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# Physico-Chemical Characteristics of Ground Water of Vuyyuru, Part of East Coast of India

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## Abstract:

**Quality of water is an important criterion for evaluating the suitability of water for drinking and irrigation. The ground water samples were collected and subjected for a comprehensive physico – chemical analysis. The following 19 parameters have been considered viz. pH, Electrical Conductivity, Alkalinity, Total hardness, Total Dissolved Solids, dissolved oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, phosphate, sulphate, chloride, nitrate, cadmium, manganese, iron, nickel, zinc, copper and lead. On comparing the results against drinking quality standards laid by World Health Organization, it was found that some of the water quality parameters were above the permissible limit and some were not. More over this study may help other regions in understanding the potential threats to their ground water resources.**

**Keywords:** Biological Oxygen Demand, Ground water samples, Sulphate, Total hardness.

## 1.0 Introduction:

Ground water is considered as one of the purest forms of water available in nature and meets the overall demand of rural as well as urban population. With the growth of industry the ground water is made susceptible for contamination due to addition of waste materials. Waste materials from the factories percolate with rain water and reach aquifer resulting in erosion of ground water quality. Groundwater is used for domestic, industrial, water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population, unplanned urbanization, industrialization and too much use of fertilizers and pesticides in agriculture (Joarder et al., 2008). Ground water meets domestic needs of more than 80 % rural and 50 % urban population besides irrigation. Around two fifth of India's agriculture output is contributed from areas irrigated by groundwater (Anita and Gita, 2008). Over exploitation of ground water through the bore well and their improper handling resulted in very low ground water levels besides contamination of even bore waters at some places. The addition of various kinds of pollutants and nutrients through the agency sewage, industrial effluents, agricultural runoff etc. in to the water bodies brings about a series of changes in the physicochemical characteristics of water, which have been the subject of several investigations (Mahananda et al., 2010). The availability of ground water depends upon the rate at which it is recycled by hydrological cycle than on the amount that is available for use at any moment in time. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored back easily and to device ways and means to protect it (Maniyar, 1990). Consequently number of cases of water borne diseases has been seen which cause health hazards [Elizabeth and Naik, 2005; Aremu et al., 2011). An understanding of water chemistry is the bases of the knowledge of the multidimensional aspect of aquatic environmental chemistry which involves the source, composition, reactions and transportation of water. The quality of water is of vital concern for the mankind since it is directly linked with human welfare. Therefore, monitoring the quality of water is one of the essential issues of drinking water management (Shama et al., 2011).Considering the above aspects of groundwater contamination, the present study was undertaken to investigate the impact of the groundwater quality water samples at Vuyyuru of Krishna district, A.P, India. To communicate information on the quality of water to

the concerned citizens and policy makers, analysis of water is utmost important. It thus, becomes an important factor for the assessment and management of ground water. Thus, in this research work an attempt has been made to assess the physical and chemical parameters of ground water like pH, electrical conductivity, Total hardness, Total dissolved solids, dissolved oxygen, Alkalinity, Biological Oxygen Demand, Chemical Oxygen Demand, Phosphate, Sulphate, nitrate, Chloride and Heavy metals (Cd, Mn, Ni, Zn, Cu, Fe and Pd). The analyzed data were compared with standard values recommended by WHO.

**1.1 The Study Area :**The study area lies within longitudes **$80^0$ 51′ 0″E** and latitudes **$16^0$ 22′0″ N** situated 30 km away from Vijayawada and 45 km from Machilipatnam, on National Highway (NH9). Vuyyuru is a popular sugar cane growing area in Krishna district of Andhra Pradesh with population of 45,000 and is a major panchayat.

