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Original Research Paper

Study on Nitrate Pollution in Groundwater in Coastal Regions of Chennai City, Tamil Nadu

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ABSTRACT

Groundwater is an important resource and the quality of groundwater has to be good for consumption purpose. Nitrate contamination in groundwater is a major problem in many places. Nitrate pollution in the groundwater of the Chennai coastal aquifers was assessed to find out the extent of pollution in the area. From the samples collected from various locations, it is identified that the concentration of nitrate in groundwater ranged between 9 mg/L and 106 mg/L, and 27.7% of the samples have high nitrate. It was found that the higher concentration of nitrate is due to the use of fertilizers and leaching from septic tanks of residential buildings in this region. It is evident from the present study that the groundwater of this area is highly contaminated with nitrate and mitigative measures are needed to be taken to treat the groundwater which is used for domestic purposes.

INTRODUCTION

Water is one of the most important natural resources for the development of agriculture, industries, navigation, etc. The relentless increase in demand for water for various purposes brought about by population growth, agriculture, industries and economic development, combined with poor efficiency in water use has raised serious problems in its availability and quality. In many basins of the world, inadequacy and unreliable supply of surface water has forced many to go for groundwater as an alternative source. Groundwater, next to surface water, is the most important water resource in meeting the domestic water requirement. Contamination of groundwater is also increasing due to urbanization. Nitrate pollution is considered as the most spread contaminant of groundwater (Hallberg & Keenay 1993). Nitrate is a common pollutant in both surface water and groundwater that causes health problems in babies and animals and also eutrophication of water bodies. Nitrate when present in high levels would cause methaemoglobinaemia where nitrate bind with red blood cells and reduce their ability to carry oxygen. This would lead to several problems like shortness of breath, heart attack and even death. Infants who drink water with high nitrate develop blueness of the skin and hence the disease is also called 'blue baby syndrome'. The consumption of nitrate rich water causes a large number of diseases like dizziness, abdominal disorder, vomiting, weaknesses, high rate of palpitation, mental disorder and even stomach cancer. The major sources of nitrate contamination in groundwater is due to decomposition of organic matters in soil, leaching of chemical fertilizers used in agriculture, human and animal waste, untreated effluent from industries rich in nitrogenous wastes, improper sewage disposal, etc. Leaching of nitrate from different sources is more concerned in areas where there are shallow aquifers and where groundwater is the only source for potable water. Several studies have been carried out in the past in several parts of the world to find the nitrate pollution in groundwater (Sankararamakrishnan et al. 2008, Majumder et al. 2008). This work has been carried out in the coastal areas of Chennai to assess the quality of groundwater pollution due to nitrate in this region.

STUDY AREA

Chennai is the fourth largest city in India, covering an aerial extent of 172 sq. km. It is situated on the east coast of south India and is the capital of Tamil Nadu state. The city lies in a relatively flat topographic gradient. The four major water courses in the city are Adyar, Coovum river, Buckingham canal and Otteri nallah. The study area lies along the latitude 13°04'N and longitude 80°16' E. The location of the study area is shown in Fig. 1. The climate is characterized by typical coastal climate with high humidity, and annual average temperature in the range of 32°C. The area experiences rainfall from the southwest (June to September) and northeast monsoons (October to December). The annual rainfall is in the range of about 1230 mm. Rainfalls are characterized by heavy downpour resulting in water logging in low-lying areas. Gales and cyclones are experienced during

the northeast monsoon. The sedimentary rocks and alluvial formation occur all along the coast, flanking the crystalline mass on the west. The sedimentary formation mainly consists of recent alluvial deposits, and tertiary and cretaceous deposits. There are also sporadic occurrences of upper Gondwana beds in between the Archaeans and the younger sedimentary formations. The sedimentary rocks consisting of Cuddalore sandstone, shales and sandstones of upper Gondwana and charnockites of Archaean era characterize the geology of the east coast. The study area under consideration is very shallow alluvial aquifer interposed with marine and bluish clay and bordered on the east by Bay of Bengal, on the west by gneissic mass overtopped by clay loam, on the south by Muttukadu backwaters and on the north by Adyar river.

