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Level and distribution of nitrate in groundwater in parts of Vellore district, Tamil nadu, India

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ABSTRACT

Nitrate is a major pollutant of groundwater in semiarid, agricultural dominated areas. An attempt has been made to understand the level, distribution of nitrate in the groundwater in parts of Vellore district, Tamil Nadu. Thirty three groundwater samples were collected and analysed for major physic-chemical as well as nitrate concentration. Nitrate concentration exceeded the permissible limit of 45mg/l in Thirty nine percent of samples. Spatial distribution diagram of Nitrate shows a higher concentration in the southwest and central part of the district. Fertilizer as well as the failure of proper sewage systems is identified as the major cause for nitrate contamination.

Introduction

Groundwater quality deterioration due to nitrate is increasing in India and most of the developing countries. Both natural and anthropogenic origin of nitrate is observed in the groundwater. However, agricultural regions of the world are more prone to high concentration of nitrate. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks leaching from natural vegetation can also add nitrate to the groundwater (WHO 2011).

High concentration of nitrate in the drinking water causes many serious health problems especially in children and young livestock. Due to its hazardous nature, the permissible limit of nitrate for drinking water has been reduced from 100 mg/l to 45 mg/l by the Bureau of Indian Standards in recent years (Reddy et al. 2009). High level of nitrate in the human body will lead to Methaemoglobinaemia, a blood disorder in which an abnormal amount of methemoglobin is produced, which prevents the oxygen distribution in the body. Groundwater contamination due to nitrate was studied by various researchers (Rao 2006; Benson et al. 2007; Murgulet and Tick 2009; Melo et al. 2011; Cheong et al. 2011). Present study was conducted to evaluate the level of nitrate in groundwater and map their spatial distribution in parts of Vellore district.

Materials and methods

Vellore district lies between latitude (12°15'23''-13°12''32) and longitude (78°24'13'' – 79°54'56''). A detailed map of the study area with groundwater sample points is shown in Fig. 1. The climate is subtropical with a range of temperature between 18.2 to 36.8° C. The relative humidity ranges from 37% to 85 %. The district receives an annual rainfall of the district is 949.8 mm. Two rainy seasons are prominent in this part of the country, namely southwest and northeast monsoons. Physiographically terrain in the E and SW parts and Plain regions in the eastern part. The landscape in the hilly terrain is undulating to rugged, flanked by hill ranges belonging to Eastern Ghats. The eastern part of the district is a gently undulating plain dotted with isolated hillocks with sharply rising peaks, sloping towards east. Vellore district comprises of both hard rock and sedimentary formations. Majority of them are hard rock formations constituting 90% of the area. Most common hard rock formations are gneisses and charnockite. Gneissic formations are found in all taluks. Soils have been classified into Sandy soil, Sandy, Red loam, Clay, Clayey loam and Black cotton soils. The red loamy soils are generally observed at the highest elevations whereas the black cotton soils invariably occupy the valley areas. Other types of soils are found at intermediate elevations. Geological formations show a wide range in age from Archaean to Recent. Charnockites, gneisses and granites forms the crystalline formations. In the consolidated formations, primary depositional features such as grain size are the major controlling factors. Ground water occurs under phreatic conditions in the weathered zone and under semi-confined conditions in the fractures. The thickness of weathered zone varies from less than a meter to about 15 m in the area depending on the topography. Potential aquifer zones are also developed in these rocks by fractures persisting to depths, particularly along lineaments and their inter sections.

For the detailed study of groundwater contamination Thirty three representative samples were collected. The water samples were collected in high quality air-tight polyethylene containers. The sample containers were thoroughly cleaned and pre-washed with detergent and rinsed with distilled water. Most of the samples were clear, thus no filtration was necessary. Collected samples were analysed with in 48hrs. Sampling, preservation and analysis of water samples were carried out following the method recommended by APHA (1995). Nitrate was measured by ion-selective electrode method using ion plus combination electrodes: ORION 97-07 NO_3 – ion electrode for nitrate equipped with an Ion meter (model 960A, ThermoOrion, USA).

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Nitrate interference suppressor solution (Orion 930710) was used for determination of nitrate.

