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Nitrate in Groundwater in Mathadi Vagu Basin Adilabad District. Telangana State, India

KEYWORDS: Groundwater, contamination, nitrate, water isotopes, agricultural fertilizers crystalline rocks.

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ABSTRACT *The objective of our study was to determine the groundwater quality in Mathadivagu basin, Adilabad district, Telanagana State, India. The study area lies between N. latitudes 19° 50' 48" and 20°13'30" and E. longitudes 78° 28' 25" and 78°58'00" with an area extent of 525 sq. kms. The current status of alluvial aquifer in the Mathadi vagu basin, where the nitrate pollution of groundwater is being increasing along the last decades. A multi approach methodology using hydrogeology, nitrate concentrations. The analytical results revealed that the groundwater in the major part of the area is highly mineralized with high concentrations of Nitrate. Out of 37 ground water samples analysed, 31 samples were found to have nitrate concentration more than 45mg/1. The maximum concentration of nitrate in the area is 407.4 mg/l. The concentration of nitrate in excess of the permissible limit i.e., 45 mg/l in drinking water causes Methaemoglobinemia, particularly in infants. Agricultural practices in the study sites are the main cause of serious nitrate pollution given the superimposition of high nitrate concentrations with the distribution of irrigated perimeters. High nitrate levels are associated with high values, clearly indicating that significant quantities of evaporated irrigation waters infiltrate along with fertilizer nitrate to groundwater system.*

Introduction
Groundwater nitrate pollution has become a widespread problem which affects all countries regardless of their development level. It reduces the potential of available freshwater resources, generates sanitation problems, especially in rural areas and jeopardizes the socioeconomic development of the country [3]. Such situations may become worse in arid and semi-arid areas where water resources are recharged slowly, irrigation returns are re-used intensively and evaporation rates are high.

Many studies have shown that anthropogenic activities, involving nitrogenous compounds such as mineral fertilizers and products of organic compounds from agriculture, septic systems and cattle manure, are the major factor leading to the increase of nitrate pollution [14].

What is nitrate?
Nitrate (NO3-) is one of the chemical forms of nitrogen. It coexists with other forms of nitrogen in a complex cycle. Nitrogen in soil and water originates from atmospheric deposition, applications of fertilizer, manure, waste material and dead plant and animal tissue. Under aerobic conditions, nitrate is a fairly stable form of nitrogen. Ammonium (NH4+) and organic nitrogen frequently convert quickly to nitrate.

Most of the nitrogen on earth is in the atmosphere, which consists of 78% N2 gas. Other forms of nitrogen, originating mainly from power plant emissions, internal combustion engines, fertilizer and manure, also occur in the atmosphere. These include nitrogen oxides (NOx and N2O), nitric acid (HNO3) and ammonia (NH3). Atmospheric nitrogen interacts with the earth's surface when N2 is "fixed" (changed chemically) by legumes or lightening, or when pollutants are washed-out in precipitation [5].

In most natural systems, inorganic nitrogen is a scarce nutrient. Plants efficiently use available nitrate and losses to groundwater and surface water are minimal. In agricultural systems, nitrate is added to increase profitability and production of non legume crops. It may be present in amounts exceeding what plants are able to use. As a result, excess nitrate can leach into groundwater or be washed into surface water. Nitrate in soil and water may also eventually cycle to the atmosphere by direct volatilization mainly under anaerobic conditions through a process called "Denitrification" [15].

Why are we concerned about nitrate in groundwater?
Human Health
Nitrate can cause a condition called Methemoglobenemia or "blue-baby syndrome" in infants under six months of age. Nitrate in drinking water used to make baby formula is converted to nitrite in the stomach. Nitrite changes hemoglobin in blood (that part of the blood that carries oxygen to the body) to Methemoglobin depriving the infant of oxygen. In extreme cases it can cause death. While Methemoglobenemia is a serious condition when it occurs, the number of cases treated prior to hospitalization has not been documented and is thought to be low. In 1992, a confirmed non-fatal case of Methemoglobenemia due to nitrate contaminated

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groundwater occurred in Trempeauleau County, Wisconsin [13]. An unconfirmed case of Methemoglobenemia due to high nitrate in drinking water was reported in July 1998 in Columbia County [8].

Several investigators have studied the chronic health and reproductive impacts of nitrate contaminated drinking water. Recent studies have implicated nitrate exposure as a possible risk factor associated with lymphoma, gastric cancer, hypertension, thyroid disorder and birth defects. In addition, a recent investigation conducted by local public health officials in La Grange County, Indiana implicated nitrate-contaminated drinking water as the possible cause of several miscarriages [13].

