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Nitrate Contamination in the Groundwater of Kalwakurthy area, Mahabubnagar District, Andhra Pradesh, India

KEYWORDS: Groundwater, Nitrate, Contamination, Kalwakurthy, Mahabubnagar District.

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ABSTRACT *Groundwater forms the major source of drinking water in the rural areas of most of the developing nations of the world. Presence of high concentration of nitrate in groundwater is a major problem in many countries as it causes health related problems. The present study is carried out to understand the distribution of nitrate concentration in groundwater in parts of Kalwakurthy Area, Mahabubnagar District, Andhra Pradesh. Though groundwater is the major drinking water source, deterioration in its quality is going unchecked. In rural areas, the nitrate contamination is rampant and much attention has not been drawn towards this anthropogenic pollution.*

In the study area 56 groundwater samples have been collected and analyzed for the major ions such as Electrical Conductivity (EC), pH, Total Dissolved Solids (TDS), Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, CO_3^-, SO_4^-, NO_3^- and F^-. The study revealed that 43% of the samples were found to be unsuitable for drinking purposes due to excess nitrate (>45 mg/l) content in the groundwater. High Nitrate concentration may cause blue baby syndrome or methemoglobinemia.

Introduction:
Water is one of the most essential requirements of all living beings. For a long time, groundwater has been considered as a well protected resource. The reason for this was the belief in self purification of the soil and as a rule the protection of groundwater by the covering layers. Man's influence on the quality of water is quite apparent and now a major concern. Groundwater has to be protected generally as it forms a principal source for drinking water and as it represents also a precious ecological part within the balance of water cycle

Nitrogen, an element considered to be the most abundant in the atmosphere, composing nearly 80% [1], can be found in many forms, the major ones being N_2, N_2O, NO, NO_2, NH_3[2]. Nitrate is part of the nitrogen cycle in nature and it represents the most oxidized chemical form of nitrogen found in the natural systems. All living systems need nitrogen for their existence since it is used to build many essential components such as proteins, DNA, RNA, vitamins, and as well as hormones and enzymes. Nitrates, though very essential for the very existence of life, is also one of the most widespread pollutants of groundwater in many parts of the world and in several instances this is due to the intensification of agriculture [3].

Nitrate is a common surface water and groundwater contaminant that can cause health problems in infants and animals, as well as the eutrophication of water bodies [4]. As the geological sources of nitrogen are very rare, the presence of nitrate in groundwater is mostly due to anthropogenic activities. Nitrate when present in high levels would cause methemoglobinemia where they bind with the red blood cells and reduce their ability to carry oxygen. The consumption of nitrate rich water cause a large number of diseases like dizziness, abdominal disorder, vomiting, weaknesses, high rate of palpitation, mental disorder and even stomach cancer etc [5-8]. Consumption of drinking water with nitrate, at concentrations greater than 50 mg/l causes Blue baby syndrome, a disease where the skin becomes blue due to decreased efficiency of hemoglobin to carry the oxygen [9]. This phenomenon can occur in infants when approximately 70% of total hemoglobin has been converted to methemoglobin [10]. As the groundwater is at a constant threat of being polluted because of natural and anthropogenic sources, the present study is carried out to understand the distribution of these ions and their probable sources. As the groundwater is at a constant threat of being polluted because of natural and anthropogenic sources, the present study is carried out to understand the distribution of these ions and their probable sources.

Study Area:
The study area covering about 237 sq. Km falls in Mahabubnagar district of Andhra Pradesh. It is located 80 km from Hyderabad, India on Srisailam highway. It is around 56 km from the District head quarter Mahabubnagar. Kalwakurthy lies in between North Latitudes 16° 34′ 30″ to 16° 42′ 00″ and East longitudes 78° 24′ 00″ to 78° 28′ 48″ (figure 1) and falls in the Toposheet No. 56 L/6 and 56 L/10. The climate of the study area is generally hot. Average Temperature in summer is 40.9^{0}C, in winter is 25^{0}C and rainfall is 604 mm.

Geology:
Mahabubnagar district forms a part of the stable Dharwar craton of south Indian shield. It exposes rocks of peninsular gneissic complex, Dharwar super group, Cuddapah super group, and Kurnool and Bhīma groups and also of Deccan traps. The Peninsular Gneissic Complex, which covers most of the area, comprises granites, gneisses and migmatites with undigested patches of older metamorphic rocks [11]. Grey granite occupies dominant portion of the area (Fig.2) these rocks are composed of quartz, feldspars, and biotite. These are medium to course grained and equigranular in texture. The typical grey colour is due to the presence of the plagioclase feldspars and quartz. The potash feldspars that are present in the rock are orthoclase and microcline but in less abundance. Biotite is the most predominant mineral in these rocks.