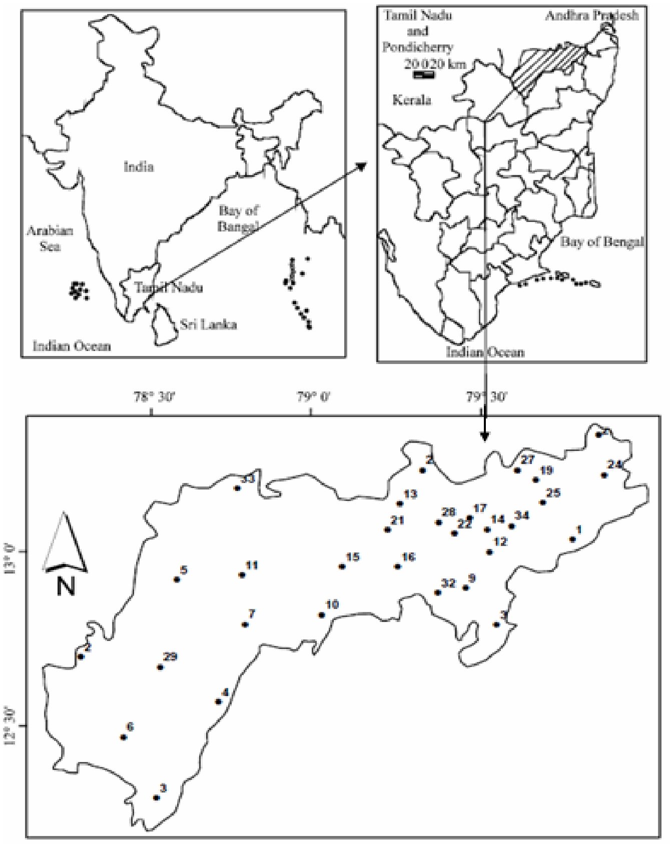

Fig 1. Location map of the study area showing sample location

Results and discussion

Occurrence of nitrate in groundwater is normally of anthropogenic nature due to the contact of soil cover with contaminants like wastewater and nitrate fertilizers (Maila et al. 2004). In the environment, the only natural process which produce nitrate is microbial nitrification. During this process micro- organisms) oxidise ammonia to a less stable nitrite and then to nitrate under anaerobic conditions (Anderson, 1990). The maximum permissible limit of Nitrate in the drinking water is 45 mg/l. A statistical representation of nitrate is shown Fig.2.Results shows the concentration of nitrate in the groundwater is 0.33- 320 mg/l. Out of 33 samples collected 61% of the samples were under the permissible limit of 45mg/l (BIS 1992), where as 39% of the samples exceeded the permissible limit. A large percentage of high concentrated groundwater will have a definite impact on human health.

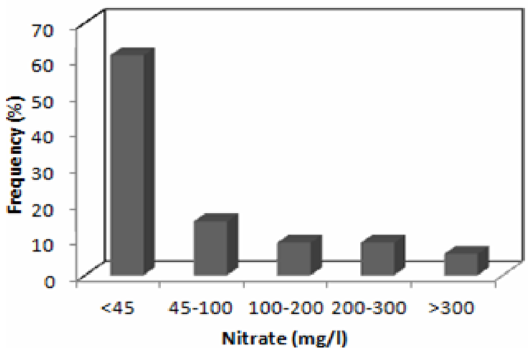

Fig 2. Frequency distribution of Nitrate concentration in water samples

Spatial distribution map of nitrate for the study area is shown in Fig.3. The map shows a drastic variation (0-320mg/l) from place to place. A large portion of the district has high concentration of nitrate (>45mg/l). This is a huge threat to the human health. Elevated concentration of nitrate found in either agricultural areas or highly populated areas. Southwest regions of the study area showed the highest concentration. Considering the agricultural practices in the Thirupathur area nitrate is directly related to the fertilizer and manures. While at the central part, which is highly populated because of the tanning industries, higher concentration of nitrate is attributed to septic tank system or the failure of the sewage systems. Northeastern part of the study area shows comparatively lesser contaminated with nitrate. A crucial control over the nitrate concentration in groundwater is obligatory since it effects in blood disorder.

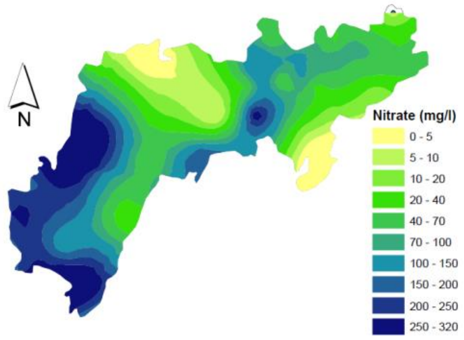

Fig 3. Map showing spatial distribution of nitrate

Conclusions

Nitrate pollution in groundwater is an emerging challenge for the water resources management in arid and semi-arid regions of the world. As an agricultural economy, many parts of India has affected by high concentration of nitrate in groundwater. Hydrochemical parameters along with nitrate was analysed for the Vellore district of Tamil Nadu, India. Nitrate showed a range of concentration from 0 to 320mg/l. Thirty nine percentages of the samples were exceeded the permissible limit of 45mg/l for drinking purposes. Spatial distribution of nitrate suggests many locations have high concentration, which is a great threat to human health.

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