Livestock Health

Nitrate intake by dairy cattle is related to the levels found in forage and drinking water. According to research conducted on dairy cattle [4], nitrate-nitrogen in drinking water at levels under 10 ppm is safe for animal and humans. Between 10-20 ppm nitrate-nitrogen, water is safe for livestock unless their feed has high nitrate levels. Problems for livestock can occur between 20-40 ppm nitrate-nitrogen if feed contains more than 1,000 ppm. If well water is between 40-100 ppm nitrate-nitrogen, feed should be low in nitrate, well balanced and fortified with vitamin A. At levels between 100-200 ppm nitrate-nitrogen in water, poor appetite occurs. If nitrate-nitrogen is over 200 ppm in water, acute nitrogen poisoning and death is likely in swine.

Aquatic Life

Nitrate does not appear to be acutely toxic to adult fish except at extremely high concentrations where mortality is due to salinity effects [15]. However, available research indicates that nitrate concentrations lower than the drinking water standard cause substantial egg and fry mortality in some salmonid fish species [7]. When rearing trout or warm water species, the US Fish and Wildlife Service recommends nitrate levels not exceed 3 ppm. Tadpoles exposed to nitrate at the drinking water standard show decreased appetite, sluggishness and paralysis prior to death [6].

Surface Water

Groundwater can carry nitrogen (in the form of nitrate) into surface water bodies. Plant available nitrogen and phosphorus in surface water promotes excessive growth of weeds and algae. This process is called "eutrophication." Nitrate supplied by groundwater discharge may cause increases in rooted aquatic plants [10].

The Mathadi vagu basin is one of tribal track region in Adilabad district. It has significant agricultural activities based mainly early fruit and vegetable production and contributes about 60% of local transport to Adilabad town. During the last three decades, the region has undergone large changes in agricultural production. Thus, handreds of hectares have been developed for irrigation, inorganic fertilizers have largely replaced animal manure as a source of nitrogen and monocultures have often replaced diversified cropping systems. Consequently, water demand has increased. Indeed, about 90 to 95% of water is used for irrigation of which 78% is provided by groundwater resources. These drastic improvements have impacted groundwater supply and quality. The chemical constituents present in the water determine its usefulness for human consumption and other uses owing to the toxicity of certain constituents of natural and manmade origin. As groundwater is relatively pure from suspended matter and pathogenic microorganisms, it is a reliable source of water supply for all the seasons. Andhra Pradesh, the southernmost state of India, does not have perennial surface water resources. Major part of the area is underlain by hard rock's of limited ground water potential. The quality of ground water in these formations is influenced by natural factors like lithology and recharge characteristics, climate, and vegetation, as well as by anthropogenic factors like agricultural activities.

Location and climate

The study area is in Mathadivagu basin in Adilabad district of the state of Telangana, the southernmost state of India. (Figure: 1). The area lies between North latitudes 17°13'48" and 17°26'30" and East longitudes 78°53'00" and 78°91'55" with an aerial extent of 525 square kms, Mathadivagu is a tributary of Saathnala River which is a tributary of the Penganga River. The proposed study area Mathadivagu basin is located Western part of Saathnala River in Adilabad town. The area enjoys a tropical climate. April to June is the hottest period of the year and the maximum temperature ranges from 36.5°C to 46.8°C. The minimum temperature varies from 9.4°C to 24°C during December to February. The annual Rainfall varies from 1251.3 mm to 1350mm. The area receives maximum rainfall from northwest monsoon during October to December.

Geology

Deccan traps, Granites and limestones are the main litho units in the area (Fig 2). It can be said that is a contact zone of these three formations.

Hydrogeology

This area is having valley, hills and plain lands. Elevation varies from 70 to 160m (amsl): Climate of this area is tropical semi arid.

Saathnala River flows along the Eastern boundary of this area, in S-N direction and at a distance of about l8 km. Groundwater in these formations generally occurs under phreatic conditions particularly in shallow weathered zones. At place, it occurs under semi-confined and confined conditions at deeper fracture zones (GW Tech. Report, 1987). Average depths of weathered zone vary from 1.60 to 13.50 m. Depth of groundwater table lies in between 1.2 to 15-0 m bgl and there is variation formation. Main crops are paddy, jawar, maize, cotton, chilies, groundnut and soya beans etc.

