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Geospatial Study on Characterization of Groundwater in Bheemunipatnam Municipality, Visakhapatnam District, Andhra Pradesh, India

Mohammed Hussen Yessuf
Lecturer(Head of the Department),
Department of Civil Engineering, College of Engineering and Technology,
Samara University, Samara, Afar, Ethiopia,

***Abstract* :- Water is a renewable natural resource which is an important constituent in human life. Surface water in almost all countries is getting highly polluted. To determine the quality of water physical and chemical parameters of water samples were determined and the results were compared with the values of WHO and IBS water quality standards. To determine groundwater configuration electrical resistivity techniques were applied to measure earth resistivity by passing an electrical current in to the ground and measuring the resulting potential created on the earth.**

Keywords :- Physical, chemical, parameter, resistivity, water quality

INTRODUCTION

The earth often called as watering planet. Despite abundant amount of water, the usable quantity of water is very meager. Thus water scarcity and rationing became a common problem in almost all major cities in this world. Owing to population rise, and other activities, there is a load on water resources which completing to extract excess groundwater leading to groundwater mining. Surface water in almost all countries is getting highly polluted. Improper use of surface water bodies and letting polluted liquid effluents from different sources are the major casual agents for pollution surface and ground water.

Water has a variety of essential uses for living things on the earth ,we human being uses water for drinking purpose, cleaning ,cooling, irrigating farms, producing energy as means of transportation , entertainment and electric power. Water can be polluted due to any external material introduced in to natural water source which makes unsuitable for different activities for human daily 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. 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 (Satyanarayana et al.2013).

India is the largest user of groundwater in the world and 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, 50 percent 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 (Anumakonda Jagadeesh 2010).

In most part of India 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 (Raja and Venkatesan, 2010.

Aim

The aim of the study is to characterize groundwater scenario in Bheemunipatnam Municipality, Visakhapatnam District, Andhra Pradesh, India.

Objectives

1. To study general physio-chemical quality of selected 20 dug wells.
2. To study geology for identification of rock types and its structure.
3. To determine groundwater configuration

STUDY AREA

Bheemunipatnam is located at 17.8866N latitude and of 83.4472E longitude occupies an area of 14km^2 with average elevation of 51 meters (170 feet). The study area is characterized by hills, plains and coastal plains. According to 2011 census, the study area has 52,110 Population with a density of 3722 persons per sq.km.

Demography

Bheemunipatnam mandal is one of the 43 mandals in Visakhapatnam district of the state of Andhra Pradesh, India. It is administered under Visakhapatnam revenue division and its headquarter is located at Bheemunipatnam. The mandal is bounded by Padmanabham, Anandapuram, Visakhapatnam mandals of Visakhapatnam district and of Bhoghapuram mandal of Vizianagaram district.

The Gosthani River joins the Bay of Bengal at Bhimli and Bheemunipatnam beach is one of the most exquisite tourist locations in Andhra Pradesh. It offers a calm and serene atmosphere for them and also ensures full-fledged entertainment for the visitors.

River Gosthani lies in the Bheemunipatnam Beach region. It is a medium sized east flowing river that originates on the Ananthagiri Hills of the Eastern Ghats. At the place of its origin the Borra Caves are located. The river meets the sea (Bay of Bengal) at Bheemanipatnam on the way to Bheemunipatnam Beach. The town on its banks is filled with numerous pilgrim centers, old churches and temples which offer a soothing sight for the visitors at Bheemunipatnam Beach. The clock tower, light house and the port adds to the charm of the place.