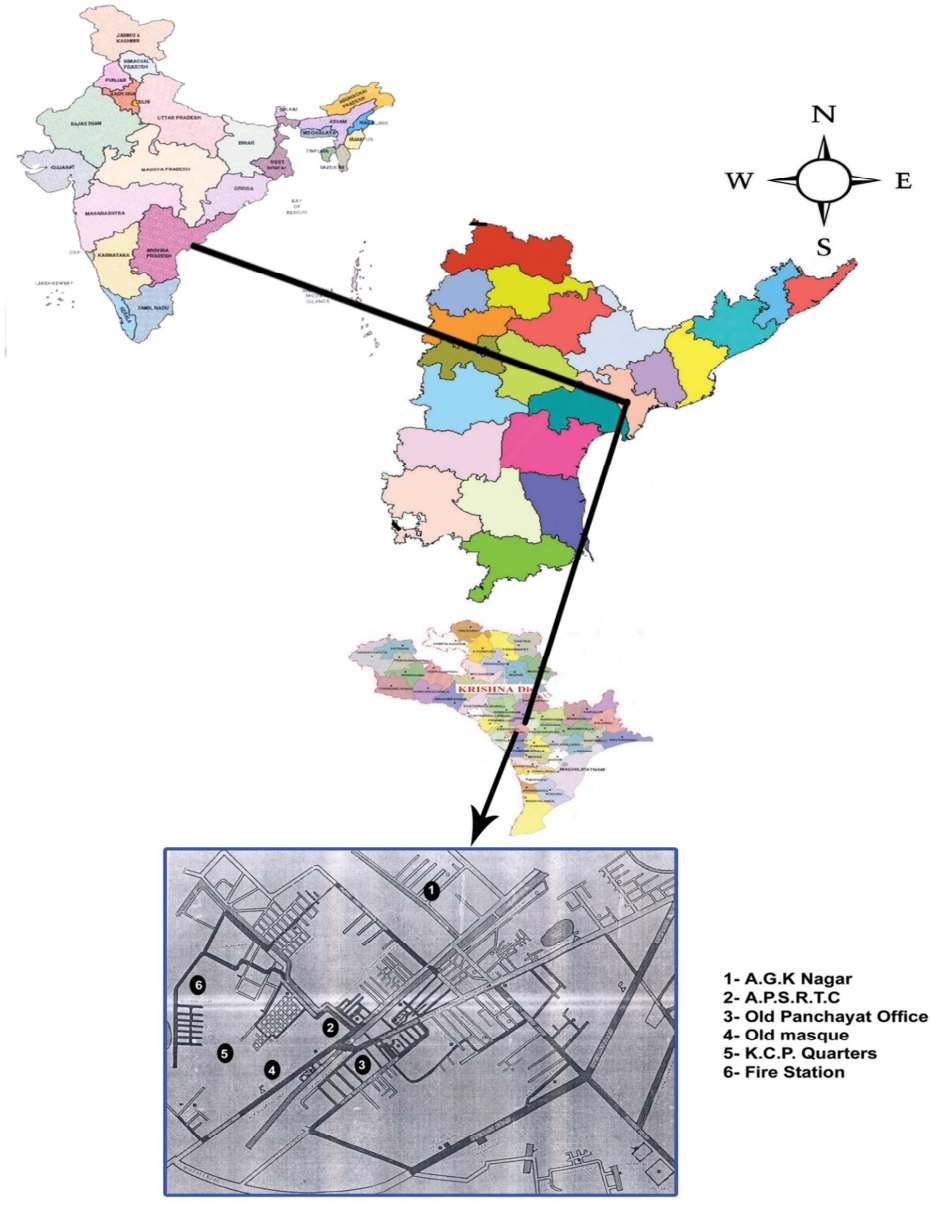


**Fig. 1 Location map of study area**

## 2.0 Materials and Methods:

### 2.1 Collection of water Samples

Groundwater samples were collected from 6 locations, Sampling is done at each station in polythene bottles of two-litre capacity. The samples were analysed various water quality parameters such as temperature, pH, electrical conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Alkalinity, Total Hardness (TH), Chloride, Phosphate, Biological Oxygen Demand, Chemical Oxygen Demand, sulphate, nitrate, iron, cadmium, lead, manganese, nickel, zinc and copper using standards procedures described in NEERI Manual (1984). The methods used for estimation of various physico - chemical parameters are tabulated in Table 1.

**Table1 Methods used for estimation of Physico - Chemical parameters**

| S. No | Parameter | Methods |
|---|---|---|
| 1 | pH | pH meter (Elico Make) |
| 2 | Electrical Conductivity | Conductivity meter (Elico) |
| 3 | Total Hardness | EDTA titration |
| 4 | Alkalinity | Indicator method |
| 5 | TDS | Filtration method |
| 6 | Chloride | Silver nitrate method |
| 7 | Phosphate | Ammonium molybdate blue method |
| 8 | Dissolved Oxygen | Wrinkler's method |
| 9 | BOD | Wrinkler's method |
| 10 | COD | Open reflux method |
| 11 | Sulphate | Turbidimetric Method (Elico) |
| 12 | Nitrate | Phenol disulphonic acid method |
| 13 | Heavy metals (Cd, Mn, Ni, Zn, Cu, Fe and Pd | Flame Atomic Absorption Spectrophotometer (GCB Avanta Make) |