Ground water occurs generally under water-table conditions in the weathered residuum and under semi-confined to confined conditions in jointed and fractured rocks at deeper levels. Ground water development is through dug wells, dug-cum-bore wells and bore wells. The depth to water table during post-monsoon period (December 2011) varied from less than 1 m. bgl to 20 m. bgl. The water table elevation in the area ranges from 230 m. amsl (northern part) to more than 300m amsl (southern part). The ground water flow direction, in general, is towards south western, north and northwestern directions.

Materials and methods

Ground water samples were collected from 37 observation wells used for domestic, agricultural and industrial purposes during December 2011. All the samples were analysed for pH, Electrical conductivity (EC), Total hardness, Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Chloride, Sulfate, Nitrate and Fluoride as per the standard analytical procedures of American Public Health Association [1].

Results and discussion

The analytical results of the samples collected from the area indicate that the ground water is generally alkaline in nature. The pH ranges from 6.28 to 7.78. The Electrical Conductivity (EC) varies from 314 μS/cm to 2590 μS/cm at 25°C. Ground water samples from wells located near the tanneries are found to be highly mineralized.

Nitrate pollution status of Mathadi vagu basin groundwater the nitrate contents of groundwater samples, presented throughout this paper as NO_3^-, range between 0 and 407 mg/L with an average of 143 mg/L. Table 2 lists some elementary statistical parameters of nitrate data in the Mathadi vagu basin. The frequency distribution of the entire sampled wells into nitrate concentration Distribution in (Figure 3) indicates that about 70 % of samples exceed the maximum per-

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missible limit of 45 mg/L in drinking water standards based on World Health Organization (WHO) standards and 57.1% of these samples crossed the recommended limit of 25 mg/L. The examination of the spatial distribution of nitrate concentrations (Figure 3) shows that the highest nitrate concentrations are observed from a bore well at Umdam village in f the study area. In the Mathadi vagu basin aquifer seemed to be spared by nitrate contamination. Also, this map demonstrates clearly that very high levels of nitrate (e.g. > 100 mg/L) are situated within the irrigated areas where agricultural activities involving nitrogen compounds are intensively used. In other respects, some localized spots of nitrate pollution spread out in the vicinity of towns as the case is of Adilabad town.

Impacts on health

The most common contaminant identified in ground water is dissolved nitrogen in the form of nitrate (NO). The World Health Organization (WHO), Bureau of Indian Standards (BIS), and the US Environmental Protection Agency (USEPA) have laid down 45mg/1 as the maximum permissible limit. Nitrate is an oxidizing agent and it readily oxidizes hemoglobin (Hb) into Methaemoglobin (MeHb) a blue colored pigment and gets reduced to nitrite (NO_2). The oxidized Hb impairs the oxygen carrying capacity of the blood and thus causes hypoxia, which may have fatal consequences in anemic individuals and infants. The MeHb formed in the infant's blood gives a characteristic blue hue to the skin and mucous membrane, thus giving the name blue baby disease or Methaemoglobinemia. This condition is particularly important in the case of infants because the infant and fetal Hb which is a_2g_2 type have greater affinity for oxygen than adult Hb which is $a_2.b_2$, type. This condition may also-result by birth due to the deficiency of enzyme known as Methaemoglobin reductace in the fetal blood. Nitrite formed from the reduction of nitrate may react with some amino acids in the intestinal tract and stomach to form Nitrosoamines, which are potential carcinogens. Chronic consumption of high nitrate waters may cause cancer and hence adverse effects on cardiovascular system and central nervous system.

Sources of Nitrate in the area

The analytical results reveal that 6 wells have nitrate below 45mg/l, the safe limit for human consumption. 7 wells have nitrate in the range of 46 to 100 mg/1 and 22 wells show nitrate in the range of 101 to 400 mg/1. One well has nitrate more than 400 mg/1. The origin of nitrate in the area is ascribed to industrial activity, sewage and animal wastes and agricultural sources.

Cotton mills are one of the established industries in the area for more than 50 years. More than 60 tannery units situated in the area have been discharging untreated effluent in the nearby streams, ponds and open land before the inception of treatment plants. These solid wastes are usually dumped in the vacant lands. High Agriculture activities are going in the area.

Most of the monitoring wells located near the town show high nitrate values. The extensive use of organic and chemical fertilizers in the area is also responsible for the incidence of high concentration of nitrate. All the nitrate salts, which are in anionic form are highly soluble in water and are repelled by most of the clay minerals invariably found in all soils. Its high mobility favors the transport of this anion to very long distances in the shallow zone. As the shallow formation water is saturated with dissolved oxygen, anaerobic conditions does not exist which favors high nitrate ground waters. The high levels of potassium with nitrate show the relation between fertilizer use and occurrence of nitrate. Most of the wells in the cultivated area have high nitrate levels, which confirm the contribution of nitrate from fertilizer use. Because fertilizers are used continuously, infiltrating water downward to the water table where they can migrate in the ground water flow regime carries a considerable part of them.