MATERIALS AND METHODS

The groundwater samples were collected from 18 wells lying in and around the area of study during the month of December, January and February. The samples were collected from Kotturpuram, Indira Nagar, Thiruvanmiyur, Kottivakkam, Palavakkam, Kanathur, Neelankarai, Kasthuribai Nagar, Uthandi and Muttukadu. 500 mL of water samples were collected in clean polythene bottles from each location of the study area. The sampling bottles were cleaned with detergent and soaked in diluted hydrochloric acid followed by washing with distilled water before collection of samples. After the collection of samples they were properly labelled indicating the source, date, time of collection and other records. The samples were kept in a cool place away from the sunlight. Samples were analysed within a short period of time so as to get more reliable and accurate results. Nitrate concentration in the groundwater samples was determined colourimetrically by cadmium reduction method (APHA 1998).

RESULTS AND DISCUSSION

The nitrate concentration of groundwater samples collected from various locations in the study area reveals variation between 9 mg/L and 106 mg/L. The results of the study are given in Table 1.

The Bureau of Indian Standards (1992) has set a standard for nitrate as 45 mg/L in drinking water. Considering this, 66.67% of the samples during December 2008, 11.11% of the samples during January 2009 and 5% of the samples during February 2009 were present above 45mg/L of nitrate. Overall, 27.7% of the samples were above the limits thus posing harm to human health if consumed. In general, the possible sources of nitrate in groundwater are nitrogen rich sediments, interaction of groundwater with nitrogen rich industrial wastes, inputs of organic nitrogen into soil, biological dinitrogen fixation by microorganisms, inputs of human and animal waste, water in unused dug wells, stagnate water and nitrogenous inorganic fertilizers, etc. (Hammer 1986, Dudley 1990, Barnes & Smith 1992).

Table 1: Nitrate concentration (mg/L) in groundwater in the study area.

Well No.	Location	Nitrate concentration (mg/L)		
		Dec. (2008)	Jan. (2009)	Feb. (2009)
1	Muttukadu Backwaters	21	9.0	19.0
2	Muttukadu	20	30	28
3	Kanathur	106	30	35
4	Uthandi	52	20	37
5	Kottivakkam	64	10	18
6	Palavakkam-1	60	50	44
7	Palavakkam-2	83	10	15
8	Neelankarai-1	52	31	27
9	Neelankarai-2	39	15	18
10	Thiruvanmiyur-1	62	17	24
11	Thiruvanmiyur-2	36	71	65
12	Indira Nagar-1	55	10	15
13	Indira Nagar-2	64	21	26
14	Indira Nagar-3	72	31	25
15	Kasthuribai Nagar-1	41	31	25
16	Kasthuribai Nagar-2	37	30	32
17	Kasthuribai Nagar-3	57	42	38
18	Kotturpuram	90	30	29

Fig. 2 shows the spatial variation of nitrate concentration in the study area during January 2009. The distribution of nitrate in groundwater shows that many parts of the study area are affected by nitrate pollution. The reason for the presence of high nitrate is that the agriculture is practiced in these areas and the application of fertilizers contributes to nitrate in groundwater, especially in the Kanathur and Uthandi areas. Other locations are mostly residential areas, particularly Palavakkam, Kottivakkam, Thiruvanmiyur, Indira Nagar, Kasthuribai Nagar and Kotturpuram, which are densely populated and lying nearby highly polluted Buckingham canal and Adyar river. Therefore, being a rapidly urbanizing area, the sewage from the septic tanks of residential buildings would have leached through the soil and contaminated the groundwater. It was found that the groundwater nitrate concentration is high in both shallow and deep groundwater samples. Thus, both these factors are responsible for nitrate contamination in this area.

CONCLUSION

Nitrate causes problems as a contaminant in drinking waters taken primarily from aquifers. The nitrate concentration of groundwater in the coastal areas of Chennai ranged from 9 mg/L to 106 mg/L. If this high concentration of nitrate is

