greater resistance of K silicates to weathering, K ions are released during weathering. But, they seem to be used up in the formation of secondary minerals (Mathews 1982). It ranges from 6.7 – 82.7 mg/l. The average concentration in the region is 28.17 mg/l. The spatial distribution diagram (fig 9) shows K concentration is higher in N and S part of the study area.
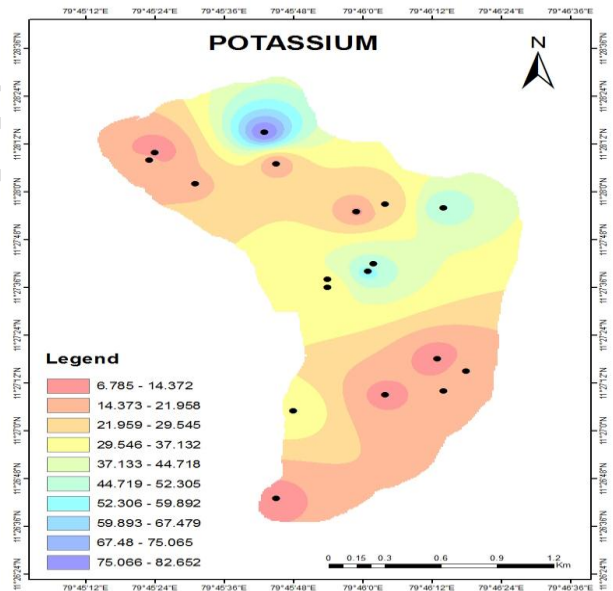

Figure 9: spatial distribution diagram for K

BICARBONATE (HCO$_3$)

The solubility of carbonate mineral in pure water is low; bicarbonate is generally derived from the silicate and carbonate weathering process. Water containing large amounts of bicarbonate and alkalinity is undesirable in many industries. Commonly less than 500 mg/I may exceed 1000 mg/l in water highly charged with carbon-di-oxide. Upon heating, bicarbonate is changed into stream, carbon-di-oxide and carbonate. The carbonate combines with alkaline earth's, principally Calcium and Magnesium to form a scale of calcium carbonate IJhat retards flow of heat through pipe walls and restricts flow of fluids in pipes. Alkalinity is a very important factor in calculating lime and soda ash requirements in softening of water and it is also an important parameter in corrosion control. It ranges from 195.2 – 567.3 mg/l. The

average concentration in the region is 292.12 mg/l. The spatial distribution diagram (Fig 10) shows HCO_3 concentration is higher in NE, S and Central part of the study area.
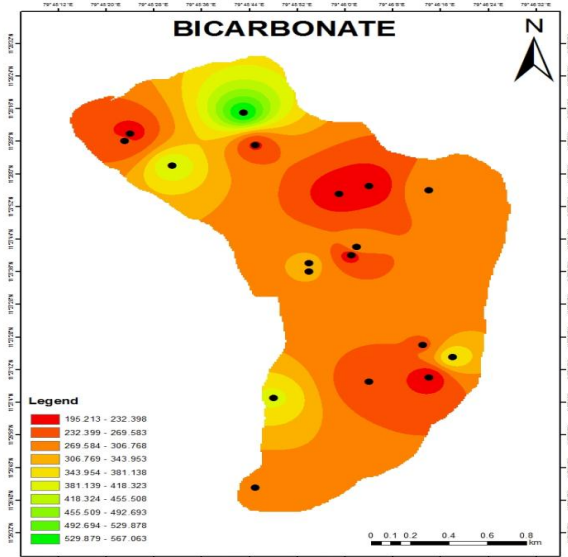

Figure 10: spatial distribution diagram for HCO_3

SULFATE (SO₄)

Sulfate combines with calcium to form an adherent, heat-retarding scale. More than 250 mg/l is objectionable in water in some industries. Water containing about 500 mg/l of sulfate tastes bitter; water containing about 1000 mg/l may be cathartic. Commonly less than 300 mg/l except in wells influenced by acid mine drainage. Higher levels like 200,000 mg/l are also noted in some brine. Sulfate concentration is well within permissible limit due to the absence of sulfide bearing minerals that undergoes oxidative weathering, at the surface and leaches down the surface. Oxidation of sulfide ores, gypsum, anhydrite and fertiisers, contributes to the sulfate concentration. It ranges from 4.5 – 72.5 mg/l. The average concentration in the region is 16.81 mg/l. The spatial distribution diagram (Fig. 11) shows SO_4 concentration is higher in NE, W and central part of the study area.
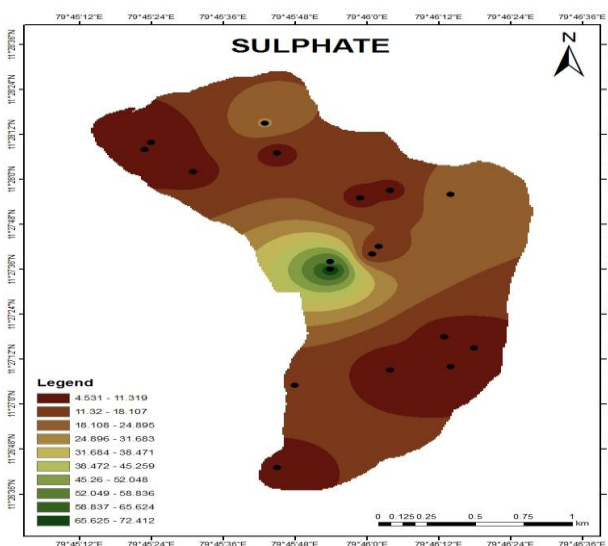