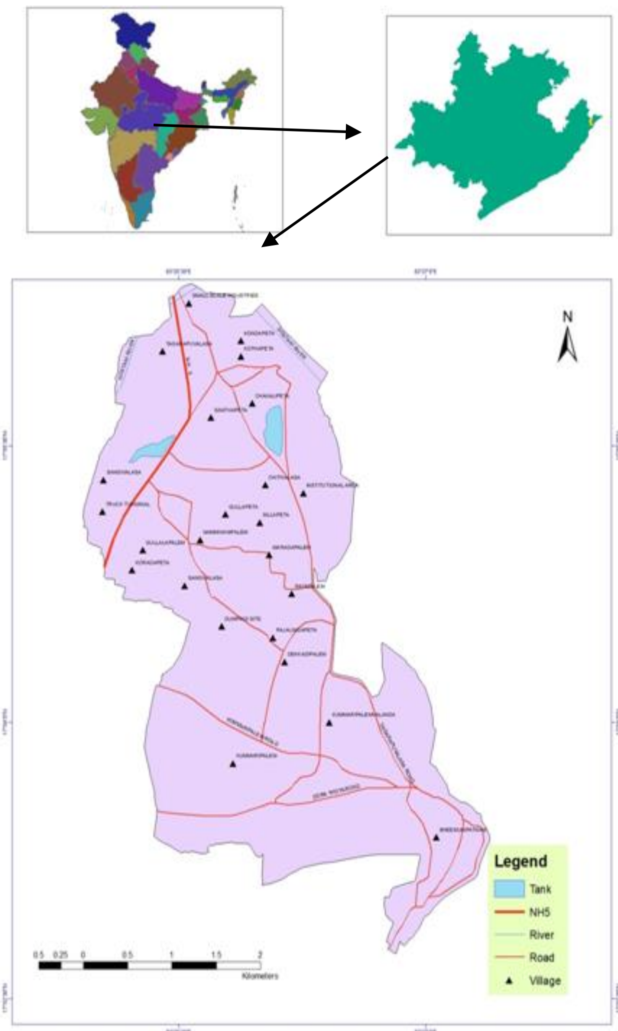

Fig. 1 Map of the study area

HYDROLOGY

Hydrology is the study of inter-relationships and interactions between water and its environment in the hydrological cycle. Water is central to human existence and life in general. Unless trapped as groundwater within closed basins, water is constantly in motion. It may be detained in glacial ice, underground, or in lakes or reservoirs; but eventually it flows and melts, seeps, or evaporates. This movement of water is continuous, but irregular in space and time. Because of this, even areas that are typically well supplied can experience droughts or floods at various times (Satterlund and Adams 1992).

Hydrological data is essential to assess quality and quantities of ground water.

The main objective of hydrological and climatic is to extract reliable data for updating ground water evaluation requirements design of pollution protection works from recharge and design of optimum ground water with draw.

CLIMATE

Bheemili is Poor man's OOTY. When Vizag City Temperatures are maintained at 44 degrees, bheemili recorded only 34 degrees in summers.

METHODOLOGY

The study area toposheet, satellite imagery and Bheemunipatnam municipal boundary map are geometrically rectified and corrected in Erdas Imagin 2014.Those thematic maps consequently digitized in ArcGIS 10.2.2 on Arc Map environment. The following thematic maps were prepared from the remote sensing data, survey of India toposheet maps and other collected datas.

- Base Map
- Drainage
- Geology/Lithology
- Geological Structure/Lineaments
- Geomorphology/Landforms
- Land Use/ Land Cover
- Slope
- Aspect
- Well inventory
- VES location map
- Groundwater physio-chemical parameters distribution pattern map

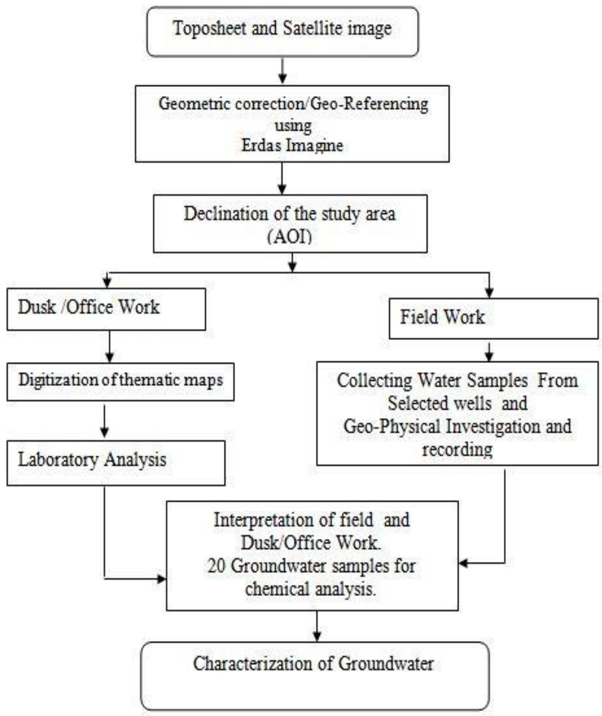

Chart. 1 Methodology

Groundwater Quality Assessment

Groundwater samples have been collected from 20 bore wells in Bheemunipatnam Municipality on 30/01/ 2016.Water samples covered in hill, plains and coastal areas of the study area. 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). The samples collected were analyzed for important physical and chemical parameters such as P^H, EC, TDS, TH, Ca, Mg, Na, NO_3, K, Fe, Cl, SO_4, F, HCO_3 and Turbidity and alkalinity were determined using standard procedures. All the chemical constituents are expressed in mg/l (milligrams/liter) except EC (which is µs/cm).The quality analysis were carried out Andhra Pradesh Groundwater department.

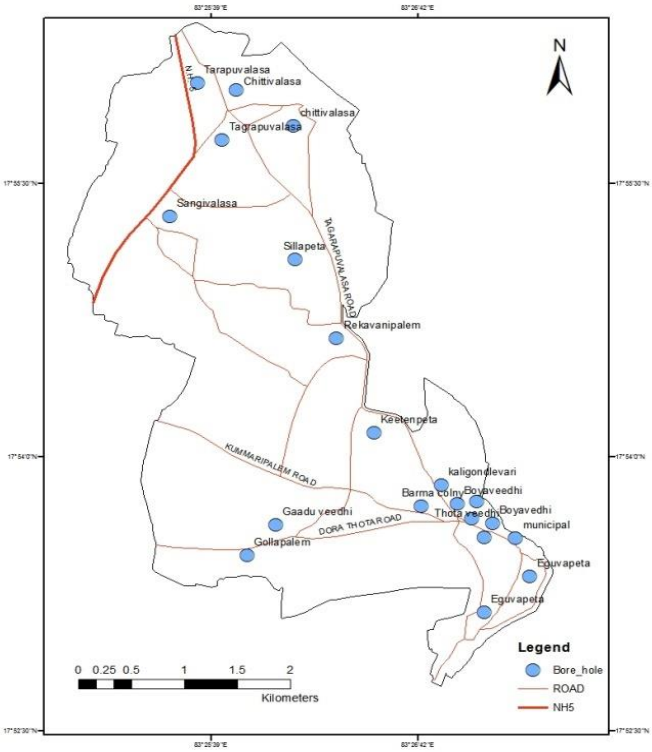

Fig. 2 Well location map

The physical features of odor, taste, color measured using standard laboratory procedures. Similarly, cations such as Ca, Mg, Na, K and anions of CO3,HCO3,F,Cl, are measured in laboratory following standard procedure in Andhra Pradesh Department, visakhapatnam.