What are current management strategies for nitrate pollution?

- There are four entities involved in agricultural nitrogen management efforts in Wisconsin:
- The Nonpoint Source Water Pollution Abatement Program cost shares the use of best management practices to protect water quality by reducing the amount of nutrients from urban and rural sources.
- The Agricultural Conservation Program is a federal program administered to restore and protect land and water resources and preserve the environment. This program uses cost sharing of best management practices and outreach efforts to reduce nutrient loads from agriculture.
- County land conservation departments provide nutrient management planning funded by DATCP's Land and Water Resource Management grants.
- The DNR wastewater program regulates the discharge of nitrogen containing wastewater and biosolids to the land surface and potentially to groundwater. The wastewater program regulates:
- Discharge of municipal and industrial wastewater to land treatment systems such as spray irrigation systems, seepage cells and ridge and furrow systems.
- Discharge of municipal and industrial sludges, biosolids and industrial liquid wastes through land application.
- Discharge of septage through land application.
- Impacts on groundwater from wastewater treatment and storage lagoons leaking in excess of groundwater standards.
- Establishes design standards and accepted animal waste management practices for the large animal feeding operations category of point sources.
- Establishes design standards and accepted waste management practices for private septic systems.
- Establishes the criteria under which sanitary permits are issued to build private septic systems, which discharge pollutants to waters of the state.
- Establishes soil site evaluation standards for placement of septic systems.

Table: 2. Statistics of chemical parameters for groundwater samples post monsoon (December 2011) of the study area

Parameters in mg/l, except pH	Min	Max	Mean	St Dev	WHO Guideline value(1984)	% of the samples crossed the WHO limits
pH	6.28	7.78	7.41	0.25	6.5-8.5	3(acidic)
TDS	167	1370	653.32	277.7	500	76
NO3	0	407.4	142.99	101.4	45	82
Total Hardness	85.46	1118.49	534.91	224.4	100	97

Table: 3. Statistics of chemical parameters for groundwater samples pre monsoon (June2012) of the study area.

Parameters in mg/l, except pH	MIN	MAX	AVG	St Dev	WHO Guideline value(1984)	% of the samples crossed the WHO limits
pH	6.91	8.37	7.63	0.32	6.5-8.5	0
TDS	186	1180	619.54	277.8	500	59
NO3	0.79	376.52	122.65	100	45	81
Total Hardness	92.01	970.2	452.16	197.6	100	97

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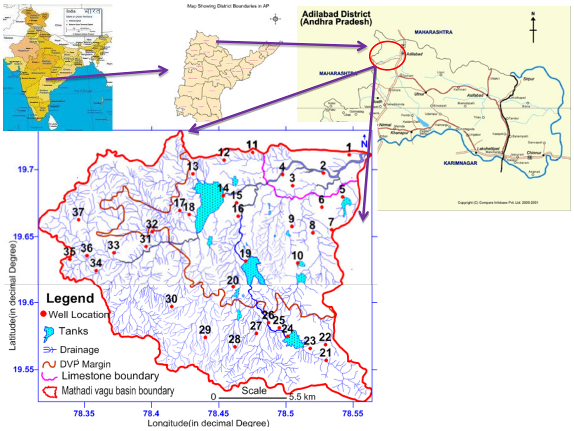

Figure: 1. Locations of the samples collected is Mathadi vagu basin, Adilabad.

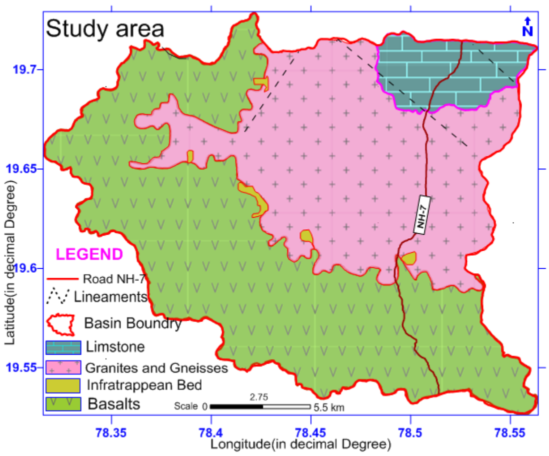

Figure: 2. Geological map, Mathadivagu basin, Adilabad.