Figure 11: spatial distribution diagram for SO_4

NITRATE (NO₃)

The dominant nutrients in the groundwater are in the order of $NO_3^- > H_4SiO_4 > PO_4^-$. Nitrogen plays a dominant role in life cycle process of plants and animals. Nitrogen in groundwater is derived from organic industrial effluents, fertilizer or nitrogen fixing bacteria, leaching of animal dung, sewage and septic tanks through soil and water matrix to groundwater (Srinivasamoorthy, 2008). In general, increase of nitrate in groundwater may be an indicator of bacterial pollution (Srinivasamoorthy, 2005). Nitrate concentration ranges from 39.12 – 1194.82 mg/L with averages of 252.45. The spatial distribution diagram (Fig 12) shows NO_3 concentration is higher in central part of the study area.

PHOSPHATE (PO₄)

Phosphate is an essential trace element for the growth of fauna and flora. Raised concentrations of phosphate in surface waters can give rise to algae blooms which indirectly cause strong oxygen depletion. Phosphate-rich water can also lead to the strong development of slime in pipes. However, it also protects metal components from corrosion ("phosphatising"). Because of its very high charge density, phosphate molecules are absorbed very strongly in soils so that groundwater frequently only has low values. Iron oxides are particularly good sorbers. In groundwater, solubility is given an additional upward limit by the formation of the mineral calcium hydroxyl phosphate which restricts solubility to a maximum 5 mg/l. Phosphate concentration in groundwater ranges from 0.25 – 13.25 mg/l with averages of 1.95. The spatial distribution diagram (Fig.13) shows PO_4 concentration is higher in Esteran part of the study area.
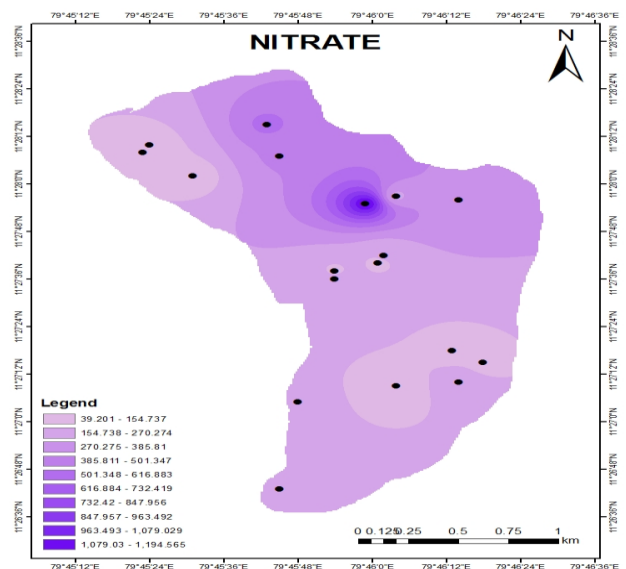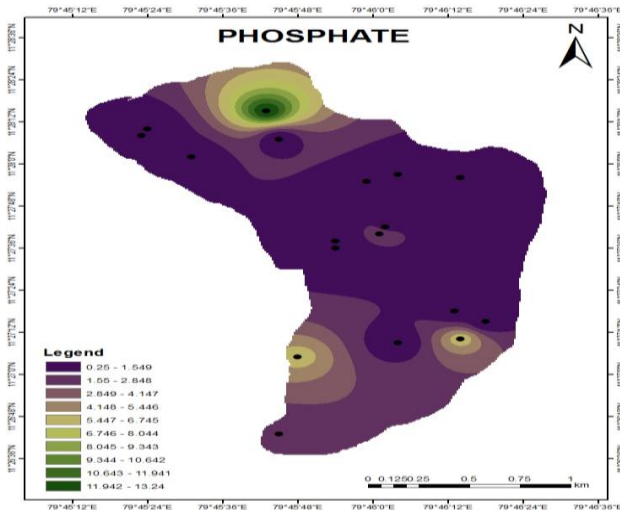