## 3. 0 Results and Discussion:

The results obtained from analysis of six ground water samples are given in Table 2.**pH:** pH is a measure of the hydrogen ion concentration in water and indicates whether the water is acidic or alkaline. The measurement of alkalinity and acidity of pH is required to determine the corrosiveness of the water. The standard values of pH for drinking water by BIS is between 6.5-8.5 while, WHO is between 7.0 - 8.5. pH value for drinking water is limited from 5.5 to 8.5 and for effluent discharge it is between 5.5 and 9 as per IS: 2490 and CPCB. High value of pH may results due to waste discharge, microbial decomposition of organic matter in the water body (Patil et al., 2012).In the present study all the samples have pH values below the prescribed values (Fig. 2).

**Electrical Conductivity:** Conductivity is ability of water to carry an electrical current. This ability mainly depends on presence of anion and cations in water and also depends on mobility, valence of ions and temperature. High electrical conductivity affected the germination of crops and it may result in much reduced yield (Srinivas et al., 2000). Higher the ionizable solids, greater will be the EC. The WHO permissible limit for EC in water is 600 micromho $cm^{-1}$. In the present study the station – 4 and 6 showed higher electrical conductivity when compared to the permissible limit (Fig. 2).

**Alkalinity:** Alkalinity value in water provides an idea of natural salts presents in water. In the present study the alkalinity are ranged from 308.8 – 488.3 mg/L. The alkalinity values are under the reasonable limit 600 mg/l as per WHO (1993). Yadav et al.,2012 reported the total alkalinity (330 – 525 mg/L) in Agra city.

**Total dissolved solids (TDS) and Hardness:** Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water (Patil and Patil, 2010) Hardness although have no health effects it can make water unsuitable for domestic and industrial use. Total Hardness of bore well water under the

area determined in the present investigation ranged from 221.1 to 420 mg/L. Similarly the minimum and maximum values of total hardness recorded were 259 and 658 mg/L respectively (Ramesh et al., 2012). Station 2 and 3 showed high TDS when compared to 1,4, 5 and 6 respectively (Table 1; Fig. 2; Fig 3a & 3b). Pandey and Tiwari, 2009 reported the Total Dissolved Solids values ranged from 145 -245mg/L.

**Dissolved Oxygen (DO):** Dissolved oxygen is an important parameter in water quality assessment and biological processes prevailing in the water. The DO values indicate the degree of pollution in the water bodies. The presence of dissolved oxygen (DO) enhances the quality of water and also acceptability. An ideal DO value of 5.0 mg/l is the standard for drinking water (Bhanja and Ajoy, 2000). Dissolved oxygen (DO) of bore well water under the area determined in the present investigation ranged between from 4.27 – 5.16 mg/L.

**BOD:** Biochemical oxygen demand (BOD) is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. It is not a precise quantitative test, although it is widely used as an indication of the organic quality of water (Suthar et al., 2012). According to WHO (1993), the permissible limit of BOD in water is 5 mg/L. However, in all six stations samples showed the permissible limits.

**COD:** Chemical Oxygen Demand (COD) is a measure of pollution in aquatic system. High COD may cause oxygen depletion on account of decomposition by microbes (Siva Kumar et al., 1989) to a level detrimental to aquatic life. In the present study COD values are found to be 5.28 to 10.14 mg/L (Fig.3b).