NO	Locations	Turbidity	E.C	TDS	P^H	Alkalini	TH	Ca	Cl	F	NO_3	Fe	CO_3 as	HCO_3 as $CaCO_3$	SO_4	Na	K	Mg
BW1	Sangivalasa	1.8	1768	1258	7.64	388	488	78	24	1	28.8	0.18	40.00	200.00	95	136.6	36.2	21.60
BW2	Tagrapuvalasa	2.2	1995	1397	7.52	392	480	76	280	1	41.6	0.12	60.00	340.00	100	237.2	12	39.60
BW3	Tagrapulasa	3.2	1715	1200	7.68	408	320	52	210	1.1	31.8	0.18	60.00	340.00	90	175.2	24.6	21.60
BW4	Chittivalasa	1.6	2760	1932	7.71	492	420	80	400	1	68.8	0.11	60.00	340.00	125	206	7.2	21.60
BW5	Sillapeta	2.4	1996	1397	7.78	396	420	72	310	1.2	33.2	0.14	60.00	200.00	152	121.7	21.9	36.00
BW6	Kattenpeta	1.8	1515	1061	7.72	288	320	52	170	0.8	18.8	0.12	60.00	240.00	87	206.4	49	39.60
BW7	Boyavedhi	2.2	1356	949	7.44	208	340	56	110	0.6	16.6	0.16	40.00	160.00	57	42.16	9.64	18.00
BW8	BarmaColony	3.2	1016	711	7.28	188	330	52	110	0.6	20.2	0.22	20.00	160.00	49	55.28	22.22	25.20
BW9	Boyavedhi	2.8	1008	705	7.32	172	320	50	130	0.7	16.1	0.16	40.00	220.00	77	189.8	38.3	21.60
BW10	Thotaveedhi	2.8	986	690	7.44	168	270	48	120	0.7	17.3	0.15	40.00	540.00	51	25.96	17.7	28.80
BW11	Gaadu Vedhi	1.8	836	585	7.16	112	220	45	100	0.6	14.4	0.13	20.00	120.00	30	41.58	2.58	32.40
BW12	Gollapalem	2.4	913	639	7.28	172	320	50	80	0.8	24.3	0.14	40.00	160.00	35	26.58	0.64	36.00
BW13	Eguvapeta	3.2	424	297	7.11	68	80	16	50	0.6	4.2	0.16	0.00	80.00	17	25.75	6.26	25.20
BW14	Eguvapeta	1.6	875	612	7.23	208	150	24	110	0.6	18.8	0.11	20.00	200.00	40	35.66	4.96	10.80
BW15	Chittivalasa	2.8	2490	1743	7.64	308	590	110	440	0.6	41.6	0.16	40.00	240.00	140	171.4	13	75.60
BW16	Sillapeta	3.1	1762	1233	7.48	372	420	78	260	1.5	38.8	0.22	80.00	440.00	82	186.2	73.1	50.40
BW17	B. Colony	2.6	1352	946	7.52	176	380	67	160	0.8	16.2	0.16	60.00	280.00	71	117	23.8	32.40
BW18	Municipal	3.2	1469	1029	7.68	168	290	50	170	0.6	22.3	0.22	40.00	260.00	68	178.7	71.4	39.60
BW19	Eguvapeta	2.2	688	482	7.32	88	210	42	80	0.6	11.2	0.12	40.00	140.00	32	40.84	10.5	36.00
BW20	Eguvapeta	3.3	722	505	7.29	112	230	45	90	0.4	13.1	0.11	40.00	120.00	50	83.7	19.5	43.20

Table: 1 Groundwater quality assessment laboratory report

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Chemical Paramete	Observed Concentration				Water Quality Standards	
	Min.	max.	Mean	Std. Dev.	WHO	BIS
PH	7.11	7.78	7.46	0.205	6.5-8.5	6.5-8.5
EC	424	2760	1382.3	622.017	800	
TDS	297	1932	968	436.152		500-2000
Ca CO_3	0	80	43	18.666	--	---
HCO_3	80	540	239	114.887	--	--
Cl	24	440	170.2	113.651	250	250
SO_4	17	152	72.4	37.201	200	200
NO_3	4.2	68.8	24.905	14.616	45	45
F	0.4	1.5	0.79	0.267	2	1-1.5
Na	25.8	237	115.18	74.111	100	100
K	0.64	73.1	23.22	20.912	10	10
Ca	16	110	57.15	21.142	75	75
Mg	10.6	75.6	32.76	14.059	50	30-100
TH	80	590	329.9	121.171		300-600
Fe	0.11	0.22	0.15	0.036		1
Alkali nity	68	492	244.2	125.445		200
Turbi dity	1.6	3.3	2.51	0.59		5

Table: 2 The Minimum, Maximum, Mean concentration and Standard Deviation of chemical parameters with water quality standard.