Figure 12: spatial distribution diagram for NO_3

Figure 13: spatial distribution diagram for PO₄

V. DISSOLVED SOLIDS

More than 500 mg/l is undesirable for drinking and many industrial uses. Less than 300 mg/l is desirable for dyeing of textiles and the manufacture of plastics, pulp paper, Rayon. Dissolved solids cause foaming in steam boilers; the maximum permissible content decreases with increases in operating pressure. Commonly contains less than 5000 mg/l some brines contains as much as 300,000 mg/l. The mineral constituents dissolved in water constitute the dissolved solids. TDS ranges from 685.61 – 2651.72 mg/l. The average The spatial distribution diagram (Fig 14) shows TDS concentration is higher in N and Eastern part of the study area. concentration in the region is 1607.26 mg/l. It shows that the area is generally free from pollution and major anthropogenic signatures.

A rapid determination of total dissolved solids can be made by measuring the electrical conductance of a groundwater. Conductance is preferred rather than its reciprocal, resistance, because it increases with salt content. Specific electrical conductance defines the conductance of a cubic centimeter of water at a standard temperature of 25°C; an increase of 1°C increases conductance by about 2 percent.
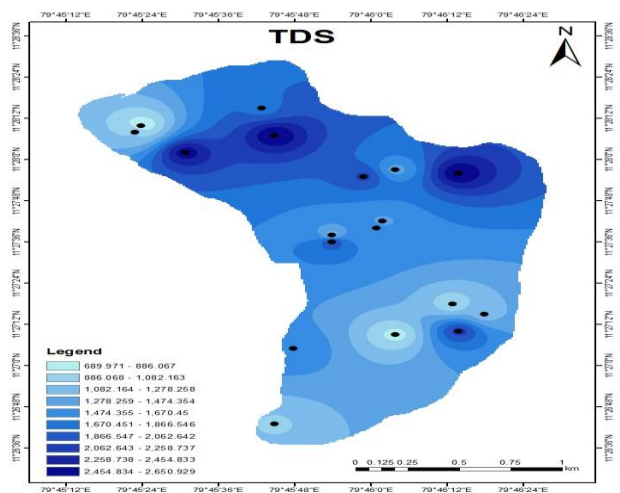

Figure 14: spatial distribution diagram for TDS

VI. CONCULSIONS

pH in the study area varies from 5.75 to 8.34 (Table 1). The pH average concentration in the region is 6.44. EC is the ability of a substance to conduct electric current. The measure of conductivity is directly proportional to the strength of the water. The EC for purest water is 0.05 $\mu s/cm^2$ (Hem, 1991). In the study area EC varies from $701\mu s/cm^2$ to 6600 $\mu s/cm^2$. On an average 2929 $\mu s/cm^2$ is observed in the region. The spatial distribution diagram pH and EC shows that (Fig 3 and 4) the higher concentration EC shows in NW and SE part of the study area. pH higher value absorbed in NW and Central part of the study area. The Chloride average concentration in the region is 812.03 mg/l. The spatial distribution diagram (Fig 5) shows Cl concentration is higher in Esteran part of the study area. Calcium ranges from 36 -156 mg/l. The average concentration in the region is 88.45 mg/l. The spatial distribution diagram (Fig 6) shows Ca concentration is higher in E and crntral part of the study area. Magnesium ranges from 7.2 to 113.8 mg/l. The average concentration in the region is 35.33 mg/l. The spatial distribution diagram (Fig 7) shows Mg concentration is higher in Eastern part of the study area. The sodium ranges from 10.5 – 83.7 mg/l. The average concentration in the region is 41.68 mg/l. The spatial distribution diagram (Fig 8) shows Na concentration is higher in central part of the study area. Potassium ranges from 6.7 – 82.7 mg/l. The average concentration in the region is 28.17 mg/l. The spatial distribution diagram (Fig 9) shows K concentration is higher in N and S part of the study area. Bicarbonate ranges from 195.2 – 567.3 mg/l. The average concentration in the region is 292.12 mg/l. The spatial distribution diagram (Fig 10) shows HCO_3 concentration is higher in NE, S and Central part of the study area. The Sulfate average concentration in the region is 16.81 mg/l. The spatial distribution diagram (Fig 11) shows SO_4 concentration is higher in NE, W and central part of the study area. Nitrate concentration ranges from 39.12 – 1194.82 mg/L with averages of 252.45. The spatial distribution diagram (Fig 12) shows NO_3 concentration is higher in central part of the study area. Phosphate concentration in groundwater ranges from 0.25 – 13.25 mg/l with averages of 1.95. The spatial distribution diagram (Fig. 13) shows PO_4 concentration is higher in Esteran part of the study area. Dissolved solids ranges from 685.61 – 2651.72 mg/l. The average The spatial distribution diagram (Fig 14) shows TDS concentration is higher in N and Eastern part of the study area.

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