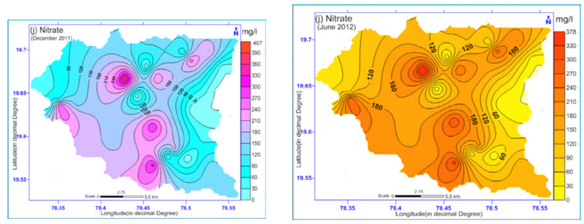

Figure: 3. Distribution of nitrate in the study area

REFERENCE [1] APHA, AWWA, WPCF Standard methods of the examination of water and waste water. 15th edition .1980. | [2] Chakkarapani, R 1988. Ground water resource and development potential of Anna district. Tamil nadu state.CGWB. P 41. | [3] Colleen, 1993; Aghzar et al., 2002; Berdaï et al., 2002 Centers for Disease Control, September 1998. A survey of the Quality of Water Drawn from Domestic Wells in Nine Midwest States, Centers for Disease Control and Prevention National Center for Environmental Health. | [4] Crowley, J.W., N.A. Jorgensen, L.W. Kahler, L.D. Satter, W.J. Tyler, M.F. Finner, 1974. Effect of Nitrate in Drinking Water on Reproductive and Produ tive Efficiency of Dairy Cattle, Water Resources Center, University of Wisconsin Technical Report WIS WRC 74-06. | [5] Hall, S.J., P.A. Matson, and P.M. Roth, 1996. NOx Emissions from Soil: a review and analysis of current knowledge, Prepared for: American Petroleum Institute, Wash. D.C. | [6] Hallberg, G.R. 1989. Nitrate in groundwater in the United States. IN: Nitrogen Management and Groundwater Protection. Elsevier, Amsterdam, pp. 35-74. | [7] Hecnar, S.J., 1995. Acute and Chronic Toxicity of Ammonium Nitrate Fertilizer to Amphibians from Southern Ontario, Environmental Toxicology and Chemistry, vol. 14 no. 12, pgs 2131-2137. | [8] Kincheloe, J.W., G.A. Wedemeyer, and D.L. Koch, 1979. Tolerance of Developing Salmonid Eggs and Fry to Nitrate Exposure, Bulletin of Environmental Contamination and Toxicology, vol. 3, pgs. 575-578. | | [9] Knobeloch, L., 1998. Department of Health and Family Services, Personal Communication. | | [10] Lillie, R.A. and J.W. Mason, 1983. Limnological Characteristics of Wisconsin Lakes, Technical Bulletin No. 138, Wisconsin Department of Natural Resources. | | [11] Lillie, R.A., and J.W. Barko, 1990. Influence of Sediment and Groundwater on the Distribution and Biomass of Myriophyllum spicatum L. in Devil's Lake, Wisconsin, Journal of Freshwater Ecology, vol. 5, no. 4, pgs 417-426. | | [12] Mason, J.W., G.D. Wegner, G.I. Quinn and E.L. Lange, 1990. Nutrient Loss Via Groundwater Discharge from Small Watersheds in Southwestern And South Central Wisconsin, Journal of Soil and Water Conservation, vol.45, no.2 pgs. 327-331. | [13] Piper, R., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leanard, 1982. Fish Hatchery Management, U.S. Fish and Wildlife Service, Washington, D.C., 517 pages. | | [14] Schubert, C., L. Knobeloch, H. Anderson, C. Warzecha, and M. Kanarek, 1997. Nitrate-Contaminated Drinking Water Followback Study, Submitted to the WI Dept. of Natural Resources and the WI Groundwater Coordinating Council. Department of Preventive Medicine, University of Wisconsin-Madison and the WI Department of Health and Family Services. 17 pages. | [15] Power and Schepers, 1989; Kaçaroglu and Gunay, 1997; Guimerà, 1998; Lake et al., 2003; Widory et al., 2004; Liu et al., 2005; Rao, 2006 Watershed/Source Water Protection Programs Targeting Mixed Farming Systems in The Upper Midwest, for: American Water Works Association Annual Conference, August, 1997, Seattle Washington. | [16] Shaw, Byron, 1994. Nitrogen Contamination sources: A Look at Relative Contributions, IN: Conference Proceedings: Nitrate in Wisconsin's Groundwater: Strategies and Challenges, May 10, 1994, Central Wisconsin Groundwater Center (UWEX), Golden Sands RC&D, WI Dept of Natural Resources and WI Dept. of Health and Social Services. | [17] USEPA, 1977. Quality Criteria for Water, US Government Printing Office, Washington DC, 20402, Stock No. 055-001-01049-4. |