Comparison of physicochemical water quality of municipal groundwater samples with WHO - World Health Organization and BIS- Bureau of Indian Standards. Below this the laboratory result of physio-chemical parametrs groundwater distribution pattern map described . **Turbidity** the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. Turbidity observations in the study area varied from 1.6 to 3.3 mg/bl with mean values of 2.51 mg/bl and S.D value 0.59. No water samples exceeding from the standard limit specified by BIS (Table 3.6). **Electrical Conductivity (E.C)** conductivity is a measure of ability of water samples to conduct an electric current proportional to the ionic strength of the water. This mostly depends on nature of various dissolved ionize substances, their actual relative concentrations and temperature. Conductivity of water is mainly attributed by the presence of Total Dissolved Solids (TDS) contained in it (APHA, 1995).The study area E.C value varied from 424 to 2760 µs/cm with mean values of 1382.3 µs/cm and S.D value 622.017. According to WHO the desirable values of Electrical conductivity is 800 µs/cm, all observations are exceed from the standard limit except BW13,BW19,BW20, all at Eguvapeta. Conductivity is in water affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate ions (that carry a positive charge). **Total Dissolved Solids** the major natural sources are mineral constituents dissolved in water constitute the dissolved solids. Concentrations in natural water commonly contains less than 5,000 mg/l; some brines contain as much as 300,000 mg/l. Effect on usability of water 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, and rayon. Dissolved solids cause foaming in steam boilers; the maximum permissible content decreases with increases in operating pressure. The total solids in a liquid sample consist of total dissolved solids and total suspended solids. The total dissolved solids indicate the general nature of salinity of water, which ranged from 297 to 1932 mg/l with a mean value of 968 mg/l. In the present study, very low concentration of TDS values of 297 mg/l were observed at Eguvapeta (BW13) locations which are nearby hilly area. The BIS specifies a desirable total dissolved solids limit of 500 -(2000 with no relaxation) mg/l and study area shows all samples are in prescribed limit except (BW13),

pH is an important parameter for determining the quality of water in an aquatic environment and used to express the intensity of acid or alkaline condition of a solution. Low pH causes gastro-intestinal disorders like hyper acidity, ulcers, stomach pain, burning sensation, etc. (de Zwart and Trivedy, 1994). The climatological and vegetation factors also influence the pH of the system. The study area pH values of groundwater ranged from 7.11 to 7.78 with an average value 7.46 and Standard deviation value 0.205. This shows that the PH value of groundwater in the study area is in permissible limit.

Alkalinity is a chemical measurement of a water's ability to neutralize acids and also a measure of a water's buffering capacity or its ability to resist changes in pH upon the addition of acids or bases. Alkalinity of natural waters is due primarily to the presence of weak acid salts although strong bases may also contribute (i.e. OH^-) in extreme environments. Alkalinity in the study area varied from 68 to 492 mg/l with mean values of 244.2 mg/l and S.D value 125.445. According to the standard limit specified by BIS values from 200 to 600 (Table 3.6) No observations exceed from the standard limit.

Total Hardness Total hardness of water is the sum of concentrations of alkaline earth metals present in it. In fresh water, these are attributed principally by calcium and magnesium, although other metals such as iron, strontium and manganese can also impact hardness when present in appreciable concentrations. Hardness has no known adverse effects on health. Cardiovascular diseases are reported to be confined more to the areas of soft water then to those having hard water (Crawford, 1972). Total Hardness (TH) in general defined as the calcium carbonate equivalent of calcium and magnesium ions expressed in ppm or mg/l. The hardness of water reflects the composition of the geological formation with which it has been in contact. The study area total hardness value varied from 80 to 590 mg/l with a mean values 329.29 mg/l and S.D Value 121.171. The desirable limit of total hardness (TH) for drinking water is specified by BIS as 300 mg/l and a maximum permissible limit of 600 mg/l.No samples exceed from the standard limit.

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Calcium (Ca) the major natural sources are amphiboles, feldspars, gypsum, pyroxenes, aragonite, calcite, dolomite, clay minerals. Concentration in natural water generally less than 100 mg/l; brines may contain as much as 75,000 mg/1. Effect on usability of water, Calcium and magnesium combine with bicarbonate, carbonate, sulfate, and silica to form a heat-retarding, pipe-clogging scale in boilers and in other heat exchange equipment. Calcium compound in water are responsible for hardness of water. Groundwater contains these ions mainly from the dissolution of salts present in bed rocks and top soils (Drever, 1982). Calcium values ranges from 16 to 110 mg/l with an average value of 57.15 mg/l and S.D 21.142 mg/l. The desirable limit of Calcium for drinking water is specified by BIS as 75 mg/l and a maximum permissible limit of 200 mg/l. It is observed that Bw1, Bw2, Bw4, Bw15 and Bw16 are within permissible limit whereas the remaining samples are blow the standard limit.