Materials and methods:
In order to assess the groundwater quality, 56 groundwater samples have been collected. The water samples collected

in the field were analyzed for electrical conductivity (EC), pH, total dissolved solids (TDS), Total Hardness (TH), major cations like calcium, magnesium, sodium, potassium and anions like bicarbonate, carbonate, chloride, nitrate and sulphate, trace element like fluoride in the laboratory using the standard methods given by the American Public Health Association [12]. Sampling was carried out using pre-cleaned polyethylene containers. The results were evaluated in accordance with the drinking water quality standards given by the (WHO, 2004) and (Bureau of Indian Standards) [13]

The pH was measured with Digital pH Meter (Model 802 Systronics) and EC was measured with Conductivity Meter (Model 304 Systronics), Sodium and Potassium was measured with Flame photometer (Model Systronics 130). Sulphates and Nitrates were measured with Spectronics 21 (Model BAUSCH & LOMB), Carbonate, Bicarbonate, Calcium, Magnesium, Total Dissolved Solids, Total Hardness, and Chloride by titrimetric methods, Fluoride concentration was measured with Orion ion analyzer with fluoride ion selective electrode. Nitrate was determined by spectrophotometer. The concentration of EC is expressed in μS/cm at 25°C and TDS, TH, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, $C1^{-}$, SO_4^{-}, NO_3^{-}, CO_3^{-}, HCO_3^{-} and F^{-} are expressed in mg /l. Location map of the water sample is shown in the (Fig.1). The analytical results are presented in Tables 1. The concentrations are compared with the standards (WHO, 2004; BIS, 2009) and the statistical parameters of the variables such as minimum, maximum mean of different chemical parameters of groundwater are given in Table 2. Distribution map is generated for Nitrate with the help of GIS software to know the spatial distribution of the concentrations Fig (2).

Results and Discussion:
The pH and Electrical Conductivity (EC) values of the study area are ranging from 7.42 to 8.8 and 78.44 to 1568.8 μ S/cm, respectively. In the study area, the Na^{+} and K^{+} concentrations are in groundwater ranging from 17 to 182 and 10 to 47 mg/L, respectively. The concentrations of calcium ranging from 16.03 to 154.03 mg/L. The concentrations of Mg^{++} and HCO_3^{-} ions found in the groundwater samples of study area are ranging from 2.91 to 83.83 and 48.8 to 219.6 mg/L respectively. The concentration of chloride ranging from 21.3 to 678.05 mg/L. Sulfate ranging from 4 to 180 mg/L. The concentration of fluoride in groundwater of the study area varies between 0.17 to 2.57 mg/L. According to BIS (2009) and WHO (2004) standards pH by 5%, EC by 4%, Total Dissolved Solids (TDS) by 7%, Total Hardness (TH) by 38%, Calcium (Ca^{++}) by 7%, Carbonate (CO_3^{-}) by 89%, Chloride (Cl^{-}) by 7%, Magnesium (Mg^{++}) by 29%, Potassium(K^{+}) by 89%, Fluoride (F^{-}) by 44% exceed the permissible limit.

Nitrate (NO_3):
Chemical analysis of nitrate shows that the concentration was higher in 24 samples which are total of 43% samples (BIS, 2009). The concentration of Nitrate was ranging from 1.1 to 112.5 mg/L with an average value of 40.2 mg/L. From fig. 2, it is clear that the value of nitrate concentration is found maximum in sample S55 (112.5 mg/l), followed by S39 (100 mg/l) and S20 (88 mg/l) representing the drinking waters of Ushodaya College Kalwakurthy, Marchala, and Panjagul areas respectively and it is observed that the concentration of Nitrate is high in the northern part of the area. The main source of this nitrate pollution is attributed to the excessive use of nitrogenous fertilizers, as these areas are mainly agricultural areas. Moreover, plants absorb nitrate fertilizer through roots, which is then transformed into microorganisms [14]. The compensation of nitrate is insignificant in the soil environment [15] and hence nitrate percolates into groundwater.

