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Research Article

Ground water quality Assessment in Uddanam region, Costal Srikakulam, Andhra pradesh, India.

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Abstract

Water plays an important role in domestic and industrial usage. The quality of drinking water is a powerful environmental determinant of health. Assessment of water quality of drinking water supplies has always been paramount in the field of environmental quality management. Assurance of drinking water safety is a foundation for the prevention and control of water borne diseases. The suitability of drinking water has many requisite potable conditions. Groundwater quality of Srikakulam has a special significance and needs greater attention of all concerned since it is the only major source for domestic consumption. The paper presents rural groundwater quality assessment of Uddanam region, Srikakulam, Andhra Pradesh, India and analyzed for their physicochemical characteristics. The results of this analysis were compared with the water quality standards of WHO and BIS. The water samples have been collected from 10 bore wells,38dugwells and 2 surface sources in Uddanam region Srikakulam. In this analysis the various physicochemical parameters such as pH, Total Dissolved Solids, Total Hardness, Ca, Mg, Na, NO_3, K, Cl, SO_4, HCO_3 and SiO_2 By Using standard procedure.

Keywords: Water quality, Groundwater Pollution, and Uddanam region.

Introduction

Water plays an important role in domestic and industrial usage. The quality of drinking water is a powerful environmental determinant of health. Assessment of water quality of drinking water supplies has always been paramount in the field of environmental quality management. Assurance of drinking water safety is a foundation for the prevention and control of water borne diseases. The suitability of drinking water has many requisite potable conditions. Groundwater quality of Srikakulam has a special significance and needs greater attention of all concerned since it is the only major source for domestic consumption. Water is an essential resource for life on the earth. 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 rural groundwater quality assessment of Uddanam region Srikakulam. Many 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 [1]. Every 8 seconds, a child dies from water related disease around the globe, 50 percent of people in develop-

ing countries suffer from one or more water related disease and 80 percent of diseases in the developing countries are caused by contaminated water[2]. 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 [3] The rapid growth of urban areas has further affected the groundwater quality due to over exploitation of resources and improper waste disposal practices [4].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[5]. Environmental health involves all the factors, circumstances and conditions in the environment or surroundings of humans that can influence health and wellbeing. The neglect of rural areas in most developing countries in terms of basic infrastructures such as pipe-borne water and sanitation facilities, expose the villagers to a variety of health related problems such as water – borne diseases [6]. Groundwater quality in Jada and environs has been evaluated for their chemical composition and suitability for human consumption and agricultural uses [7]. The physico-chemical quality of groundwater in Geidam of Nigeria has analysed by [8]). In this study, the levels of some physical and chemical water quality parameters in hand-dug wells located in the residential areas and in the vicinities of rural settlement near the coastal area of Srikakulam district, Andhra pradesh were assessed.

STUDY AREA

Uddanam region is a part of south eastern of Srikakulam ghat terrain located 200 km from the city of Visakhapatnam. The Uddanam region, covering an area of about 290 sq km, is imposed between "18.56219– 19.16563"N latitude and "84.30934–84.76844"E longitude (Fig 1). The area is covered by survey of India topo sheets 65O/1,O/2 & O/3 on 1:50,000 scale. The area is fairly connected to NH-5 in addition to local highways,

Communication

The study area, being closed to the city of Srikakulam, is well connected through roads and rail network. A number of local highways are connected to different locations of nearby NH-5. Tekkali is another town on NH-5 is also connect to the study area on the western side, while Palasa town provides the major connectivity and approach to the interior villages of problematic . However, Somepeta, Vajrapu kotturu, Kanchili located in central part of the affected areas provides connectivity to almost all the villages in that area.

Drainage

The main rivers that drain the district are Vamsadhara and Nagavali. The other important rivers flowing in the district are Suvarnamukhi, Vegavati, Mahendra Tanya and Bahuda. Among the rivers Vamsadhara, Nagavali and Suvarnamukhi are perennial. The general drainage pattern is dendritic to sub-dendritic and occasionally parallel at places. The drainage in western part of the district resembles dendritic type, where as in the central part it is parallel to sub-dendritic. The overall drainage is of medium to coarse textured towards west and north of the district, whereas in central and southern parts it is very coarse. The drainage density varies from less than 0.2 to 1 km/km2. In Palakonda area the density is of 0.6 to 1 km/ sq.km While areas with a density of more than 0.2 km/sq.km are observed in Ichapuram, Sompeta, Narasannapeta and Srikakulam. The density is less than 0.2 km/sq.km in plain area of Tekkali.