Chloride (Cl) the major natural sources are chief source is sedimentary rock (evaporates), minor sources are igneous rocks. Concentrations in natural water commonly less than 10 mg/l in humid regions but up to 1,000 mg/l in more arid regions. About 19,300 mg/l in seawater, as much as 200,000 mg/l in brines. Effects on usability of water 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. The Chloride ion concentration varied between 24 and 440 mg/l with a mean values of 170.2 mg/l and standard deviation value is 113.651 mg/l. Very high concentration are observed, 280 mg/lb (BW2) at Tagrapuvalasa, 400 mg/l (BW4) at Chittivalasa , 310 mg/l (BW5) at Sillapeta, 440 mg/l (BW15) at Chittivalasa, 260 mg/l (BW16) at Sillapeta samples were exceeds permissible limits as prescribed by BIS. A very low concentration is observed 24 mg/l (BW1) at Sangivalasa.

Fluoride (F) the major natural sources are amphiboles (hornblende), apatite, fluorite, mica. Concentrations in natural water generally do not exceed l0 mg/l. Concentrations may be as much as 1,600 mg/l in brines. Effects on usability of water, fluoride concentration between 0.6 and 1.7 mg/l in drinking water has a beneficial effect on the structure and resistance to decay of children's teeth. Fluoride in excess of l.5 mg/l in some areas causes "mottled enamel" in children's teeth. Fluoride in excess of 6.0 mg/l causes pronounced mottling and disfiguration of teeth. The Fluoride concentration varied between 0.4 to 1.5 mg/l with a mean values 0.79 mg/l and standard deviation (S.D) value 0.267 mg/l.No samples were exceed the permissible limit except (BW16) 1.5mg/lb , at Sillapeta is max. limit. This might be due to the fact that the residents damp rubbish materials on sewer lines leading to blockade and forming stagnant water. **Nitrate (NO3)** the major natural sources atmosphere, legumes, plant debris, animal excrement. Concentrations in natural water commonly less than 10 mg/l. Effects on usability of water ;Water containing large amounts of nitrate (more than 100 mg/l) is bitter tasting and may cause physiological distress. Water from shallow wells containing more than 45 mg/l has been reported to cause methemoglobinemia in infants. Small amounts of nitrate help reduce cracking of high-pressure boiler steel. The Nitrate (NO_3) concentration varies between 4.2 to 68.8 mg/l with a mean values 24.905 mg/l and Standard deviation value, at 14.616 mg/l. Nitrate concentration only one sample are exceeding the permissible limits that is Chittivalasa (BW4). It might be cultivation around the well and might have using nitrate fertilizers for farming activity.

Sulphate(SO_4) Major natural sources, Oxidation of sulfide ores; gypsum; anhydrite. Concentration in natural water commonly less than 300 mg/l except in wells influenced by acid mine drainage. As much as 200,000 mg/I in some brines. Effect on usability of water 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 1,000 mg/l may be cathartic. Content in groundwater is made possible through oxidation, precipitation, solution and concentration, as the water traverses through rocks (Karanth 1987). The Sulphate values of groundwater are between 17 to 152 mg/l with an average value of 72.4mg/l and S.D is 37.201 (Table 3.6) this shows that all samples are in the range of desirable prescribed limits as suggested by WHO and BIS.

Iron (Fe) Major natural sources are igneous rocks, amphiboles, ferromagnesian micas, ferrous sulfide (FeS), ferric sulfide or iron pyrite (FeS_2), magnetite (Fe_3O_4). Sandstone rocks, oxides, carbonates and sulfides or iron clay minerals. Concentrations in natural water generally less than 0.50 mg/l in fully aerated water. Groundwater having a pH less than 8.0 may contain 10 mg/l rarely as much as 50 mg/l may occur. Acid water from thermal springs, mine wastes, and industrial wastes may contain more than 6,000 mg/l. Effect on usability of water more than 0.1 mg/l precipitates after exposure to air, causes turbidity, stains plumbing fixtures, laundry, and cooking utensils, imparts objectionable tastes, colors to foods and drinks. More than 0.2 mg/l is objectionable for most industrial uses. Iron (Fe) concentration varies from 0.11 to 0.22 mg/l with mean values of 0.15 mg/l and S.D value 0.036. No observations are exceed the standard limit.

Carbonate (CO_3 as $CaCO_3$) the major natural sources are limestone, dolomite. Concentrations in natural water commonly less than 10 mg/l in groundwater. Water high in sodium may contain as much as 50 mg/l of carbonate. Effects on usability of water upon heating, bicarbonate is changed into steam, carbon dioxide, and carbonate. The carbonate combines with alkaline earths-principally calcium and magnesium-to form a crust-like scale of calcium carbonate that retards flow of heat through pipe walls and restricts flow of fluids in pipes. Calcium carbonate concentration varies from 0 to 80 mg/l with mean values of 43 mg/l and S.D value 18.666. Very high concentrations observed 80mg/bl BW16, 80mg/bl BW14 at Sillapeta and Eguvapeta respectively, where as lowest 0 mg/bl (BW 13) at Eguvapeta, 150m away from BW14 which has the highest same place at Eguvapeta .This might be the residents damp rubbish materials on sewer lines leading to blokade

Bicarbonate (HCO_3) the major natural sources are oxidation of sulfide ores, gypsum, anhydrite and concentration in natural water commonly less than 300 mg/l except in wells influenced by acid mine drainage. As much as 200,000 mg/l in some brines. Effects on usability of water 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 1,000 mg/l may be cathartic. Bicarbonate concentration varies from 80 to 540 mg/l with mean values of 239 mg/l and S.D value 114.887. Very high concentration of 340 mg/l, at BW2,BW3 and BW4 and 540 mg/l at BW10, 400 mg/l at BW16 and 280 BW17 are observed (Table.2).