Following remedial steps can reduce the risk of nitrate contamination:

1. Proper well location: wells should be located uphill (up gradient) and at least 100 feet away from septic tanks, leach fields, animal confinement areas, and fertilized areas.
2. Proper well construction: make sure that the well casing extends above the ground, and construct an earth berm around the well to divert surface runoff away from the wellhead. Also, make sure your well has at least a 50- foot-deep annular seal (grouting around the outside of the well casing) and an intact concrete slab on the wellhead.
3. Operate your septic system correctly: maintaining the septic system regularly will help avoid system failure, which can lead to water contamination, the spread of disease, and the need for costly repairs. Follow these guidelines:

a. Do not run heavy vehicles over the area above your septic tank, drain pipes, or leach field.
b. Avoid planting trees or shrubs near drain pipes or the leach field. Roots can clog the lines.
c. Do not dispose of chemicals or non-biodegradable materials in your toilet or drain.
d. Conserve water.
e. If you have two leach fields, switch them every year and
f. Reverse Osmosis, ion exchange and biological denitrification method can be used to reduce nitrate concentration

Conclusion:
Hydrochemical studies of the Kalwakurthy area and its environs indicate that the concentration of nitrate is higher than permissible limit (45 mg/l) in most of groundwater collected from bore wells. The chief sources of nitrate pollution in the study area are agricultural activities, septic tanks, and human and animal wastes. Among the agricultural sources, the common sources are inorganic fertilizer, urea. Septic systems, animal waste, and fertilizer are all potential sources of nitrate contamination. Water that comes into contact with a source of nitrate can carry that contamination through the soil and into the groundwater supply. The appropriate remedial measures should be implemented in order to restore the aquatic ecology of the polluted area.

The most effective way of reducing the nitrogen content of groundwater in the areas where agriculture is the main occupation is to reduce the application of fertilizers in consultation with agriculture scientists and change the cropping pattern by going in for irrigated dry crops which consume less water and fertilizers. It is suggested that frequently modifying the cropping sequences offer possible ways to scavenge the nitrogen and provide fluoride-free drinking water in the study area.

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Table 1: Analytical Data of the Groundwater in the Study Area

S. NO	NO_3^- (mg/L)	S. NO	NO_3^- (mg/L)	S. NO	NO_3^- (mg/L)
S1	25	S23	66	S45	75
S2	25	S24	21	S46	28
S3	88	S25	5.1	S47	3
S4	9	S26	20	S48	67
S5	13	S27	85	S49	50
S6	22	S28	66	S50	3
S7	5	S29	31	S51	20
S8	66	S30	66	S52	28.1
S9	9	S31	66	S53	67
S10	15	S32	88	S54	24
S11	8.2	S33	31	S55	113
S12	1.1	S34	35	S56	20
S13	66	S35	15		
S14	66	S36	7.5		
S15	1.1	S37	75		
S16	6.1	S38	28		
S17	13	S39	100		
S18	20	S40	113		
S19	66	S41	24		
S20	88	S42	41		
S21	6.1	S43	33		
S22	11	S44	75		

Table 2: Comparison of Results of the Study Area with BIS, WHO Standards

Parameter	Minimum	Maximum	Mean	Median	Std. Dev	Acceptable Limit(WHO,2004) (BIS, 2009)	% of samples exceeding the limit
pH	7.42	8.8	8.04	8.1	0.29	6.5-8.5	5
EC	78.44	1569	387.88	314	272.86	1500	4
TDS	50.2	1004.03	248.2	201	174.57	500	5
CO_3^-	0	15	7.411	6	3.46	10	89
HCO_3^-	48.8	219.6	122.35	122	38.81	500	Nil
Cl^-	21.3	678.05	123.75	56.85	135.62	250	7
TH	75	560	206	172	104.28	200	39
Ca^{++}	16.03	154.03	41.232	32.000	26.535	75	5
Mg^{++}	2.91	83.83	26.326	23.000	17.107	30	29
Na^+	17	182	55.589	44.500	35.608	250	Nil
K^+	10	47	15.161	14.000	6.771	10	89
SO_4^-	4	180	29.705	20.000	33.83	200	Nil
NO_3^-	1.1	112	39.63	28	31.84	45	43
F^-	0.17	2.57	1.13	0.94	0.66	1	46