Climate and rainfall

The climate of the district is moderate and characterized by high humidity all through the year along with oppressive summer and good seasonal rainfall. The period from January to December is generally the season of fine weather. The average annual rainfall of the district is 110.8 mm, which ranges from nil rainfall in January and 270.7 mm in September and October. September and October are the wettest months of the year. The mean seasonal rainfall distribution is 103.3 mm in southwest monsoon (June-September), 133.1 mm in northeast monsoon (Oct-Dec), 8.2 mm rainfall in Winter (Jan-Feb) and 50.8 mm in summer (March–May)[9]

Sample collection and treatment

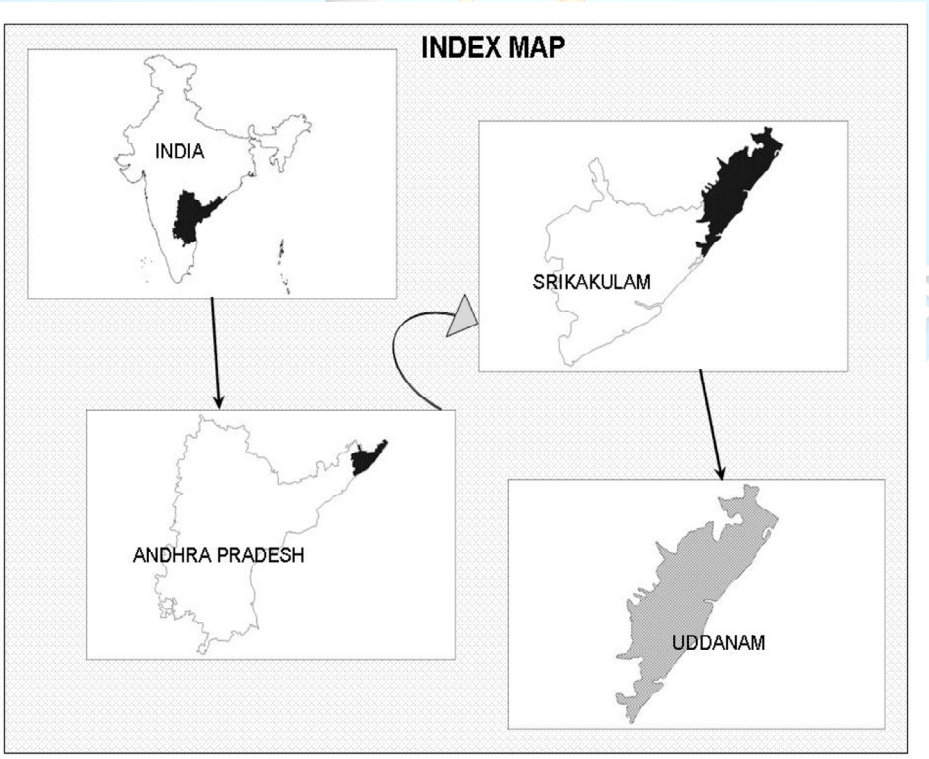
A total of 51 locations were selected for the characterization of the physicochemical properties of the ground water. All water samples were collected in a single sampling campaign during spring season.

All the wells chosen for Ground water sampling were commonly utilized for irrigation water supply and/ or domestic purposes. Geographic coordinates of each sampling site were recorded with a handhold GPS unit using UTM coordinate system and WGS84 datum. To determine the general quality of the water in the study area, general precautions like keeping the container clean, rinsing with water sample, avoiding re-aeration through trickling water along the sides, sealing the container etc., described by[14]; WHO/GEMS Water quality operational guide, [12,10] were strictly adopted. The physical parameters like pH, temperature, electrical conductivity, total dissolved solids, dissolved oxygen, salinity of the water samples were determined in the field using the water analyzer kit. The water samples were analysed for major cations (Na^+, TH, K^+) and anions (Cl^-, SO_4^{2-}, HCO_3^-) and minor elements like Silica, Phosphate, Nitrate. The chemical analysis was carried out as per the procedure given in APHA[28]. The major, minor and trace elements were analyzed in the laboratory using the following methods. Chloride, Bicarbonate, Total Hardness (Titrimetricmethods) Nitrate, Silicate (UV Visible Spectrophotometer(190nm-900nm))Sulphate (Nephelometer) Sodium and Potassium (Flame photometer).

Materials and methodology

Groundwater samples were collected after well inventory survey from 11 representative wells during September 2014 (Figure 1). The samples were collected after 10 min of pumping and stored in Poly Ethylene bottles at 25°C. Immediately after sampling, pH and electrical conductivity were measured in the field by using water analyser instrument. Total dissolved solids (TDS) were calculated from EC multiplied by 0.64 [27].NitrateNO_3 and ortho-phosphate(PO_4) by spectro photometer, sulphate (SO_4) analysed using Nephelometer, sodium(Na) and potassium (K) studied by flame photometer, bicarbonate (HCO_3), calcium(Ca), and Total hardness (TH) were determined by volumetric methods. High purity analytical reagents were used throughout the study, and chemical standards (Merck, Germany) for each element were prepared separately.

Figure 1.Location and administrative map of uddanam region.