Sodium(Na) the major natural sources are feldspars (albite), clay minerals, evaporites, such as halite (NaCl) and mirabilite ($Na_2S0_4.l0H_2o$), industrial wastes. Concentration in natural water generally less than 200 mg/1; about 10,000 mg/l in seawater, about 25,000 mg/l in brines. Effects on usability of water more than 50 mg/l sodium and potassium in the presence of suspended matter causes foaming, which accelerates scale formation and corrosion in boilers. The study area Sodium (Na) values ranges from 25.75 to 237.2 with an average value of 115.18 mg/l and S.D values 74.111.The minimum value recorded 25.75 mg/lb (BW13) at Eguvapeta and the maximum concentration observed 237.2(BW2) at Sillapeta, and BW1, BW3, BW4,BW5,BW6,BW9,BW15,BW16,BW17 and BW18 shown in (Table 3.5) are exceeds the permissible limit.

Potassium (K) the major natural sources are feldspars (orthoclase and microcline), feldspathoids, some micas, clay minerals. Concentration in natural water generally less than about 10 mg/l; as much as 100 mg/I in hot springs, as much as 25,000 mg/I in brines. Effects on usability of water sodium and potassium carbonate in re-circulating cooling water can cause deterioration of wood in cooling towers. More than 65 mg/l of sodium can cause problems in ice manufacture. Potassium (K) values ranges from 0.64 mg/l to 73.1mg/l with an average value of 23.22 mg/l and S.D values of 20.912. And BW1, BW3, BW5, BW6, BW8, BW9 ,BW10, BW15, BW16, BW17,BW18,BW19 and BW20 shown (Table3.5), concentration levels are exceeding the range of standard limits specified by WHO and BIS (Table 3.6).

Magnesium (Mg) the major natural sources are amphiboles, olivine, pyroxenes. Concentration in natural water generally less than 50 mg/I; dolomite, magnesite, clay ocean water contains more than minerals 1,000/mg/l, and brines may contain as much as 57,000 mg/1. Effect on usability of water Calcium and magnesium combine with ions of fatty acid in soaps to form soapsuds; the more calcium and magnesium, the more soap required to form suds. A high concentration of magnesium has a laxative effect, especially on new users of the supply. Magnesium (Mg) concentration varies from 10.6 mg/l to 75.6 mg/l with mean values of 32.76 mg/l and S.D is 14.059 mg/l. According to BIS the desirable values of Mg is 30 mg/l and a maximum permissible limit of 100 mg/l (Table 3.6). No water sample were exceeds from the standard limit.

Geology

The district geology map has been geometrically rectified in Erdas-Imagine 2014 and AOI is selected. The different geological units and structural trends were digitized in ArcGIS 10.2.2. Spatial discrepancy of different rock units has been adjusted considering terrain elements of satellite image. The study area covering rocks of garnet sillimanite gneiss (Khondalite), hypersthenes granite (charnockites), Quartzite, are the chief rock types which occur as bedded and banded as well as massive formations.

Geologically, the study area belongs to Precambrian age and characterized by occurrence of meta-sediments and intrusive meta-igneous bodies. Apart from meta- sediments the area is covered by calcium carbonate calcretes dune sands, beach sands with economically important black sand concretions along the seashore (Jagannadha Rao et al. 2012).

Kondalite

It is medium to course grained, light dusty brown colored with a varying infilling of brown to dark brown materials composed of garnet, plagioclase, biotite, silliminite and minerals and zircon, etc. The kondalite derived from high alumina clays which were also rich in iron some varieties were rich in feldspar in some these rocks undergone weathering, it gives laterite and bauxite the high grade metamorphism seen in kondalites is also an indication of the tectonic activity. About 97 % of the area is occupied by khondalite rock .

Charnockite

Charnockite was once thought to be igneous, but it is now known as metamorphic.Charnockite is also called as blue granite.It is majorly consists of hypersthenes mineral this rock is highly used as road and building materials. This rock is hard and massive not good ground water reservoir rock in this area. Charnockites occur in very small area at the backside of Bheemili hill near to Gollapalem.

Quartzite

Quartize is a hard rock ,non-foliated metamorphic rock which was originally pure quartz sandstone. Sandstone is converted in to quartzite through heating and pressure usually related to tectonic compression. Pure quartzite is usually white to gray though quartzite often occur in various shades of pink and red due to varying amount of iron oxide (Fe_2O_3). Due to its massiveness it is not a good source of groundwater, however, in certain cases it acts as a ridge which allow good groundwater in the area. Only 3% of the area occupied with this type of rock.