**Table 2: Physico - Chemical characteristics of ground water samples**

| Parameters | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 |
|---|---|---|---|---|---|---|
| pH | 7.16 | 7.29 | 7.39 | 7.36 | 7.32 | 7.62 |
| EC µmhos/cm | 540.44 | 526.66 | 520.11 | 623.55 | 530.77 | 609.33 |
| TDS (mg/L) | 647.25 | 894.77 | 907.95 | 699.25 | 746.25 | 625.65 |
| Alkainity (mg/L) | 308.88 | 488.33 | 485.55 | 368.33 | 366.66 | 324.88 |
| Total Hardness (mg/L) | 400.55 | 420 | 474.44 | 319.44 | 358.88 | 221.11 |
| DO (mg/L) | 4.27 | 4.41 | 4.97 | 5.16 | 5.11 | 5.06 |
| BOD (mg/L) | 1.64 | 1.65 | 1.78 | 1.98 | 1.84 | 1.58 |
| COD (mg/L) | 10.14 | 8.28 | 9.08 | 11.58 | 7.56 | 5.28 |
| Phosphate (mg/L) | 0.36 | 0.32 | 0.39 | 0.31 | 0.66 | 0.44 |
| Sulphate (mg/L) | 78.82 | 74.05 | 43.46 | 61.57 | 81.39 | 43.17 |
| Chloride (mg/L) | 198.36 | 247.94 | 222.04 | 212.9 | 172.45 | 247.05 |
| Nitrates (mg/L) | 2.47 | 5.35 | 2.41 | 2.78 | 3.32 | 3.11 |
| Cadmium (mg/L) | 0.02 | 0.03 | 0.05 | 0.01 | 0.08 | 0.07 |
| Manganese (mg/L) | 0.68 | 0.15 | 0.07 | 0.53 | 0.56 | 0.29 |
| Iron (mg/L) | 0.56 | 0.36 | 0.20 | 0.21 | 0.19 | 0.16 |
| Nickel (mg/L) | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 |
| Zinc (mg/L) | 0.29 | 0.39 | 0.57 | 0.36 | 0.05 | 0.23 |
| Copper (mg/L) | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Lead (mg/L) | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.06 |

**Phosphate ($PO_4^{3-}$):** Phosphate may occur in ground water as a result of domestic sewage, detergents, agricultural with fertilizers and industrial waste water. The phosphate content in the study area was found in the range of 0.31 mg/L to 0.66 mg/L (Fig. 3b). Samples obtained more than the normal range due to percolation of sugar mill effluent in addition to the agricultural runoff. This is true, because, the sugar manufacturing process involves the usage of super phosphate of lime or phosphoric acid which may contribute phosphate to the effluent (Dhembare *et al*., 1998)

**Sulphate:** Sulphate is found in small quantities in ground water. Sulphate may come into ground water by industrial or anthropogenic additions in the form of Sulphate fertilizers. Sulphates of bore well water in the study area ranged from 43.17 to 81.39 mg/L. The sulphate values of the entire sample for all stations lie within the permissible limits of WHO (1993) (250 mg/L).

**Chloride:** Chloride a major anion in potable and industrial water has no adverse effect on health, but imparts bad taste to drinking water. The chloride concentration serves as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects (Fried and Combarnous, 1971). Chlorides of bore well water in the study area ranged from 172.46 to 247.94 mg/L.

**Nitrate ($NO_3$):** The high nitrogen content is an indicator of organic pollution. It results from the added nitrogenous fertilizers, decay of dead plants and animals, animal urines feces, etc. They are all oxidized to nitrate by natural process and hence nitrogen is present in the form of nitrate of bore well water under the area determined in the present investigation ranged from 2.41 to 5.36 mg/L (Fig. 3b). The increase in one or all the above factors is responsible for the increase of nitrate content (Rahman, 2002). The ground water contamination is due to the leaching of nitrate present on the surface with percolating water. Nitrate in high concentration has been observed in ground water of Churu of Rajasthan (Kugali et al., 2013). Moreover, the increased nitrate level in drinking water may adversely affect the central nervous system (Chern et al., 2005).