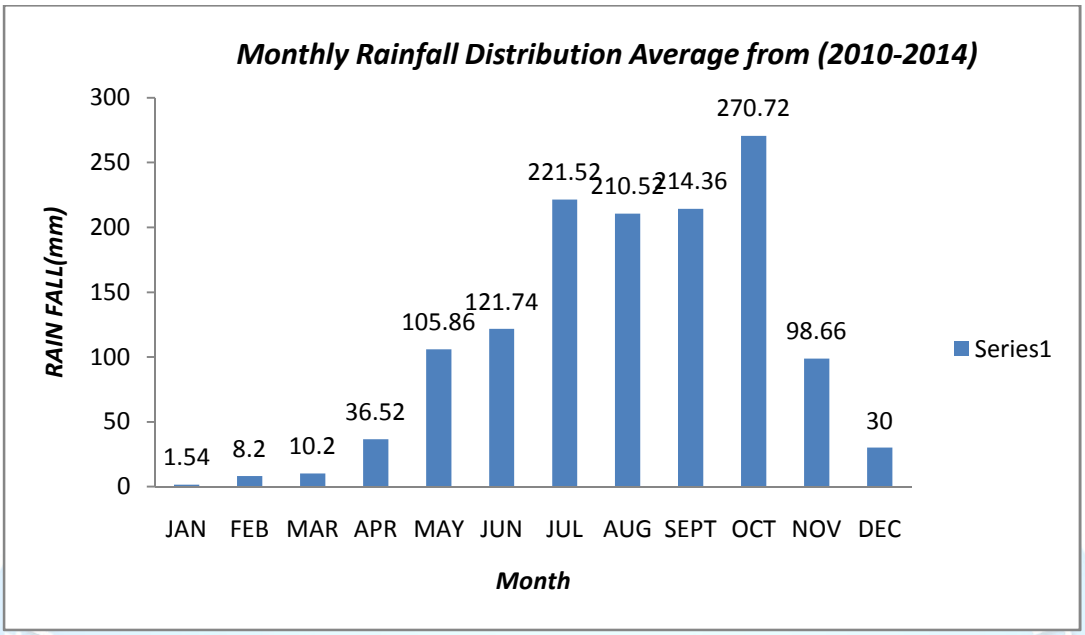


Fig.2 : Monthly Rainfall distribution average from (2010-2014)

Results and discussion.

Total Dissolved Solids (TDS)

TDS is defined as the residue of filtered water sample after evaporation. The bulk TDS include bicarbonates, sulphates and chloride of calcium, magnesium, sodium, potassium, silica, potassium chloride, nitrate and boron. According to Hem [10] TDS was calculated using the relationship given below TDS (in ppm) = 0.64 * EC (in micro-mhols/cm). Analysis of water samples of the study area revealed that the presence of TDS varies between 71 to 3116 ppm. Among all the values of the TDS are higher Sample number 1, 2, 3, 9, 11, 15, 19, 22, 24, 35, 37, 38, 40, 41, 45, 48, 50 exceeds the limit due to brackish water. Subsequently, four classes of water were proposed based on the procedures adopted from [11] and is given in Table **2** which confirms majority of samples belongs to fresh water category.

Hydrogen Ion Concentration (pH)

The pH of a solution is defined as the negative logarithmic of the ion concentration and is normally expressed in moles per liter at a given temperature. pH of a solution can affect the toxicity of other elements and has very pronounced effect on many chemical reactions which are important to industry, irrigation and domestic water treatment. The pH value was determined in the field using water analyser kit and the values vary between 6.1-9.0

Chemical Constituents

Calcium

Calcium is a major constituent of igneous rocks. The major sources of calcium in ground water around basaltic are plagioclase and pyroxene. The range of calcium content in ground water is largely dependent on the solubility of calcium carbonate, sulphide and rarely chloride. The maximum acceptable limit of calcium for domestic use is 75ppm [12]. The calcium content of the water samples were estimated by EDTA titration method. The water samples (500cm^3) were acidified with 10 cm^3 of concentrated nitric acid and concentrated to 25 cm^3 using evaporation method [13]. After chelation, extraction and subsequent mineralization, calcium ion was determined by atomic adsorption spectrophotometer. The range of calcium varies from 11.9 to 142 ppm. Among 50 collected water samples, sample numbers 1, 2, 9, 11, 13, 15, 16, 21, 22, 24, 38, 41, 50 have shown high content of Ca^{2+} concentrations in the study area. The higher concentration of Ca^{2+} in ground water is due to the weathering of pyroxenes present in the basaltic rocks and plagioclase feldspar as a dominant source in the study area.