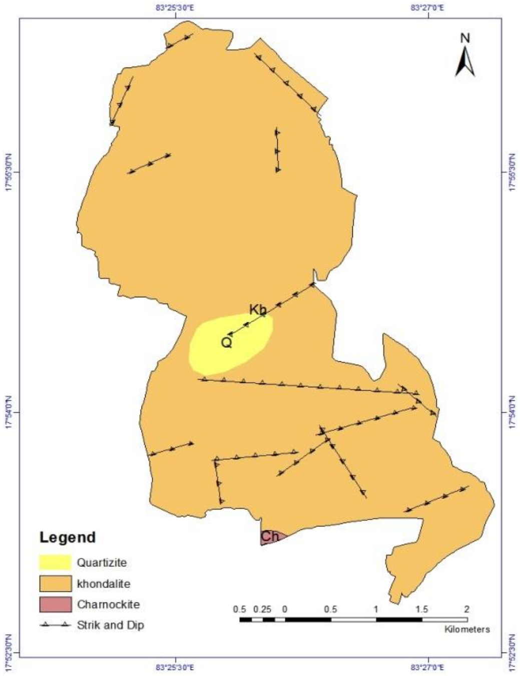

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Fig. 3 Geology Map of the study area

No	Geology types	Area in Square Kilometer (km^2)
1	Kondalite	13.5
2	Quartzite	0.458
3	Charnockite	0.0304

Table :4 Rock types (Area in km^2)

Geomorphology

Geomorphic maps can be utilized for regional landuse planning and restoration of the eco-balance (Chopra, 1990). Structural hills, denudational hills, residual hills, inselbergs and pediment inselberg complexes are the run-off zones and Pediplain shallow, pediplain moderate, pediplain deep, piedmont slope and valley fill shallow are suitable areas for infiltration (recharge zones) and landforms of fluvial and denudational origin have direct control over groundwater occurrence and distribution. (Jagadeeswara Rao et al, 2009).

No	Geomorphic Unit	Village Name	Area (km^2)	Lu/Lc
1	River	Tagarapuvalasa	0.21	Gosthani River
2	Lake	Chakalipeta	0.07	lake
3	Pediplain moderate weathered	Santhapeta,cillapeta, Sangivalasa Dekkadipalem,Rayapalem	9.12	Plantation. Fallow land ,scrub
4	Beach Sand	Bheemilli Beach	0.14	Sandy
5	Inselberg	Tagarapuvalasa	0.06	Built-up
6	Flood Plain	Keetenpeta, Chitivalasa,	1.15	Healthy dry forest forest,
7	Pediment slope	Tagarapuvalasa, Eguvapeta	1.77	Built-up
8	Structural Hill	Gollapalem	0.96	Scrub
9	Valley Fill	Gaddu Veedhi,Barma Colony	1.24	Evergreen forest, plantation

Table: 3 Area under geomorphic units

Geo-Engineering Studies

The study area with its access roads and location of sounding areas is presented in a map a network of motorable roads and footpaths makes access the area possible to conduct the work. Jagadeeswara Rao et al, (2009) studied ground water exploration is possible from the units of pediplain deep, pediplain moderate, pediplain shallow, valley fill shallow and piedmont slope is the order of abundance. The vertical electrical sounding (VES) work conducted by the group of 5 members the first two persons holds the two ends of current electrode which are reckoned as A and B and the other two persons moves the two potential electrode which is M and N along the direction of current electrode A and B respectively. Electrical methods of geophysical prospecting are the most important methods and they yield significant insights into the resistivity distribution for the subsurface structural studies and groundwater investigations. The electrical resistivity method is one that has been widely used because of the theoretical, operational and interpretational advantages. The advantages of electrical methods also include control over depth of investigation, portability of the equipment, availability of wide range of simple and elegant interpretation techniques, the related software, etc. Although most of the geophysical methods find application in subsurface structural studies and groundwater prospecting, the choice of a particular method for delineating potential aquifer zone in a given area depends solely on electrical resistivity method.

This study involves a geo-electrical investigation and groundwater monitoring of Bheemunipatnam distinct. Twelve Vertical Electrical soundings (VES) were carried out across the area using the Schlumberger electrode array configuration, with maximum-current electrode separation (AB/2) of 100m.To determine groundwater configuration and GPS recording of the study areas were collected for further analysis In this case Schlumberger Arrangement chosen. Electrical resistivity techniques measure earth resistivity by passing an electrical current in to the ground and measuring the resulting potential created on the earth.

A Vertical Electrical Soundings (VES) were carried out at 12 selected places across the area The VES conducted by the group of 5 members the first two persons holds the two ends of current electrode which are reckoned as A and B ,the other two persons moves the two potential electrode reckoned as M and N along the direction of current electrode, the fifth person operates the resistivity meter and records voltage and current on data format sheet. The apparent resistivity calculated using the formula ρ(**Ωm**)=configure constant(K)*voltage(V)/current(I)

IPI2win and gINT Version 8 software used to produce resistivity graph and fence diagram for the evaluation and interpreting resistivity data.

DATA USED

For the present study of groundwater quality assessment and geophysical investigation of groundwater the following data and equipments has been used.

a. Surveyor General of India Toposheet 65 O/5 (on 1:50,000 scale) first edition and Satellite Images.

