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Urban Groundwater Quality Assessment: A Case Study Of Greater Visakhapatnam Municipal Corporation Area (Gvmc), Andhra Pradesh, India

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ABSTRACT: *Water is indispensable for the existence and survival of life on earth. Water is needed in almost every sphere of human activity. Groundwater pollution is one of the environmental problems in urban areas. The paper presents urban groundwater quality assessment of Greater Visakhapatnam Municipal Corporation (GVMC), Andhra Pradesh, India and analyzed for their physicochemical characteristics. The results of this analysis were compared with the water quality standards of WHO, BIS and CPHEEO. The water samples have been collected from 21 bore wells in GVMC area in Visakhapatnam city. In this analysis the various physicochemical parameters such as P^H, EC, Total Dissolved Solids, Total Hardness, Ca, Mg, Na, NO_3, K, Fe, Cl, SO_4, Cr, Cu, HCO_3 and Manganese were determined using standard procedures*.

Keywords: *Water quality, Groundwater Pollution, and Urban Areas.*

I. INTRODUCTION

Water is an essential resource for life on the earth we drink it, bathe it, relax in it, fish in it, keep cool with it, irrigate the plants, produce energy with it and also use it for transportation and recreation. Water pollution simply means contamination of water due to any external material or in other words, introduction of something to natural water which makes unsuitable for human consumption. There is no doubt that water pollution is the result of the human activity. The rapid growth of population, urbanization, industrialization and increasing use of chemicals have resulted in water pollution and this problem is increasing day by day in spite of several measures taken in this direction. This is not only a problem of developed countries and urban areas but has also become an uncontrollable problem of developing countries as well as several areas. There are some natural elements which create water pollution. These are gases, soil, minerals, humus materials, water created by animals and other living organisms present in water.

The present study is an attempt to analyses the urban groundwater quality assessment of Greater Visakhapatnam Municipal Corporation Area (GVMC). Numbers of research papers were published relating to groundwater quality analysis. India is the largest user of groundwater in the world. In our country, more than 60 percent of the irrigation requirements and 85 percent of drinking water supplies are dependent on groundwater (Harender Raj Gautam 2010). Every 8 seconds, a child dies from water related disease around the globe, 50percent of people in developing countries suffer from one or more water related disease and 80 percent of diseases in the developing countries are caused by contaminated water (Dr.Anumakonda Jagadeesh 2010). In the most part of our country ground water is a major source of drinking water, Groundwater in several parts of India is affected by arsenic and Fluoride pollution due to the geo-genic contamination and anthropogenic pollutions (CGWB, 2010). The rapid growth of urban areas has further affected the groundwater quality due to over exploitation of resources and improper waste disposal practices (G.Raja and P.Venkatesan 2010).

The groundwater in rural areas can be polluted as a result of farming activities and an important source of pollution of the groundwater with nitrate is the excessive use of nitrate fertilizers (Cornelia Muntean et..al 2006). Industrial water supply wells show significantly elevated concentrations of CHSs and to a lesser degree most inorganic parameters, when compared to agricultural or public water supply wells located outside the urban areas (M.M.Nazari et..al 1993). Saleem et al (2011) studied the groundwater quality monitoring strategies and database model developed for Gulbarg city. Groundwater quality in Jada and environs has been evaluated for their chemical

composition and suitability for human consumption and agricultural uses (J.M.Ishaku et al 2011). The physico-chemical quality of groundwater in Geidam of Nigeria has analysed by M.Hijab et al (2012). Physical and chemical parameters of groundwater such as electrical conductivity, P^H, total dissolved solids, Na, K, Ca, Mg, Cl, HCO_3,CO_3, SO_4, NO_3, NH_3, PO_4, Fe and F were determined by Nosrat Aghazadeh and Asghasi Mogaddam (2010).

II. STUDY AREA

Visakhapatnam, a port city on the east coast of India is located between 17°32'30"- 17°52'30"N Lat. and 83°04'30"- 83°24'30"E Long (Fig.1). The reconstituted Greater Visakhapatnam Municipal Corporation has an area of 515 Sq.Km with a population of more than 1.5 million. It is ranked as second largest urban agglomeration in Andhra Pradesh. The city receives an average annual rainfall of 950mm and the period from the middle of June to the first week of December is marked as rainy season. During the period between September and November, storms and depressions originating in the Bay of Bengal cross the east coast in the neighbor hood causing heavy rains and gales. As per Thornth waite's classification, Visakhapatnam and its environs come under the semi – arid (D) category. The topography of the city, with hills on three sides and sea on the fourth giving it much beauty, seems to increase the possibility of it falling a victim to pollution. Water supply has always been inadequate in this city with the crisis growing along with the cities progress. Today's water requirement is 360 million gallons per day. The existing Thatipudi, Gossthani, Meghadrigadda and Mudasarlova can hardly meet 50% of the need. Raiwada water scheme can add a little more, therefore the supply capacity needs to be augmented. In 2005 Govt.of Andhra Pradesh upgraded the Visakhapatnam Municipal Corporation to Greater Visakhapatnam Muncipal Corporation (GVMC) by merging within the Gajuwaka municipality and 32 grama panchayats. The total population of GVMC is now morethan 16,40,000 and there are 72 wards distributed in 6 zones. Visakhapatnam has been home for a number of large and medium industries such as the Hindustan Petroleum Corporation, Vishakapatnam Steel plant, Bharat Heavy Plates and Vessels, Hindustan Polymers and Coramandal Fertilizers.

III. OBJECTIVES

To assess the Groundwater Quality and Groundwater Pollution of the Greater Visakha Municipal Corporation Area (GVMC).

IV. METHODOLOGY

The water samples have been collected from 21 Bore Wells in Greater Visakha Municipal Corporation area in 2012. The total water sample locations covered by Industrial and Urban areas. In this present study, various physical and chemical parameters of water samples were determined and the results were compared with the values of various water quality standards such as World Health Organization (WHO), Bureau of Indian Standards (BIS) and Central Public Health and Environmental Engineering Organization (CPHEEO). The samples collected were analyzed for important physical and chemical parameters such as P^H, EC, Total Dissolved Solids, Total Hardness, Ca, Mg, Na, NO_3, K, Fe, Cl, SO_4, Cr, Cu, HCO_3 and Manganese were determined using standard procedures. All the chemical constituents are expressed in mg/L (milligrams/liter) except pH and EC.