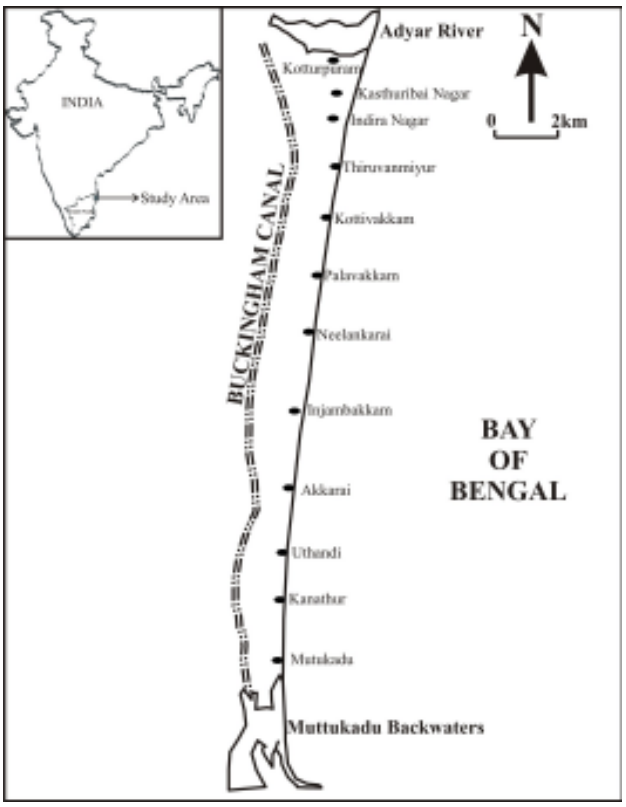

Fig. 1: Location of the study area.

present in drinking water, it will lead to several health disorders. Nearly 27.7% of the groundwater samples have high nitrate concentration in groundwater, thus, posing a potential harm. The major reason for high nitrate in groundwater of the region is the application of fertilizers for agriculture and also due to leaching of human wastes from septic tanks. Hence, it is necessary to treat the groundwater by reverse osmosis or other methods before consumption or to provide some alternate source for drinking water. The quality of drinking water can be improved by denitrifying the groundwater before being used for consumption. Another possibility is to recharge the groundwater aquifers through possible methods to improve the quality. Moreover, it is also important to educate the local population about keeping their surroundings clean and to follow hygienic sanitation practices.

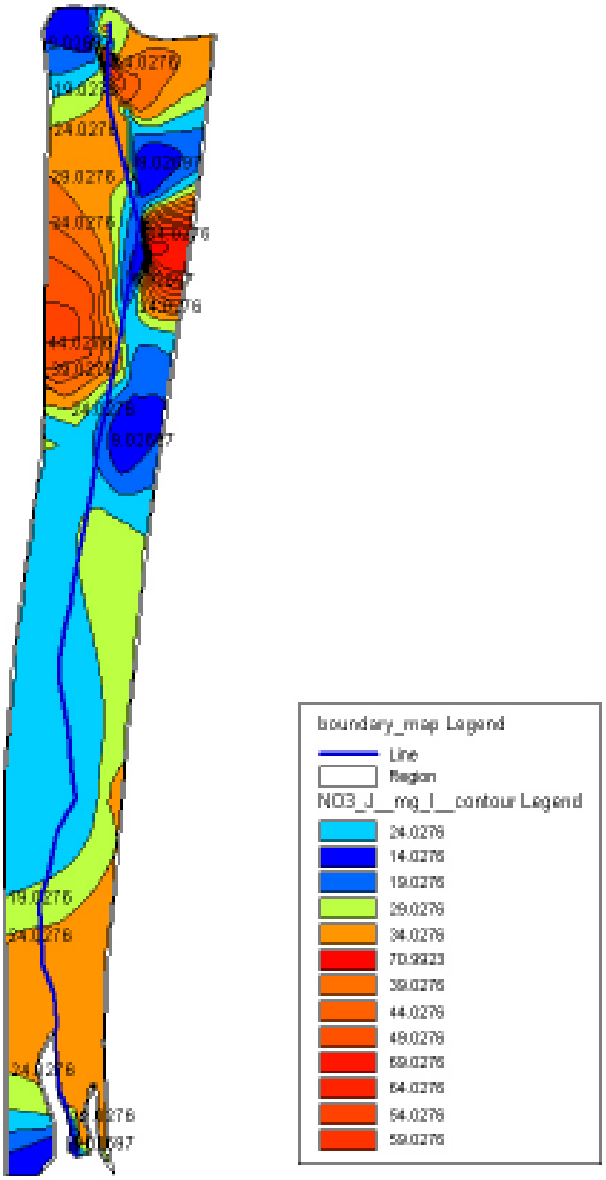

Fig. 2: Spatial variation of nitrate concentration during January 2009.

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