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b. Hand held GPS etrex 10 for reading accurate location and Bheemuipatnam town map collected from municipality.
c. Electrical resistivity meter,(Technical know-how of NGRI)
d. ArcGIS 10.2.2 and Erdas Imagine 2014 for digitization and geo-referencing.
e. IPI2win and AutoCAD 2016 used to produce resistivity graph and cross-section of soil layer.
f. Selected 20 dug well groundwater samples collected for chemical analysis. The water samples were collected into 1/2L pre-washed polyethylene bottles.

Interpreted thickness of layers

S.No	Thickness (M)	Expected layer
1	0-5	Red Soil
	5-20	Weathered Rock
	20-80	Moderately Fractured Rock
	80 Onwards	Hard Rock

Table:5 VES 1 Thotavedhi, 170 53.864' N 830 26.405' E

No	Thickness (M)	Expected layer
2	0-1	Red Soil
	1-5	Sand
	5-30	Moderately Fractured Hard Rock
	30-100	Fractured Rock

Table :6 VES 2 keetinpeta, 17^0 54 .198 N 83^0 26 .25' E

S.No	Thickness (M)	Expected layer
3	0-5	Soil
	5-10	Weathered Rock
	10-100	Highly Fractured Hard Rock

Table :7 VES 3 Dekkadipalem, 170 54 .388' N 830 25.977' E

S.No	Thickness (M)	Expected layer
4	0-5	Soil
	5-10	Weathered Rock
	10-30	Hard Rock
	30-100	Fractured Rock

Table: 8 VES 4 Gollapalem, 170 54 .026' N 830 25 .291' E

S.No	Thickness (M)	Expected layer
5	0-2	Red Soil
	2-10	Weathered Rock
	10-80	Fractured Rock

Table :9 VES 5 Sangivalasa, 170 54 .268' N 830 25 .062' E

No	Thickness (M)	Expected layer
6	0-1	Red Soil
	1-20	Rock
	20-100	Fractured Rock

Table:10 VES 6 Kumaripalem, 170 54 .146' N 830 26 .862' E

No	Thickness (M)	Expected layer
7	0-1	Red Soil
	1-20	Rock
	20-100	Fractured Rock

Table:12 VES 7 Rakananipalem, 170 54.146' N 830 26.86' E

No	Thickness (m)	Expected layer
8	0-5	Red Soil
	5-10	Weathered Rock
	10-100	Fractured Rock

Table:13 VES 8 Sillapeta, 17^0 54 .739' N 83^0 26 .686' E

No	Thickness (M)	Expected layer
9	0-3	Red Soil
	3-10	Weathered Rock
	10-100	Fractured Rock

Table15 VES 9 Gaadu Veedhi, 17^0 55.381' N $83^0$25.329' E

No	Thickness (M)	Expected layer
10	0-5	Red Soil
	5-10	Weathered Rock
	10-100	Fractured Rock

Table 16VES 10 Gadu Vedhi,170 53. 694' N 830 25.952 ' E

No	Thickness (M)	Expected layer
11	0-7	Soil
	7-15	Weathered Rock
	15-40	Saline Water Zone
	40 onwards	Moderately Fractured Rock

Table :17 VES 11 Kumaripalem, 17^0 55 .975' N 83^0 24 .734' E

No	Thickness (M)	Expected layer
12	0-5	Red Soil
	5-20	Weathered Rock
	20-80	Moderately Fractured Rock
	80-100	Fractured Rock

Table :18 VES 12 Sillapeta, 17^0 54 .977' N 83^0 26.268 ' E

CONCLUSIONS

The physico-chemical parameters of groundwater of the study area shows that pH, Mg, TH, SO_4, Alkalinity, Turbidity were within the limits of drinking water quality standard specified by WHO and BIS. Total Dissolved Solids (TDS) all samples wells not exceed the standard limit except (BW13) at Eguvapeta. HCO_3, very high concentration levels are observed at BW2, BW3, BW4, BW10, BW16 and BW17 in (Table 3.5). Chlorine (Cl) at BW2, BW4, BW5, BW15 and BW16 exceed from the standard limit. Observation indicates that water wells around the Chittivalasa huge tank has high chlorine concentration whereas water wells found away from the tank has low concentration. NO_3 concentration in the study area within the range of the standard limit except BW4 at Chittivalasa because it might be farmers around well uses fertilizers for their crops in agricultural land. (Flurine concentrations in the study area are not exceed the standard limit except (BW16) at Sillapeta. This might be the residents dump rubbish materials on sewer line blockade and forming stagnant water gradually infiltrate and join in to the well. Sodium (Na) and potassium(K) from the total of 20 samples 10 were exceeds the permissible limit, those wells are found along the sea coast and near bay river. The study area covering a rock of garnet sillimanite gneiss (Khondalite), hypersthenes granite (charnockites), Quartzite, are the chief rock types which occur as bedded and banded as well as massive formations. About 97 % of the area is occupied by khondalite rock and the remaining 3% occupied by charnockites and Quartzite, Kondalite 13.5km^2, Quartzite 0.458km^2 , Charnockite 0.0304km^2.The geo-physical investigation (Vertical Electrical Sounding) resistivity graph interpretation indicates that most of VES locations have four layers namely red soil, weathered rock, moderately fractured hard rock and hard rock where as three layer location show red soil, weathered rock, fractured rock .

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