V. RESULTS AND DISCUSSION

The results of the present study are shown in table-1, which provides a comprehensive picture of the chemical characteristics of the water samples under analysis. The pH values of groundwater ranged from 6.8 to 8.3 with an average value 7.61 and Standard deviation value 0.47. This shows that the groundwater of the study area is mainly alkaline in Nature. The value of EC varied from 390 µmS/cm to 2467 µmhos /cm with an average value of 1224 µmhos/cm and Standard Deviation value is 471.6(Fig.4). The maximum limit of EC in drinking water is prescribed as 1500µmhos /cm as per WHO (1993) standard. Marripalem, Anakapalli (NT), Maddilapalem, Old Gajuwaka , M.V.P.Colony were exceeding the permissible limit (Table 1&2). The TDS value ranged from 261.3 to 1520 with a mean of 852 mg/l (Fig.5). The BIS specifies a desirable total dissolved solids limit of 500mg/l and study area shows all samples were exceeding permissible limit as prescribed by BIS (1991) except B.S.Layout, Anakapalli School(S), are within the permissible limit(Table 1&2). Calcium (Ca) values ranged from 110 – 310 mg/l with an average value of 176 mg/l and S.D 53.2. The desirable limit of Calcium (Ca) for drinking water is specified by BIS (1991) as 75 mg/l and a maximum permissible limit of 200 mg/l. It is observed that Anakapalli all samples, Aganampudi, Old Gajuwaka, Peda Gantayada were exceeding maximum permissible limit. Magnesium (Mg)

concentration varies from 35 mg/l to 109 mg/l with mean values of 60 mg/l and S.D is 19(Fig.8). According to BIS (1991) the desirable values of Mg is 30 mg/l and a maximum permissible limit of 100 mg/l. All samples were exceeding maximum desirable limit. A total hardness value varies from 171 to 365 mg/l with a mean values 237 mg/l and S.D Value 49.8(Fig.6). The desirable limit of total hardness (TH) for drinking water is specified by BIS (1991) as 300 mg/land a maximum permissible limit of 600 mg/l. It is observed that Anakapalli all samples were exceeding maximum permissible limit except Anakapalli S & Anakapalli LP, remaining of samples are within the desirable limit. The Chloride (Cl) ion concentration varied between 106 to 321 mg/l with a mean values 194mg/l and S.D 59.64(Fig.9). Anakapalli 2, Anakapalli 8, Old Gajuwaka , Peda Gantyada, M.V.P Colony samples were exceeding desirable permissible limit prescribed by BIS (1991). Sodium and Potassium are present in a number of minerals. The increasing pollution of groundwater has resulted in a substantial increase in the sodium content of drinking water. Sodium (Na) and Potassium (K) values ranged from 33 to 245 mg/l and 9 to 69 mg/l with an average value of 85 mg/l and 27.8 mg/l , S.D values 29 & 17.7(Fig.12&11) respectively (Table.1&2). The Sulphate (SO^4) values of groundwater ranged from 50 to 167 mg/l with an average value 85.1 mg/l and S.D is 29 (Fig.14) this shows that Anakapalli 1,2,4,5, 8 were exceeding the maximum desirable limit prescribed by BIS (1991).

People can be exposed to chromium through breathing, eating or drinking and through skin contact with chromium or chromium compounds. The level of chromium in air and water is generally low. In drinking water the level of chromium is usually low as well, but contaminated well water may contain the dangerous chromium(IV); hexavalent chromium. For most people eating food that contains chromium (III) is the main route of chromium uptake, as chromium (III) occurs naturally in many vegetables, fruits, meats, yeasts and grains. Chromium (VI) is a danger to human health, mainly for people who work in the steel and textile industry. People who smoke tobacco also have a higher chance of exposure to chromium. The main human activities that increase the concentrations of chromium (III) are steal, leather and textile manufacturing.

The maximum concentration of Cr (VI) permitted in domestic water supplies is 0.05 mg/l. The Chromium (Cr) content of the samples water ranged from 0.02 to 0.21mg/l with an average value 0.1 mg/l and S.D is 0.07(Fig.17). Marripalem, N.A.D Junction, Anakapalli all areas, Kurmannapalem, R.T.C Complex, Maddilapalem, Kancharapalem, New Gajuwaka, Pedagantayada values exceeding the desirable limit (Table 1&2). Copper can be found in many kinds of food, in drinking water and in air. Because of that we absorb eminent quantities of copper each day by eating, drinking and breathing. The absorption of copper is necessary, because copper is a trace element that is essential for human health. Although humans can handle proportionally large concentrations of copper, too much copper can still cause eminent health problems People that live in houses that still have copper plumbing are exposed to higher levels of copper than most people, because copper is released into their drinking water through corrosion of pipes. In the working environment, copper contagion can lead to a flu-like condition known as metal fever. Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting and diarrhea. Intentionally high uptakes of copper may cause liver and kidney damage and even death. Whether copper is carcinogenic has not been determined yet. Since copper is both essential and potentially toxic element, there may be risks to living being if there is too little or too much of copper in the environment. Large doses of copper irritate stomach. The values range from 0.01 to 0.06 mg/l and mean value 0.033 and S.D value 0.015(Fig.18). Peda Gantyada, Anakapalli are exceeding the desirable limit. Iron can be found in meat, whole meal products, potatoes and vegetables. The human body absorbs iron in animal products faster than iron in plant products. Iron is an essential part of hemoglobin; the red coloring agent of the blood that transports oxygen through our bodies. Iron may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Inhalation of excessive concentrations of iron oxide may enhance the risk of lung cancer development in workers exposed to pulmonary carcinogens. Iron (III)-O-arsenite, pentahydrate may be hazardous to the environment; special attention should be given to plants, air and water.