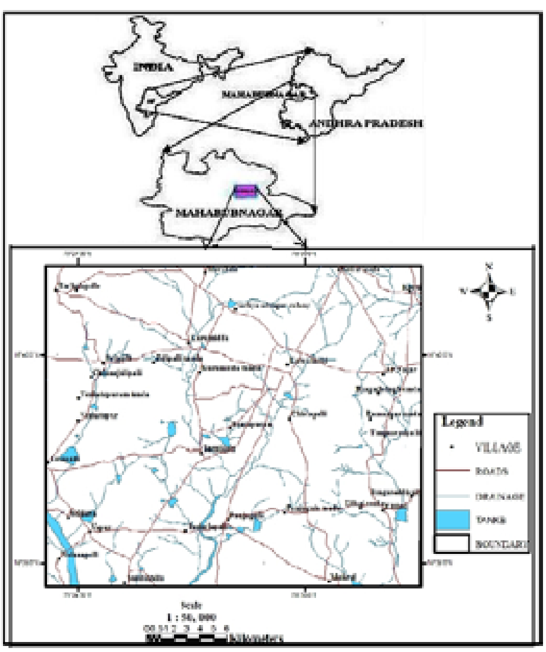

Fig 1. Location Map of the Study Area with Water Samples

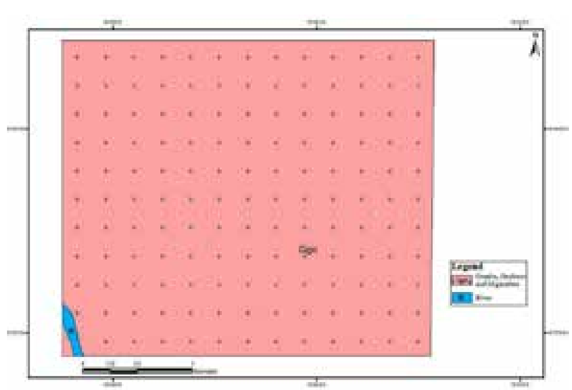

Fig 2: Geological Map of the Study Area

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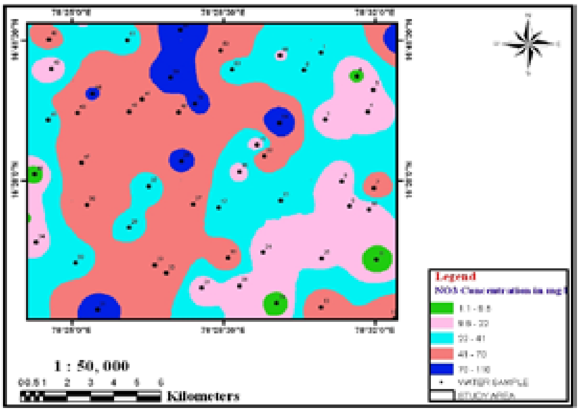

Fig 3. Map Showing Distribution Pattern of Nitrate (NO_3^-)

REFERENCE

1. Berner E., and Berner R., The global water cycle (pp. 102–119). New Jersey: Prentice Hall (1987). | 2. Gaillard J. F., Feb. 1 Lecture on Nitrogen cycle as referred in Nitrogen pollution of groundwater-prepared by Lee Haller et al (1995) | 3. Goldberg V. M., Groundwater pollution by nitrates from livestock wastes. Environ Health Perspect, 83, 25– 29 (1989). | 4. Fennesy M.S., and Cronk J.K., The effectiveness and restoration potential of riparian ecotones for the management of nonpoint source pollution, particularly nitrate. Crit Rev Environ SciTechnol, v. 27, pp.285-317 (1997). | 5. Pearlstein N.A., and Attala R., Neurologic sequel of plubism in children. Clinical Pediatics, v. 5, pp. 292-298 (1976). | 6. Reddy K.S.N., The essentials of forensic medicine and toxicology (5th Edition), Sugune, Hyderabad, India, 81 p (1981). | 7. Thind a. s., Role of toxic element in human on experiment condition. Journal of air and water pollution control, v. 22, pp. 267-270 (1982). | 8. Burt T.P., Heathwaite A.L., and Trudgill S.T., Nitrate process patterns and Management, John Willey, New York, 444p (1993). | 9. Canter L.W., Nitrates in Groundwater from agriculture practices causes, prevention and clean- UP. July. Report to United Nations Development Program, University of Oklahoma, Norman, Oklahoma (1987). | 10. WHO Guidelines to drinking water quality. World Health Organization, Geneva (1983). | 11. Geological Survey of India., Geology and minerals map of Mahabubnagar district, Andhra Pradesh, India (1995). | 12. American Public Health Association (APHA), Standard methods for Examination of water and wastewater. Sixteenth edition, A.P.H.A Washington (1995). | 13. BIS (Bureau of Indian Standards)., Indian standard drinking water specifications IS 10500: 1991, edition 2.2 (2003-09), New Delhi; Bureau of Indian Standards (2003). | 14. Srinivasa RY., Reddy TVK., and Naidu PT., Groundwater quality in the Niva River basin, Chittor district, Andhra Pradesh, India. Environ Geol (1):56-63 (1997). | 15. Srinivasa RY., Reddy TVK., and Naidu PT., Groundwater quality in the Niva River basin, Chittor district, Andhra Pradesh, India. Environ Geol (1):56-63 (1997). | 16. Lance JC., Nitrogen removal by soil mechanism. J Water Pollution Control 44:1352–1361 (1972). |