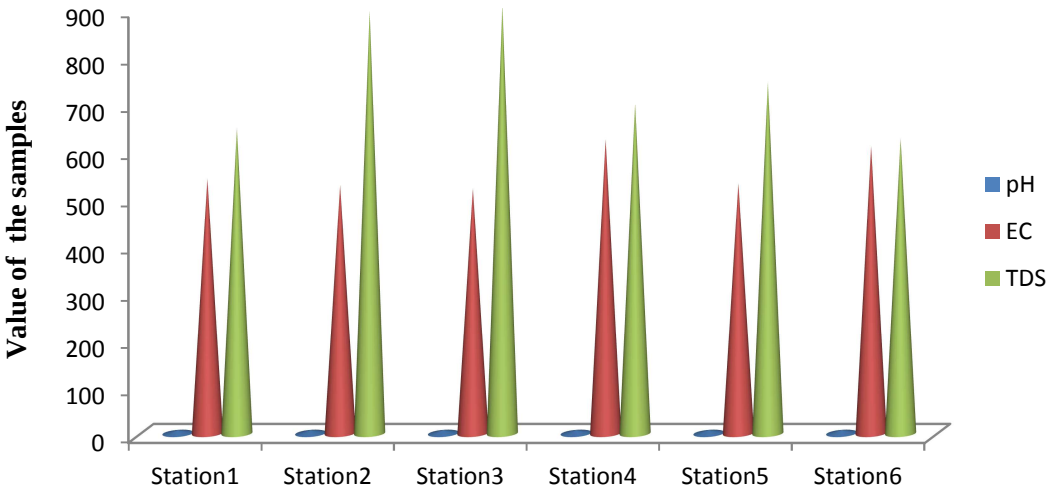


**Fig. 2** physical parameters of Ground water

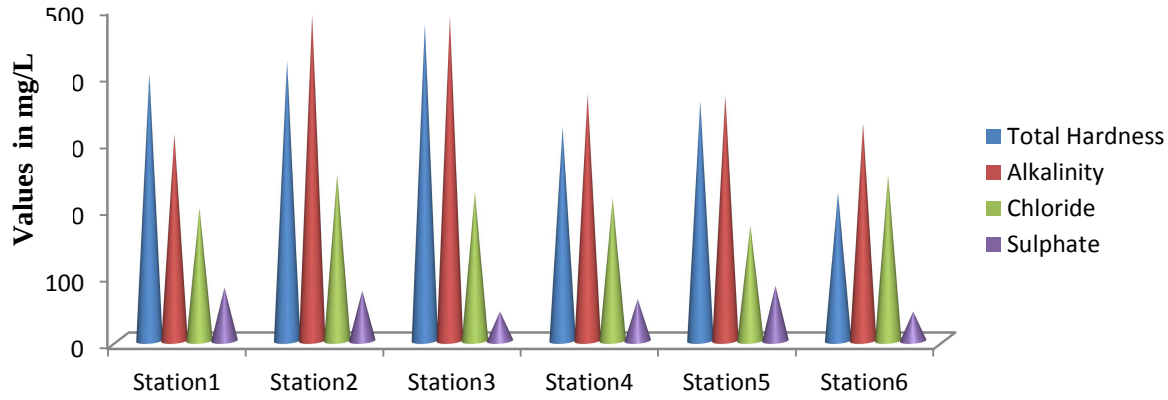


**Fig. 3a.** Chemical parameters of Ground water

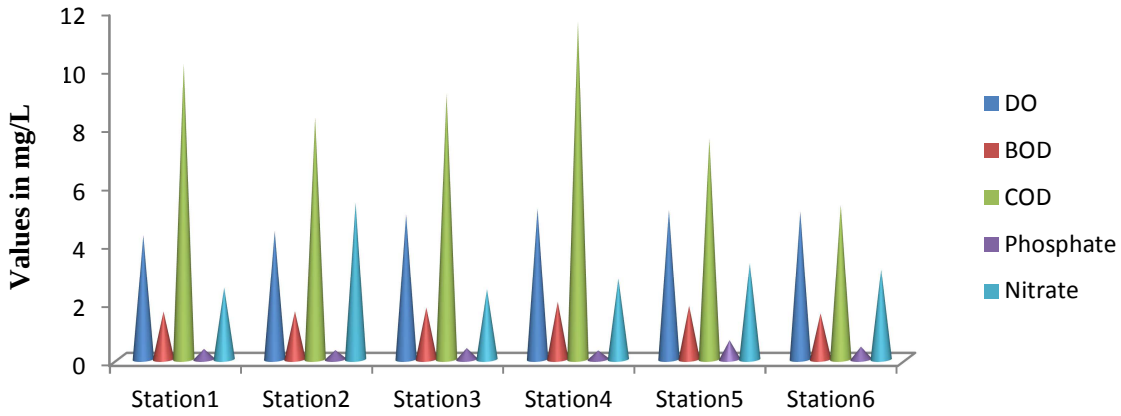


**Fig 3b.** Chemical parameters of Ground water

## 3.1 Heavy metals

**3.1a Cadmium (Cd):** In the present study the concentrations of Cadmium of all the stations ranged from 0.01 to 0.08 mg/L (Fig. 4). All the values were within the permissible limits. Important source of cadmium is the use of mineral phosphate fertilizer, which typically contains high cadmium concentrations in addition to other elements (Lambert et al., 2007).