Table 1. Physico-Chemical characteristics of groundwater samples of GVMC Area (Mg/L)

BORE WELL No	Name of Locations	P^H	EC µS/cm	TDS	TH	Ca	Mg	Na	No3	K	Fe	Cl	S04	Cr	Cu	HCo3	Mn
BW1	B.S.Layout	7.62	390	261.3	250	155	95	75	75	21	0.11	192	72	0.03	0.02	400	0.07
BW3	Murli nagar	8.2	1035	973	183	124	59	50	42	14	0.14	173	59	0.02	0.01	336	0.02
BW4	Marripalem	7.4	1520	963	210	167	43	62	43	24	0.14	135	92	0.08	0.03	367	0.09
BW5	NAD Junction	7.5	490	967	201	136	65	33	41	10	0.1	167	50	0.12	0.02	283	0.06
BW6	Anakapalli1(NT)	7.2	1790	1199.3	365	310	55	57	44	19	0.17	162	93	0.07	0.02	880	0.07
BW7	Anakapalli2(Ge.C)	7.17	1360	911.2	294	225	69	115	31	31	0.22	264	56	0.21	0.03	720	0.05
BW8	Anakapalli3(VR)	7.3	910	609.7	194	117	77	114	41	33	0.2	158	73	0.13	0.05	600	0.04
BW9	Anakapalli4(Th.P)	7	890	596.3	235	182	53	110	47	56	0.19	146	81	0.19	0.03	700	0.03
BW10	Anakapalli5(Scho)	7.3	740	495.8	193	110	83	120	77	60	0.25	160	92	0.17	0.03	600	0.08
BW11	Anakapalli6(ABSB)	7.12	860	576.2	253	180	73	99	29	54	0.5	150	109	0.13	0.02	840	0.06
BW12	Anakapalli7(LP)	7.4	810	542.7	257	200	57	93	58	39	0.8	106	99	0.08	0.04	740	0.07
BW13	Anakapalli8(Ag.P)	6.82	1310	877.7	306	260	46	124	35	28	0.15	260	78	0.09	0.06	700	0.04
BW14	Kurmannapalem	7.36	1370	917.9	239	130	109	245	54	69	0.42	200	130	0.14	0.05	1100	0.06
BW15	R.T.C Complex	7.9	1500	980.5	200	165	35	53	39	9	0.2	128	126	0.17	0.04	496	0.03
BW16	Maddilapalem	8.3	1700	890	229	185	41	58	36	16	0.33	230	78	0.18	0.01	341	0.02
BW17	Kancharapalem	7.5	1230	735	204	145	59	78	41	21	0.27	167	76	0.21	0.04	376	0.05
BW18	Akkayyapalem	8.1	1123	1073	174	126	49	49	36	13	0.13	159	58	0.02	0.05	326	0.03
BW19	Old Gajuwaka	8.2	2467	1520	299	241	58	61	33	17	0.1	321	167	0.03	0.02	329	0.09
BW20	New Gajuwaka	8.3	1300	767	171	124	47	78	44	18	0.11	225	50	0.1	0.03	367	0.1
BW21	PeddaGantyada	8.1	1390	1020	267	228	39	41	41	14	0.2	279	73	0.2	0.04	326	0.09
BW22	M.V.P Colony	8.1	1523	1016	245	196	49	73	39	18	0.2	293	76	0.03	0.06	325	0.04

Note: P^H, EC-Electrical conductivity, TDS- Total Dissolved solids, TH-total hardness, Ca- Calcium, Mg- Magnesium, Na- Sodium, No3- Nitrate, K- Potassium, Fe-iron, Cl- Chloride, S04-Sulphate, Cr-Chromium, Cu-Copper,HCo3-bicarbonate and Mn-Manganese

It is strongly advised not to let the chemical enter into the environment because it persists in the environment. Although it is abundant in earth's crust, it is absorbed in different forms at different rates. Iron deficiency is quite common among people throughout the world. Standard of iron in drinking water is 0.3mg/lt. Long term consumption of drinking water with high concentration of iron may lead to liver diseases. In the present study iron content varies between 0.1 to 0.8 mg/l and mean value is 0.2 mg/l, S.D is 0.16(Fig.15). Anakapalli (6), and Kurmannapalem (7) are exceeding the desirable limit (Fig.2).

Table.2 The minimum, maximum, average concentration and standard deviation of chemical parameters with water quality standard.

Chemical Parameters	Observed Concentration				Water Quality Standard		
	Min.	Max.	Mean	Std. Dev.	WHO	BIS	CPHEEO
P^H	6.82	8.3	7.61	0.47	6.5-8.5	6.5-8.5	6.5-9.2
Ec	390	2467	1224	471.9	--	--	--
TDS	261.3	1520	852	276.6	500	500	500
TH	171	365	237	49.8	300	300	300
Calcium	110	310	176	53.2	75	75	200
Magnesium	35	109	60	19	50	30	150
Sodium	33	245	85	29	100	100	100
Nitrate	29	77	44.1	12.59	45	45	45
Potassium	9	69	278	17.7	10	10	10
Iron (Fe)	0.1	0.8	0.235	0.166	0.3	0.3	0.3
Chloride	106	321	194	59.64	250	250	1000
Sulphate	50	167	85.1	29	200	200	400
Chromimu	0.02	0.21	0.11	0.07	0.05	0.05	0.05
Copper	0.01	0.06	0.033	0.015	0.O5	0.05	0.05
HCo3	283	1100	531	233	--	--	--
Manganese	0.02	0.1	0.06	0.02	0.1	0.1	0.1

Note: WHO- World Health Organization, BIS- Bureau of Indian Standards, CPHEEO- Central Public Health and Environmental Engineering Organization.

Manganese is a very common compound that can be found everywhere on earth. Manganese is one out of three toxic essential trace elements, which means that it is not only necessary for humans to survive, but it is also toxic when too high concentrations are present in a human body. When people do not live up to the recommended daily allowances their health will decrease. But when the uptake is too high health problems will also occur. Manganese effects occur mainly in the respiratory tract and in the brains. Symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. Manganese compounds exist naturally in the environment as solids in the soils and small particles in the water. Manganese that derives from human sources can also enter surface water, groundwater and sewage water. It is one of the most important trace elements essential for organisms. Shortage of Mn causes fatness, Glucose intolerance. Manganese effects occur mainly in the respiratory tract and in the brains. Manganese can also cause Parkinson and lung embolism. Chronic Manganese poisoning may result from prolonged inhalation of dust and fume. The central nervous system is the chief site of damage from the disease, which may result in permanent disability. Symptoms include languor, sleepiness, weakness, emotional disturbances, recurring leg cramps, and paralysis. Mn is found to vary between 0.02 to 0.1 mg/l and mean value 0.06 and S.D value 0.02 (Fig.9).