Table 1.Sample location

Source	Village	Latitude	Longitude	Source	Village	Latitude	Longitude
DW1	Burjapadu	19.0572	84.7274	SS26	kothapalli	18.8835	84.5267
DW2	Ampuram	18.9927	84.5898	DW27	Loharibanda	18.8510	84.5414
DW3	Byripuram	19.0496	84.5510	BW28	Nallabodluru	18.8131	84.5163
DW4	Gollakanchili	18.9750	84.5764	DW29	Narayanapuram	18.8310	84.5088
DW5	Jennaghai	18.9728	84.5539	SS30	Kobbarichetluru	18.8000	84.4805
DW6	Jellunda	19.0121	84.5624	BW31	Loddabhadra	18.8096	84.4455
BW7	Mukundapuram	18.9872	84.5950	BW32	Lakshmipuram	18.7549	84.4141
DW8	Rekha devipuram	19.0337	84.5646	BW33	Peda neelavathi	18.7955	84.4791
DW9	Saripalli	19.0011	84.5696	BW34	Rangoi colony	18.8123	84.4824
DW10	sasanm	18.9338	84.5251	DW35	Battigalluru	18.8575	84.5793
DW11	Thalathampara	18.9517	84.6190	DW36	Baruva	18.8817	84.5856
BW12	R Balliputtuga	19.0315	84.6559	DW37	Ekkuvuru	18.8525	84.5771
BW13	China jalluputtuga	19.0431	84.7020	DW38	Lakkavaram	18.9154	84.5756
DW 14	Chepala kapasakurdi	19.0223	84.7186	DW39	Mamidipalli	18.8596	84.5570
BW15	Idduvanipalem	18.9730	84.6832	DW40	Thotvuru	18.8434	84.5697
DW 16	Kotta kojjeria colony	19.0608	84.6463	DW41	Vadapalem	18.8777	84.5901
BW17	Kottawaraka	18.9790	84.6518	BW42	Bendi	18.7148	84.4664
BW18	Mutyalapeta	19.0276	84.7050	BW43	Bypalli	18.7488	84.4834
DW19	Nelavanka	19.0395	84.7219	BW44	Chinavanka	18.7243	84.4631
DW20	Peda karrivanipalem	18.9810	84.6882	BW45	Marripadu	18.7703	84.4682
BW21	Pathawaraka	18.9764	84.6542	BW46	M goduru	18.7586	84.4969
DW22	Rajapuram	19.0448	84.6680	BW47	Nukalivanipeta	18.6800	84.4428
BW23	Bahadapalli	18.8030	84.5215	DW48	Peda badam	18.7385	84.4902
DW24	Bellupatia	18.9111	84.4899	BW49	Thoturu	18.7601	84.5120
BW 25	Bethalapuram	18.8041	84.5454	BW50	Tadivada	18.7098	84.4460

(DW=Dug well, BW=Borewell, SS=Surface Source)

Magnesium

Magnesium is an important constituent of basalt. It's solubility in water is around five times that of calcium. Calcium and Magnesium together cause the hardness of water. EDTA titration was used to determine the magnesium concentration in the samples. The range of magnesium varies from 0.4 to 125 ppm. All samples are within range of Mg limit except sample number 1, 15, 19, 24 due to weathering of pyroxenes present in the basaltic rocks in the study area.

Sodium

Sodium is an important constituent for determining the quality of irrigation water. Sodium bearing minerals like albeit and other members of plagioclase feldspars, naphthalene and sodalite weather to release the primary soluble sodium products. Most sodium salts are readily soluble in water, but take no active part in chemical reactions. Sodium has wide variation in its concentration in ground water. The sodium content of the samples was determined by a flame photometer. Sodium content in the water samples varies between 6.1-417 ppm. Majority of collected water samples shows exceed limit range because of the locations are near to the sea.

Potassium

Although potassium is nearly as abundant as so-

dium in igneous rocks, its concentration in ground water is comparatively very less as compared to sodium. This is due to the fact that the potassium minerals are resistant to decomposition by weathering. The potassium concentration in the water was determined with the help of Flame photometer. Analysis of water samples in the study area indicates that potassium value varies between 1-172 ppm. half of the water samples lies in the potassium acceptable limit.

Table.2 The minimum, maximum of chemical parameters with water quality standards.

\	N	Min	Max	WHO Standards	BIS Standards
EC	50	111	4870	-	-
TDS	50	71	3116.8	500	500
pH	50	6.1	9	6.5-8.5	6.5-8.5
Na	50	6.1	417.4	200	-
K	50	1	172	-	20
TH	50	30.3	676.7	300	200
Ca	50	11.9	142.9	75	75
Mg	50	0.4	125	50	30
HCO_3	50	48.8	1049.2	-	-
Cl	50	13.5	803.1	250	-
SO_4	50	0.4	100.2	500	200
NO_3	50	0.4	11.7	50	45
SiO_2	50	37.8	267.3	-	-

Table 3. Water Quality Classification Based on TDS [25]

TDS in ppm	Water Quality
0 -1000	Fresh water
1000 – 10, 000	Brackish water
10, 000- 100, 000	Salty water
> 100, 000	Brine

Table 4. Water Classes Based on Hardness [26]

Hardness as CaCO3	Water Class
0 -75	Soft
75- 100	Moderately hard
150 – 3000	Hard
> 3000	Very hard

Chloride

Chloride concentrations vary widely in natural water and it is directly related to mineral content of the water. It is known that the sea water intrusion is showing abnormal concentration of chloride. Chloride ion is a predominant natural form of chlorine and is extremely soluble in water. The major sources of chloride in natural water are sedimentary rocks particularly evaporates. Igneous rocks contribute only a fraction of total chloride. Other sources are industrial and domestic wastewater. The limit for domestic purposes is fixed at 250mg dm^{-3} [14]. The chloride content in the samples was determined by using 0.1N $AgNO_3$ solution. In the present study chloride ion content in all the ground water samples ranged from 13.5 to 803 ppm. Among 50 collected water samples, sample numbers 1, 2, 14, 15, 19, 24, 35, 37, 38, 40, 41, 48, 50 have shown high content of chloride due to effect

of cashew industries and excessive use of fertilisers, poor drainage conditions and reuse of irrigation water.