**3.1b Manganese (Mn):** The concentrations of Manganese (Mn) in the present study ranged from 0.07 to 0.68 mg/L. The Manganese concentrations were slightly exceeding the desirable limit (0.05 mg/L) in all the stations (Fig. 4). According to the study the values of manganese are recorded between the range of 0.01 – 0.08 ppm (Zahir Hussain and Mohamed Sheriff, 2013).

**3.1c Iron (Fe):** The concentrations of Iron in the present study in all the stations ranged between 0.160 and 0.560 mg/L. Concentrations of Iron (Fe) in the study area showed wide variations. Abdul Jameel et al., 2012 investigated the iron content of the ground water sample in the monsoon has maximum value of 0.46 ppm at S6 and minimum of 0.12 ppm at S5,respectively.

**3.1d Nickel (Ni):** In the present study Nickel are found to be 0.01to 0.03 mg/L (Fig. 4). The minimum and maximum concentrations of nickel were found to be 0.011to 0.098 mg/L in and around tirupati, Chitoor district, A.P. (Hanuman Reddy et al., 2012).

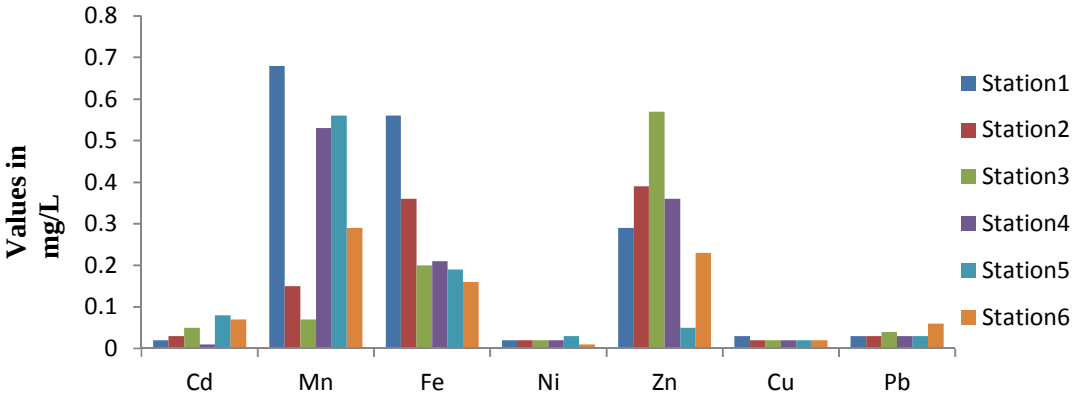


**Fig. 4 Heavy metals in ground water**

**3.1e Zinc (Zn):** The concentrations of Zinc (Zn) were below the desirable limit. In the present study all the stations showed values between 0.05 and 0.56 mg/L. Zinc is a nutritionally essential element. It is necessary for growth and is involved in several physiological functions. Buragohain et al., 2009 also investigated the zinc contents in ground water are much below the guideline value of 5 ppm.

**3.1f Copper (Cu):** The concentrations of Copper (Cu) were below the desirable limits. All the stations showed the concentrations between 0.02 and 0.03 mg/L (Fig. 4). The low concentrations of copper might be due to non utilization of copper compounds either as raw material or intermediates in the nearby industrial areas and agricultural practices.

**3.1g Lead (Pb):** The concentrations of Lead in the present study ranged between 0.03 and 0.06 mg/L.The concentrations of lead (Pb) were in general very low and less than the permissible limits. Shrivastava and Mishra, 2011 reported the lead metal ranged from 0.006 to 0.110 mg/L in surface water and 0.003 to 0.060 mg/L in ground water samples.

## 4.0 Conclusion:

The present study was undertaken with an aim to analyze certain physico - chemical parameters in the ground water samples in Vuyyuru, Krishna district. In nutshell, the parameters analyzed have shown that they are all within the permissible limits for drinking water except EC, TDS TH and Mn in certain water samples. Eighty percent of the wells located from 150 to 300m are contaminated and have been showing higher values for 20 % of the total parameters studied. Heavy metal pollutants have the values of Fe, Cu, Zn and Pb below the WHO maximum permissible values. It may be concluded that there is definite impact of industrial waste on the quality of ground water in near future.

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