VI. CONCLUSION

Groundwater pollution is one of the environmental problems in urban areas, resulting out of improved living standards, growing population and interference with natural eco-system. In this study, the most of the major ions of the water samples from industrial area have been found in excess of BIS, WHO and CPHEEO recommended guide line values due to impact of industrial effluents. The water quality of the various areas in GVMC clearly

indicates that the water samples are highly polluted. It is observed that the water taken from Old Gajuwaka, Pedagantyada, Akkayyapalem set polluted followed by Port area. These areas situated nearer to the Steel Plant, BHPL, Fertilizers industries. So, the proper environment management plan may be adopted to control the release of effluent. But most of the chemical parameters of water samples were found bore well within the limit and groundwater is suitable drinking purpose. It is suggested that regular monitoring of groundwater quality is required to assess pollution activity from time to time for taking for necessary measures to mitigate the intensity of pollution activity. There must be strict implementation of environmental laws to maintain groundwater quality. There is an urgent need to educate people and bring awareness about the causes, affects and prevention of groundwater pollution and also the consequences of impacts of pollution on human health.

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FIGURES:

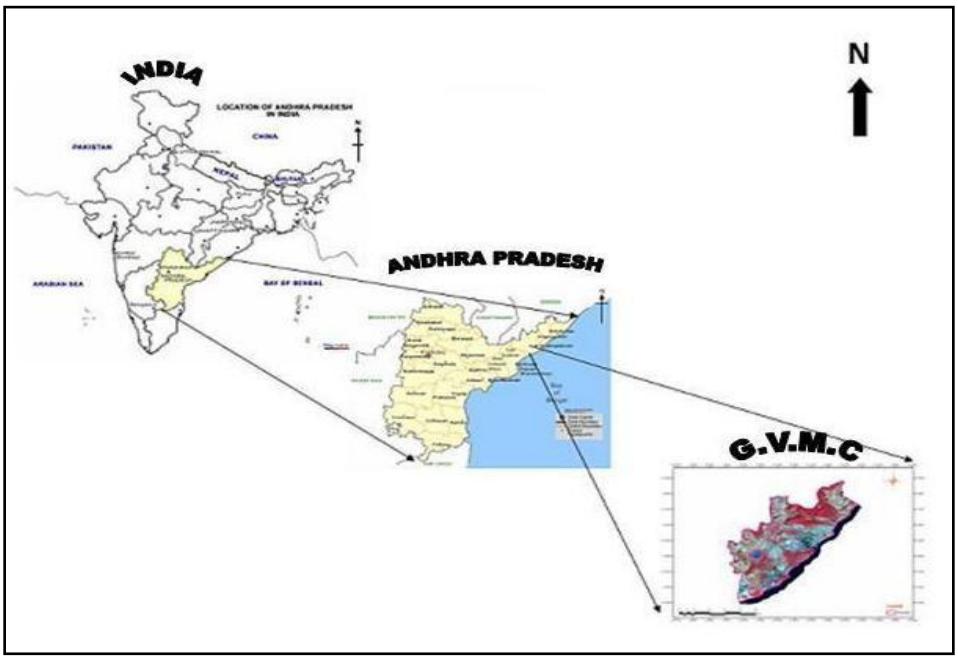

Fig.1: Location map of the study area

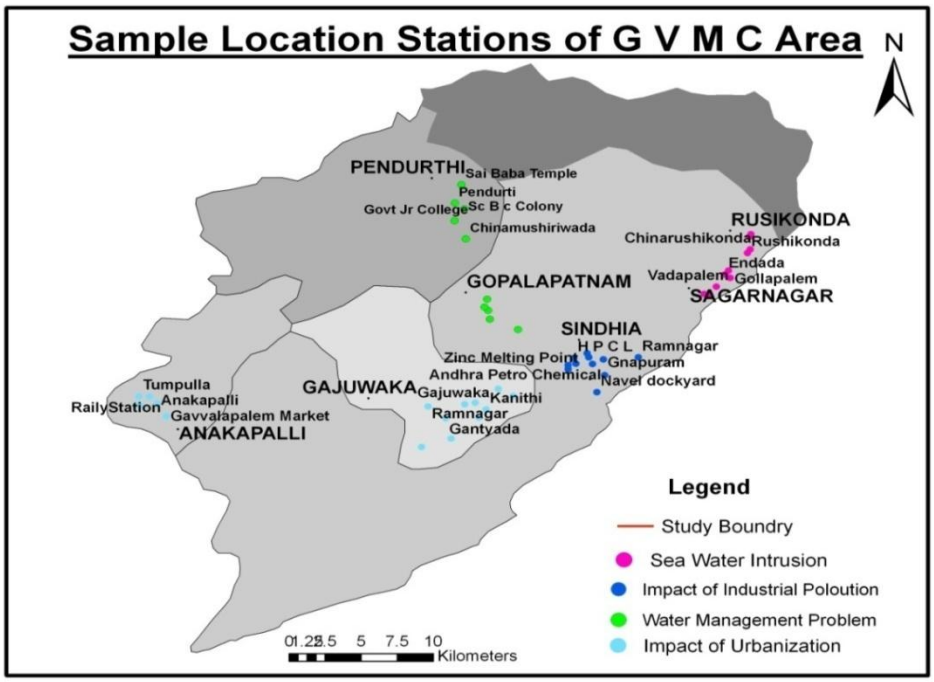

Fig.2: Groundwater Sample Locations in GVMC Area

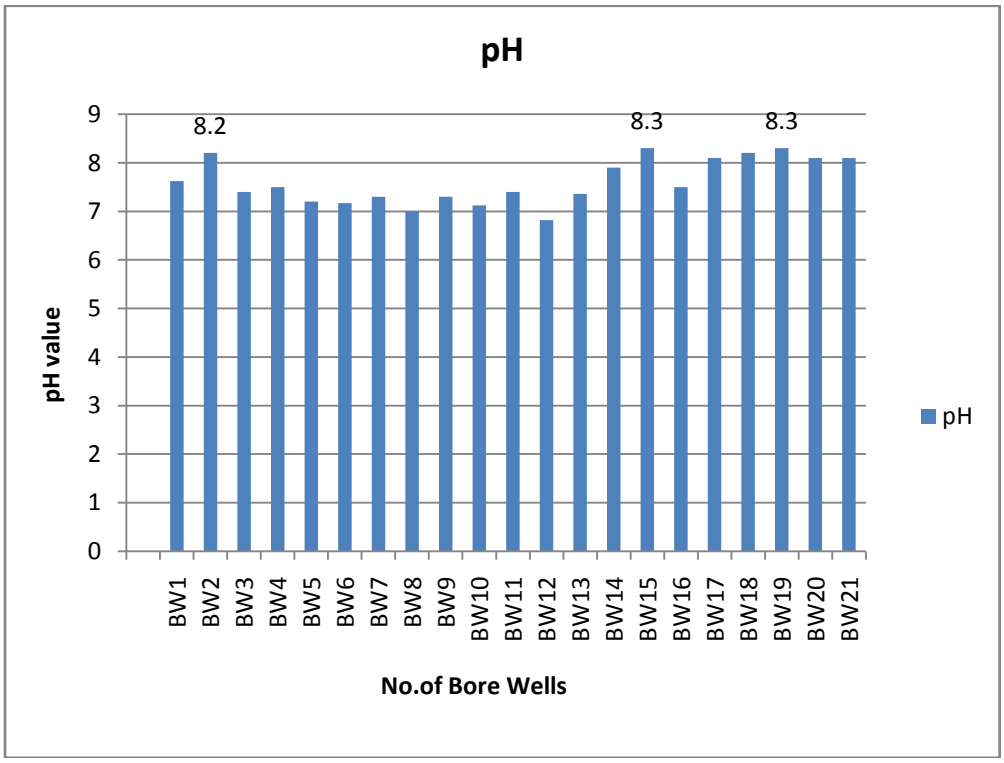

Fig 3. The values of pH of water samples

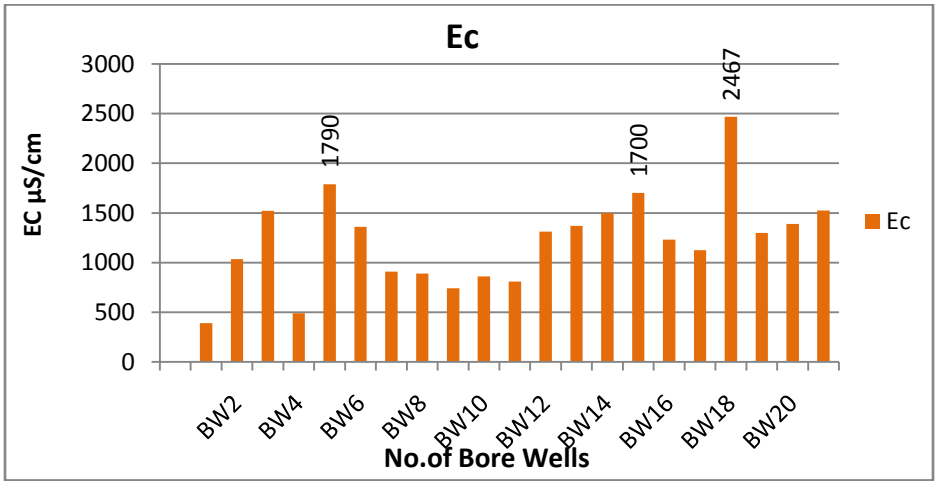

Fig 4. The values of Conductivity of water samples

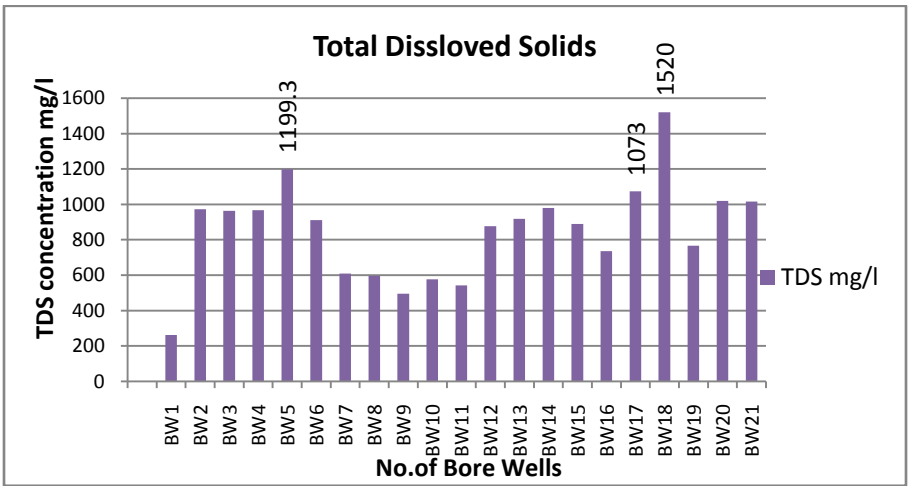

Fig 5. The Concentrations TDS in the water samples

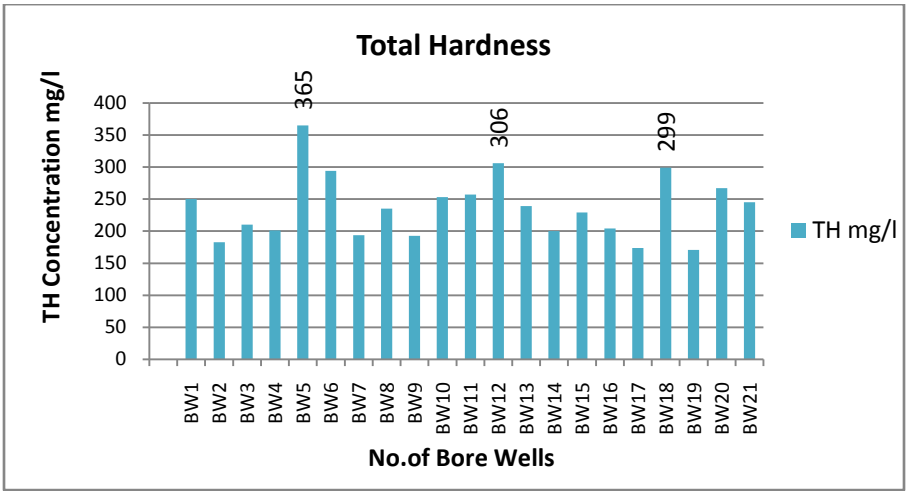