Sulphate

The sulphate content in the atmosphere precipitation is only about 2ppm, but a wide range in sulphate content in ground water is made possible through reduction, precipitation, solution and concentration. The primary mineral sources of sulphate ions include evaporate minerals such as calcium, gypsum and sulphates of magnesium and Sodium. The sulphate concentrations in the water samples were determined by Nephelometer and results revealed that all analysed samples in permissible limit. The sulphate content in the samples varies between 0.4 to 100.2 ppm.

Total Hardness TH

Hardness is often referred to as the soap consuming property of water. Hardness may be divided into two types, carbonate and non-carbonate. Carbonate hardness includes portions of calcium and magnesium, and certain amount of bicarbonates. Total hardness is defined as TH= (2.497 Ca + 4.11 Mg); where Ca and Mg are expressed in ppm [15]. Total hardness of the study area varies between 30.3 to 676.7 ppm. Classification of water was done based on hardness given by Sawyer (1960) [16] and is listed in Table **3** suggested that all water samples in the category of hard.

Nitrate

Naturally high nitrate concentration may occur in ground water in semi arid or arid areas where there is wide spread terminate activity, or where natural vegetation is dominated by leguminous species such as acacias. Nitrates and Nitrites are the most abundant forms of dissolved nitrogen in ground water and surface water due to agricultural and domestic activities [17]. In the absence of bacterial contamination greater than 1,00,000 ug/l should not normally be used for bottle-fed infants. Nitrate levels in surface water can change quite quickly, but levels in ground water usually change very slowly unless the ground water is heavily influenced by surface water. Test results for nitrate are often expressed as nitrate nitrogen(NO3-N) OR "nitrogen that was in the form of Nitrates". Concentration of NO3-N rarely exceed 10,000 ug/L and are usually less than 1000 ug/l. Elevated levels are primarily associated with human contamination fertilizers and sewage. High concentration of nitrates can stimulates the growth of aquatic plants and may be a health hazard to juvenile mammals. In the digestive system, nitrates are reduced to nitrites. As nitrates enter the blood stream, haemoglobin is oxidized to methemoglobinemia (blu baby disease) may result from drinking waters with high nitrate concentrations. Rendering it incapable of transporting oxygen. The concentration of nitrate ranges from 0.4 mg/L to 11.4mg/L. among all the water samples lies in the Nitrate acceptable limit.

Alkalinity and Bicarbonates

Dissolved carbon dioxide, bicarbonate and carbonates produce alkalinity in water. Carbonates and bicarbonates are being estimated from the alkalinity values (18). The concentration of bicarbonate ranges from 48 mg/L to 1049 mg/L. The high bicarbonate concentration observed due to both silicate mineral weathering of basalt and dissolution of carbonate present in the alluvium seem to be the potential sources of bicarbonates in the water.

Silicate

Silica released as a result of chemical breakdown of silicate minerals in rocks and sediments by chemical weathering is acquired by circulating groundwater and therefore the source of silica (SiO2) in groundwater is almost exclusively and unequivocally a result of water– rock interaction[19] . Concentration of SiO2 in groundwater varies from 1 to 30 mg/l, the median value being 17 mg/l [20]. On the other hand, solubility of silica in water is directly proportional to temperature .The concentration of silica varies between 37.8 mg/L to 267 mg/L in the study area. Almost all location are shows higher concentration of silicates in the study.

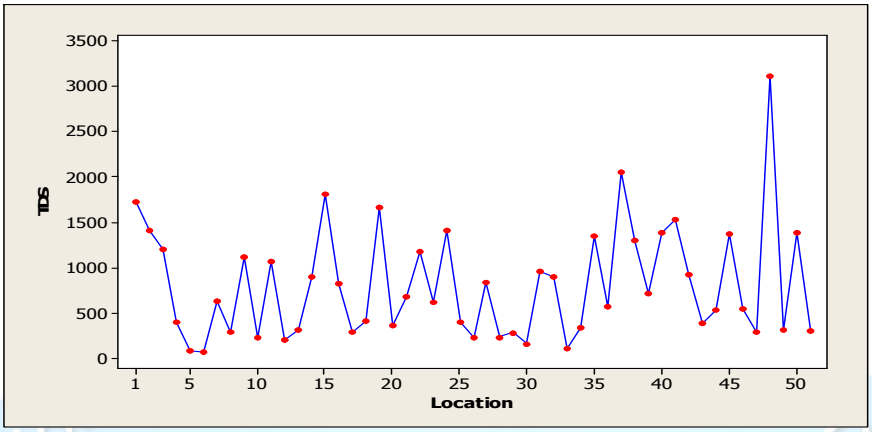


Fig 3. Variation of TDS (mg/L)in all the locations.