Fig 6. The Concentrations total hardness ions in the water samples

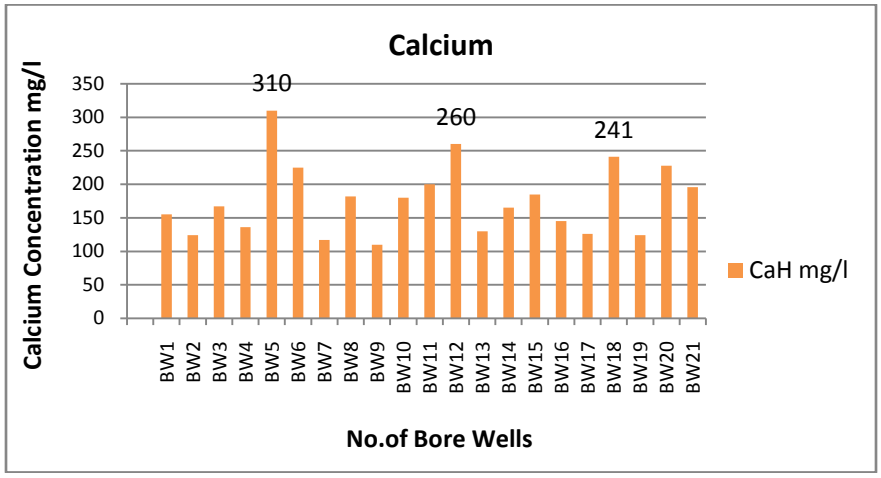

Fig7. The Concentrations of calcium ions in the water samples

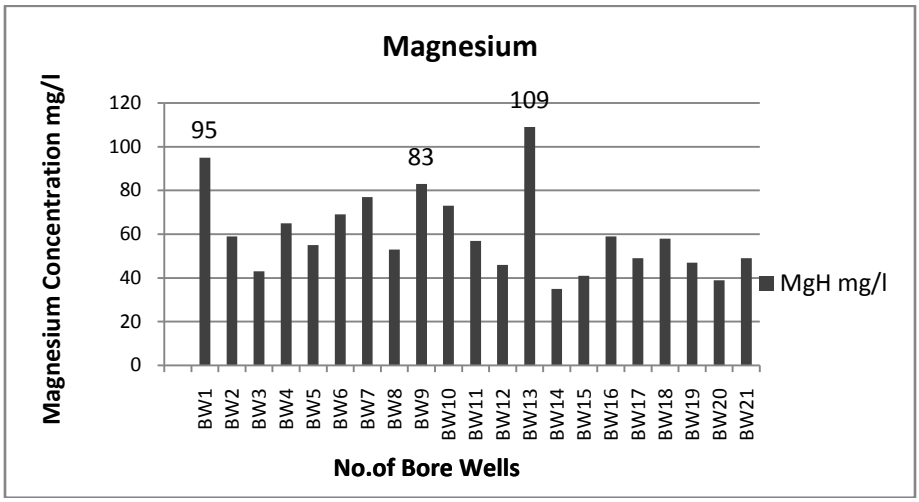

Fig 8. The Concentrations of magnesium ions in the water samples

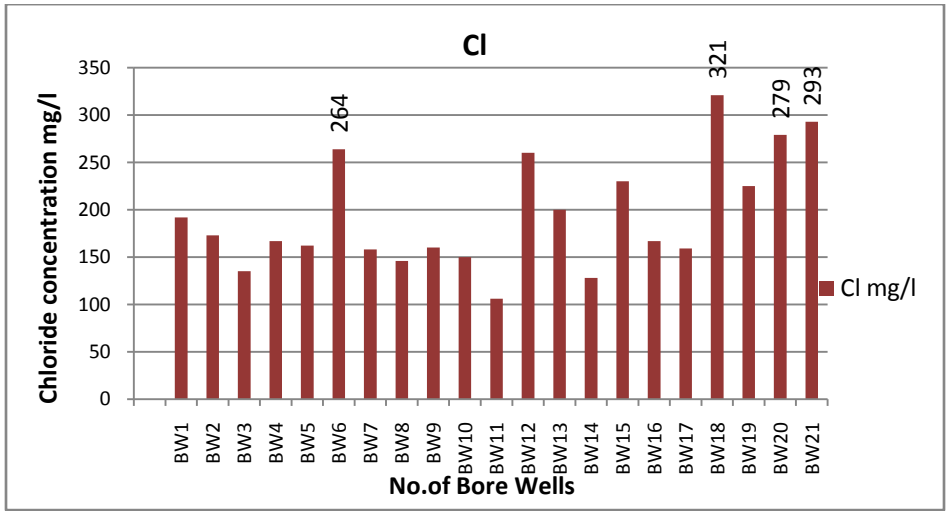

Fig 9. The Concentrations of Chloride ions in the water samples

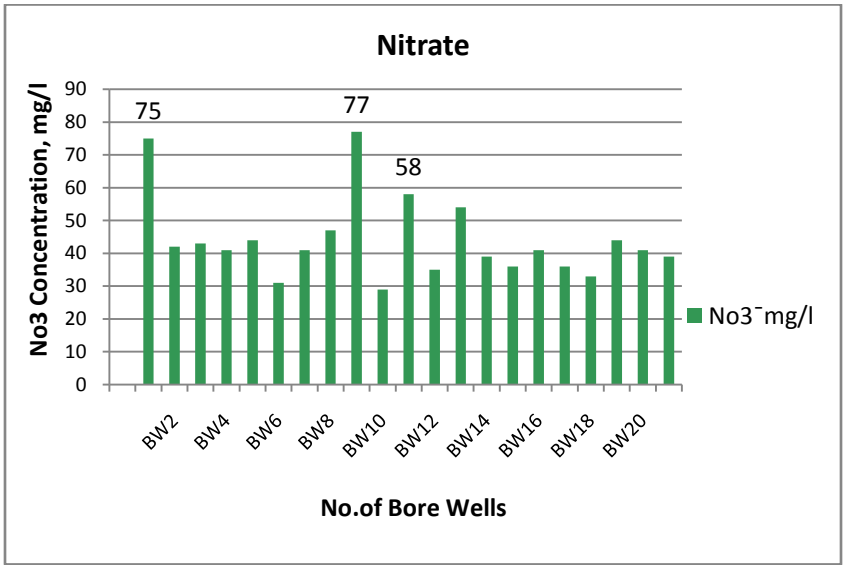

Fig 10. The Concentrations of Nitrate ions in the water samples

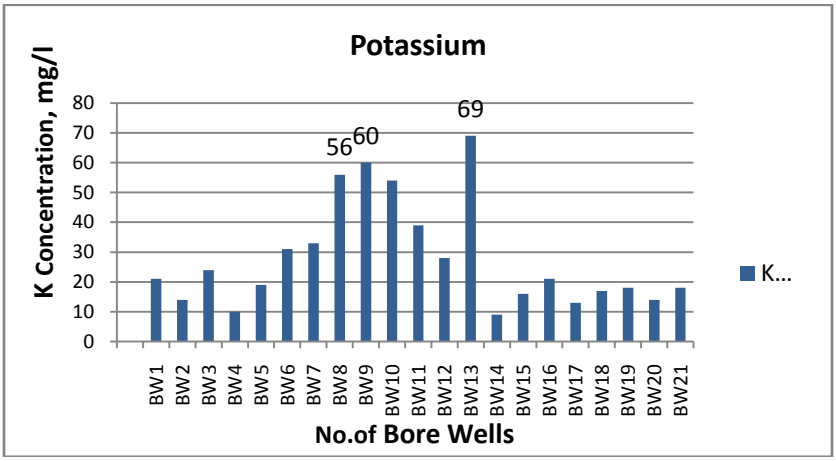

Fig 11. The Concentrations of Potassium ions in the water samples

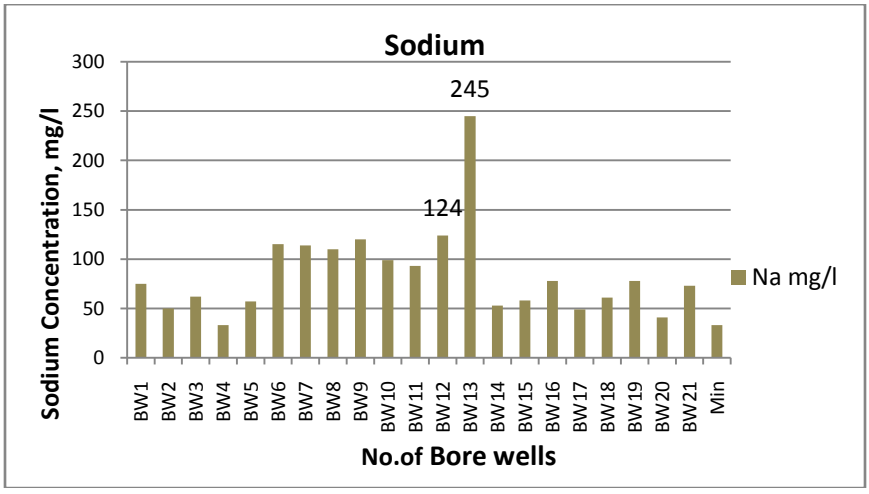

Fig 12. The Concentrations of Sodium ions in the water samples

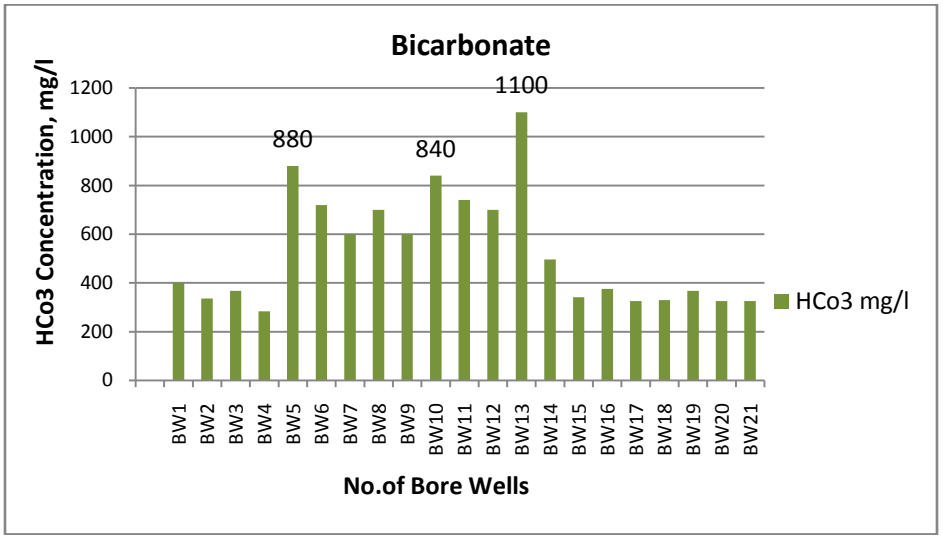

Fig 13. The Concentrations bicarbonate ions in the water samples

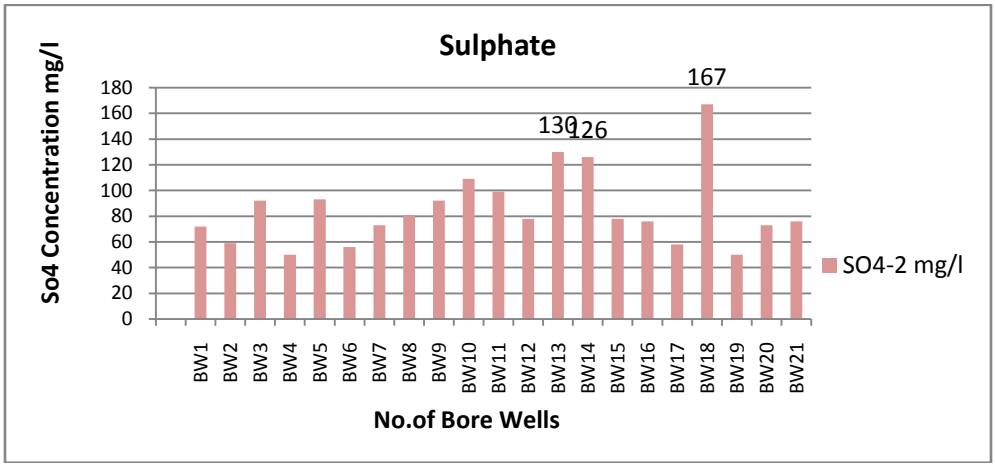

Fig 14. The Concentrations Sulphate ions in the water samples

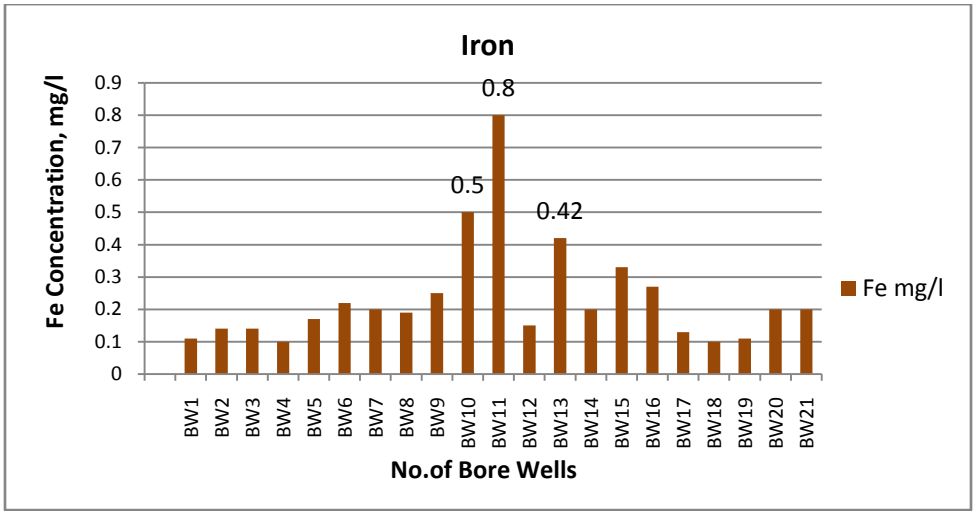

Fig 15. The Concentrations Iron ions in the water samples

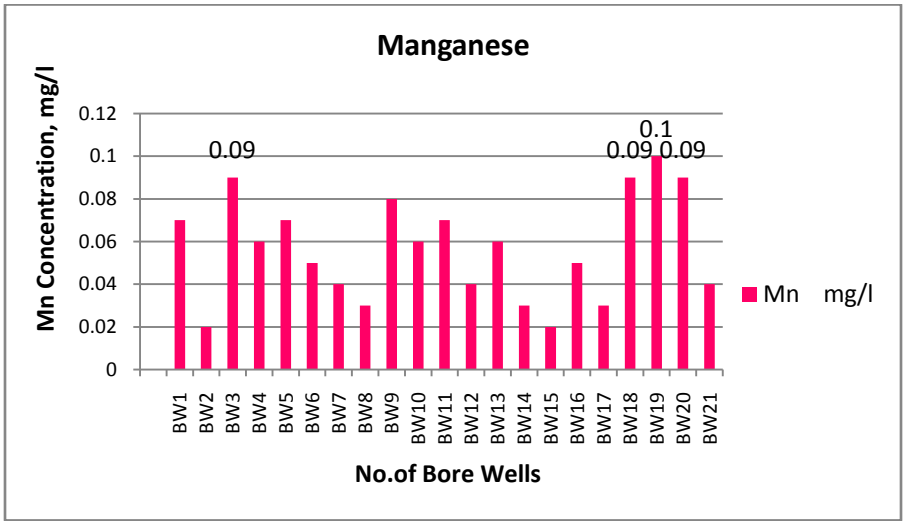

Fig 16. The Concentrations Manganese ions in the water samples

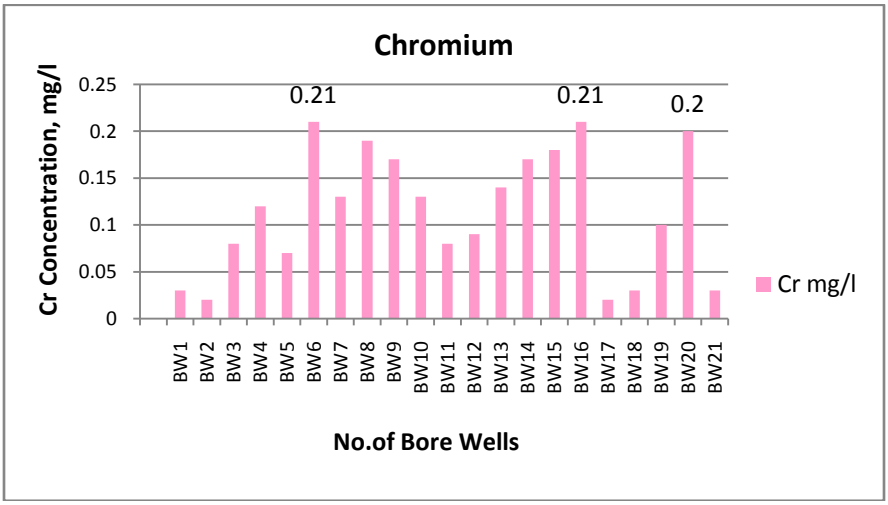

Fig 17. The Concentrations Chromium ions in the water samples

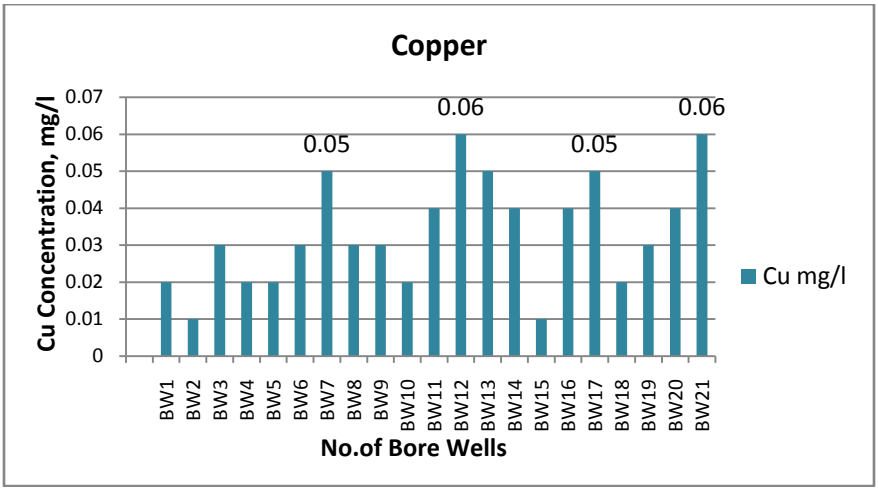

Fig 18. The Concentrations Copper ions in the water samples