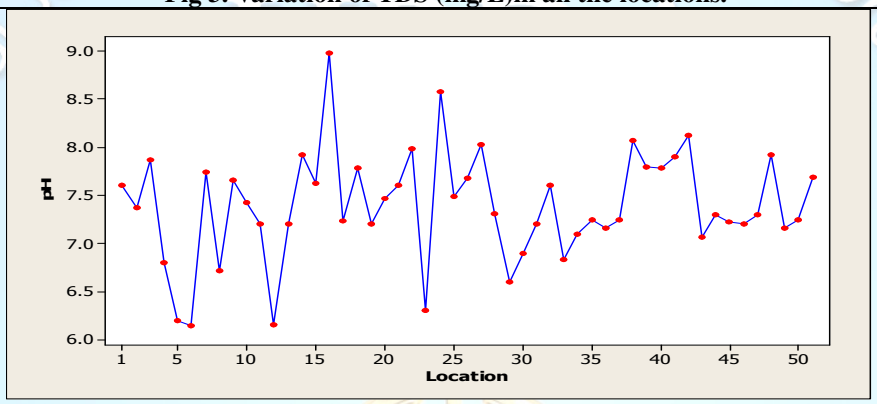


Fig 4. Variation of pH in all the locations.

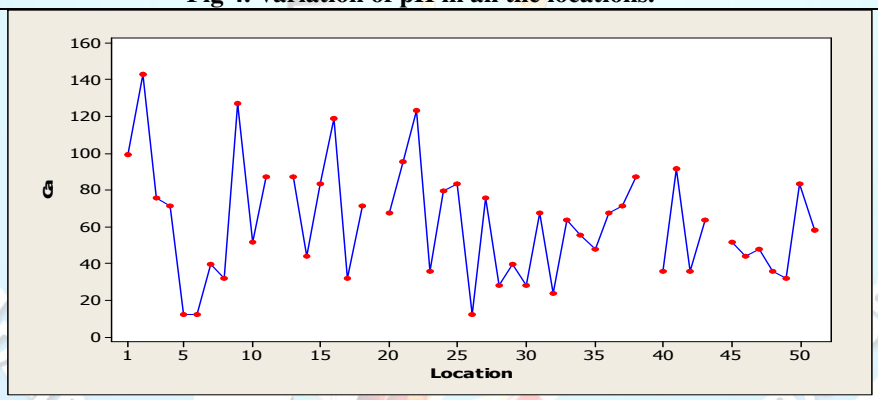


Fig 5. Variation of Ca (mg/L) in all the locations.

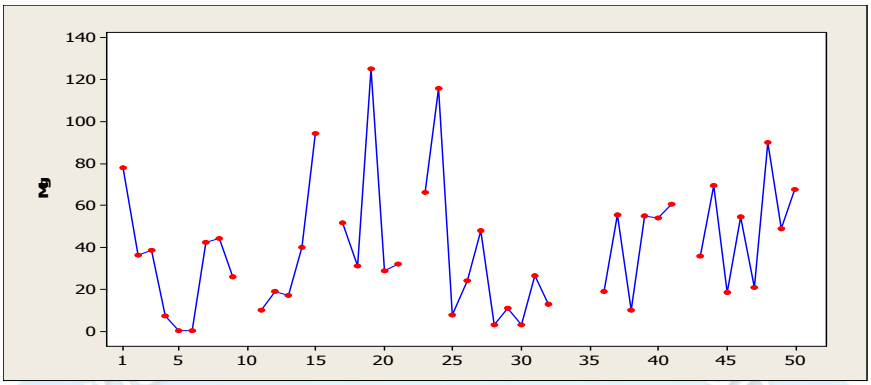


Fig 6. Variation of Mg (mg/L) in all the locations

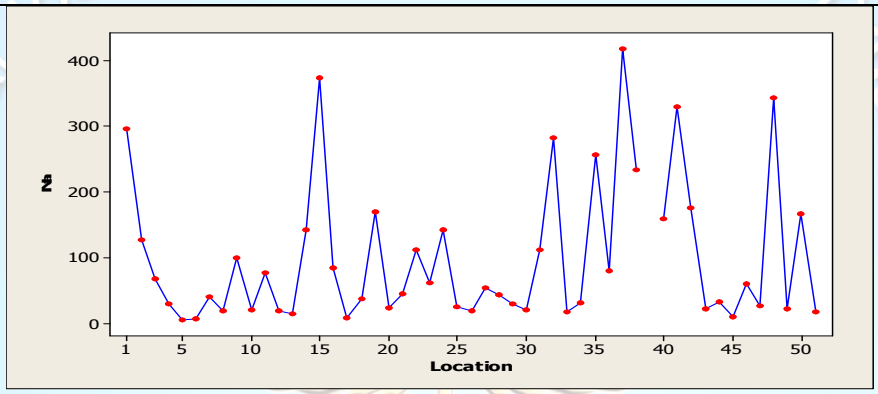


Fig 7. Variation of Na in all the locations

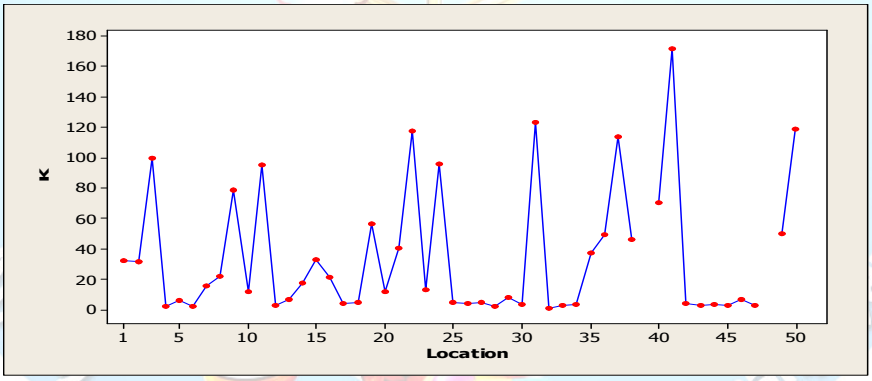


Fig 8. Variation of K (mg/L) in all the locations

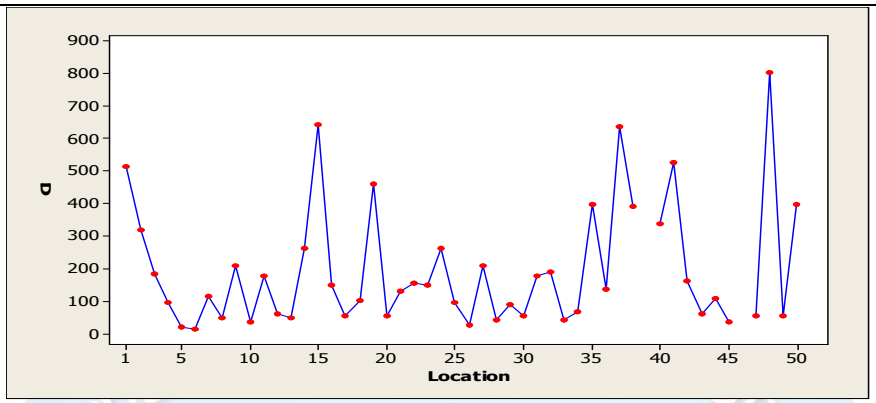


Fig 9. Variation of Cl (mg/L) in all the locations

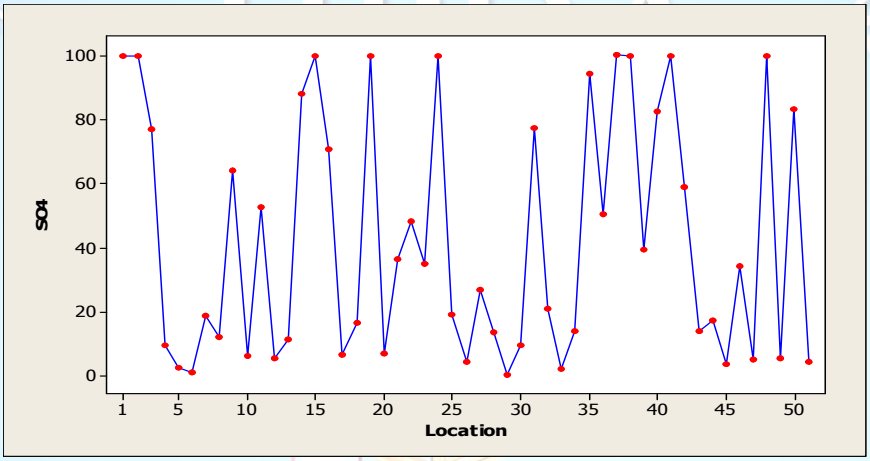


Fig 10. Variation of SO_4 (mg/L) in all the locations

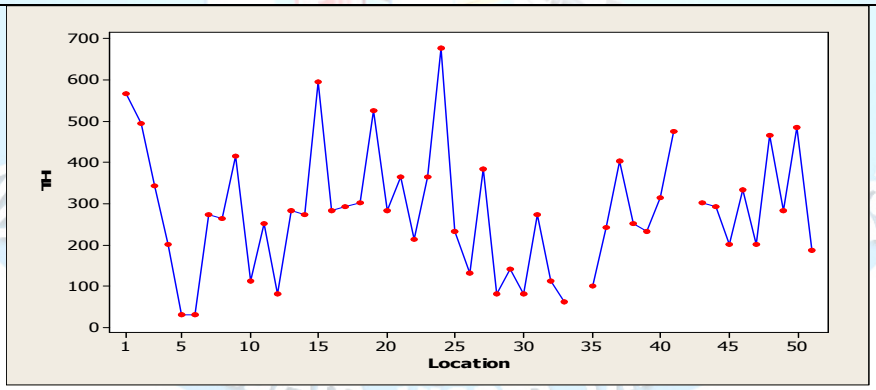


Fig 11. Variation of TH (mg/L) in all the locations

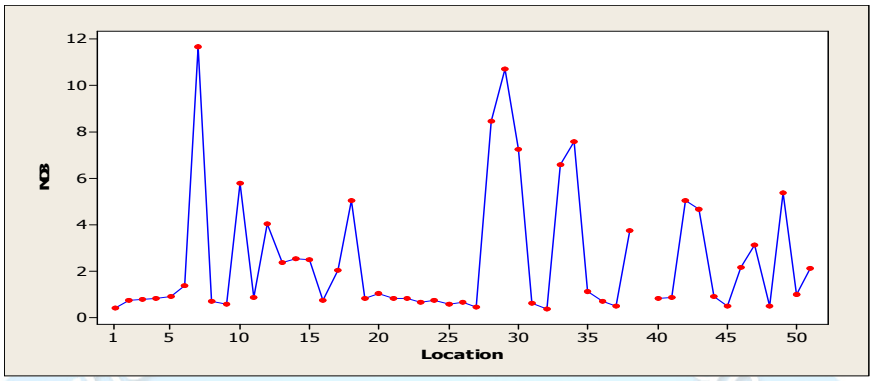


Fig 12. Variation of NO_3 (mg/L) in all the locations

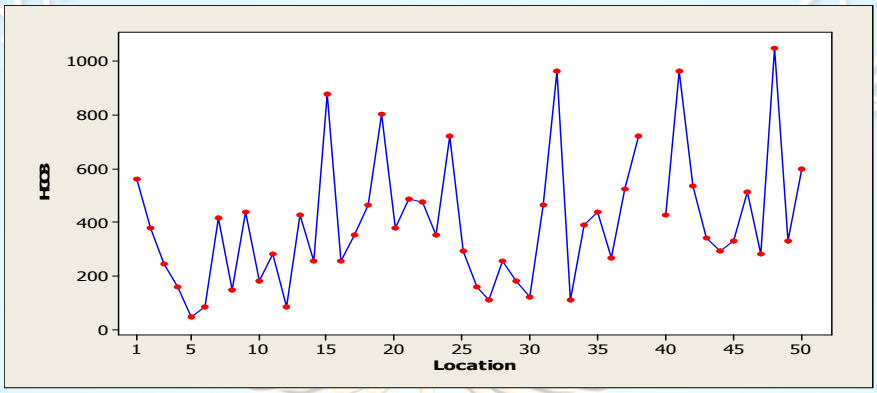


Fig 13. Variation of HCO_3 (mg/L) in all the locations

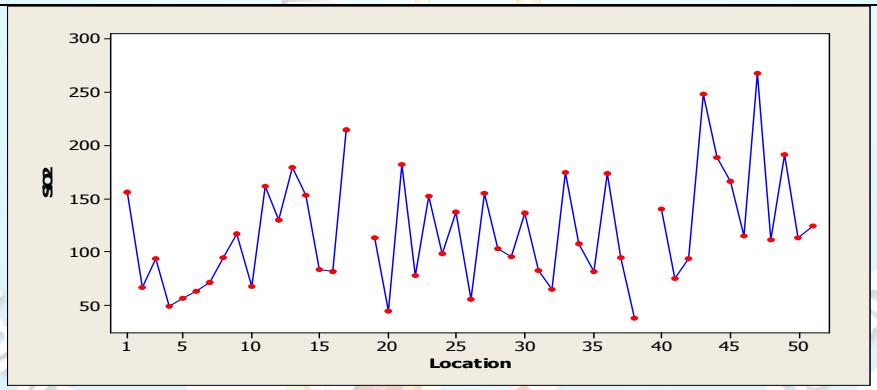


Fig 14. Variation of SiO_2 (mg/L) in all the locations

Conclusion

During last decades need on groundwater increased tremendously with population and water demands. In the present study, samples from 50 locations surrounding Uddanam region showed high concentration of silicates. People are suffering from different health hazards due to which we have chosen this area for assessment of water quality. From this study it is found that the water in some parts is not safe for consumption/irrigation purposes. Except for silicates, the composition of TDS ,Na ,Cl , and Ca of most of the ground water samples lies in the range of drinking water with comparison data (WHO&BIS 2012) standards for drinking water. It is suggested that regular monitoring of groundwater quality is required to assess the pollution activity from time to time for taking

necessary measures to mitigate the intensity. 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, effects and prevention of groundwater pollution and also the consequences of impacts of pollution on human health. This study has revealed that SiO_2 values are of great significance in understanding the level of origin of groundwater and hydro geochemical processes, geo-genic or anthropogenic,that may influence the distribution of major ions in groundwater.

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