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EVALUATION OF THE ORIGIN, HEALTH THREATS AND FATE OF NITRATE NITROGEN IN THE GROUNDWATERS OF BANGALORE, INDIA

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Abstract - Nitrates are responsible for a number of health threats, both in human beings and animals and known to be potent carcinogens. In the present study, nitrate contents have been quantitatively estimated in the groundwaters of Bellandur area during the pre-monsoon and post-monsoon periods of 2016 by collecting 30 samples in each season. The analysis data indicates a large variation of nitrate from 4 mg/L to 394 mg/L in the pre-monsoon and 6 mg/L to 418 mg/L in the post-monsoon seasons. 54% of the samples have shown high nitrate contents (>45 mg/l), which is more than the permissible limits of drinking water as per the Bureau of Indian Standards, BIS 10,500. An attempt has been made to identify the possible sources of the high nitrate level in groundwater and some mitigative measures for the same have been suggested.

Keywords - Concentration; Groundwater; Health; Nitrate; Pollution; Toxicity.

I. INTRODUCTION

In many countries across the globe, public concern over the deterioration of groundwater quality from nitrate contamination has grown significantly in recent years. The presence of high nitrate concentration (>45mg/l) in groundwater is harmful to health and hence their occurrence in high concentrations in groundwater is a matter of great concern. Inorganic nitrogen fertilizers, septic tanks, poor dug wells and defective sewerage systems are the suspected major sources of nitrate in groundwater (1,2). Nitrate is often considered an agricultural pollutant because high concentrations above 10 mg-N/L have been found in aquifers located beneath agricultural fields where fertilizer and manure use is common. Soil bacteria may also increase nitrate levels in groundwater by oxidizing ammonia into nitrite and then to nitrate ion in oxygen-rich water (3). In addition to agricultural practices, there are other potential sources that can contribute to the increase of nitrate concentrations in groundwater. Urban sources of nitrate-N may have a high impact on groundwater quality because of the high concentration of potential sources in a smaller area than agricultural land (4). Nitrate sources can be group in diffuse sources (parks and gardens, atmospheric deposition), intense point sources (industrial chemical spills or landfill leachate) and multi-point sources such as leaking sewers and septic tanks (5). The main sources of nitrate and other pollutants of urban groundwater is sewage, nitrate can reach the aquifer by sewer leakage and on-site disposal systems such as septic tanks.

Health effects of nitrates on human beings

Groundwater is a major source for drinking purposes. Nitrates and nitrites in food may cause methaemoglobinemia in babies (6), where due to the oxidation of ferrous iron in hemoglobin to ferric state, the oxygen-carrying capacity of the red blood corpuscles is lost and the affected baby dies. Other health problems associated with nitrate toxicity include oral cancer (7), cancer of the colon, rectum or other gastrointestinal cancers (8–10), Alzeimer's disease, vascular dementia of Biswanger type or multiple small infarct type (11), multiple sclerosis (12-13), neural tube defects (14), cytogenetic effect in children (15), Non- Hodkins's lymphoma (16-17) and hypertrophy of thyroid (18).

In Bangalore, close to the study area, when an eight-year-old girl's finger nails turned blue, a doctor's diagnosis revealed that she suffered from Methemoglobinemia, a condition he associated with nitrate poisoning. Having ruled out other sources of poisoning, the doctor recommended that her family get the borewell water tested. The test revealed high levels of nitrate contamination in the water. Nitrate levels in these areas are as high as 300 mg/l mainly because of sewage contamination of groundwater. At St. Johns National Academy of Health Sciences, one of the very few facilities in the city for a methemoglobin test, 31 such cases were reported in 2015.

Thus, the present study aims to assess the extent of nitrate contamination in the study area and suggest mitigative measures for the same.

II. DETAILS OF THE STUDY AREA

Bellandur is the area to the south of Bangalore city, India, covering 23 sq km and the catchment area comprises of Bellandur, Challaghatta, Yamalur, Agara, Madiwala, Puttenahalli and Yelachenahalli. The area lies between latitude 1205313011 to 1205615011 East and Longitude 770341 to 7704114011 North. It is covered under Survey of India Toposheet number 57H/9. On the northwestern side of Bellandur tank, the Koramangala and Challaghatta valley sewage treatment plant is situated.

The total wastewater generated in the catchment is about 3,00,000 m3/day. The designed capacity of the plant is 1,63,000 m3/day of wastewater. But currently it is treating only 1, 00,000 m3/day. The incapability of the network of pipes to transport the generated wastewater is one of the main reasons for less flow in to the sewage treatment plant (STP). The remaining 2, 00,000 m3/day of wastewater requires complete treatment. At present, this wastewater is directly entering various tanks in the catchment, and polluting them. The study area is encompassed by about 156 industries

III. MATERIALS AND METHODS OF ANALYSIS

Thirty water samples each were collected from both the borewells and open wells in the area during April (pre-monsoon) and November (post-monsoon) seasons of 2016 in one litre PVC containers, sealed and were analyzed for nitrates, using a UV- visible spectrophotometer, in accordance with the Standard Methods for the Examination of Water and Wastewater as per American Public and Health Association, APHA (19). The location map of the area with the sampling stations is presented in Fig 1.

IV. RESULTS AND DISCUSSIONS

The results of nitrate analysis of groundwater samples are presented in Table I. The analysis has shown that the nitrate concentration in 53.33% of the groundwater samples is well above the permissible limit of 45 mg/l prescribed by the Bureau of Indian Standards, BIS (20). The maximum, minimum and mean concentrations of nitrate are found to be 394, 4 and 90.9 mg/l respectively during pre-monsoon and 418, 6 and 101.7 mg/l respectively during post-monsoon season. The Sample percentage based on different ranges of nitrate concentration is shown in Fig 2. The nitrate contours during pre-monsoon is presented in Fig. 3. The nitrate concentration is slightly on the higher side during post-monsoon season. This may be attributed to the lack of drainage conditions, longer contact of groundwater with the aquifer material and anthropogenic activities (21). Nitrates also have high solubility and immediately dissolve in rain water & percolate to the ground water. Further, the nitrate concentrations are quite high in open wells, when compared to hand pumps and borewells as shown in Table II. This is mainly because of the poor structure and improper maintenance.

The inorganic nitrogenous fertilizers are used to increase the growth rate of agricultural production. The nitrogen content in these fertilizers is quite high. In view of the nitrates solubility in water, they rapidly increase the nitrate pollution level in the groundwater (22). Further, the indiscriminate discharge of wastes from industrial, municipal and domestic activities in the neighbourhood, coupled with leaking drains and inadequate sewage treatment in the study area has led to the elevated levels of nitrates.

Sample no	NO_3 concentration, mg/L (Pre- monsoon)	NO_3 concentration, mg/L (Post-monsoon)
1	66	82
2	210	224
3	54	52
4	18	27
5	24	33
6	102	104
7	290	335
8	126	155
9	32	40
10	10	10
11	22	28
12	6	8
13	84	97
14	58	68
15	50	54
16	280	284
17	6	6
18	394	418
19	32	40
20	78	92
21	32	40
22	52	66
23	266	292
24	230	252
25	20	20
26	28	35
27	55	62
28	40	48
29	36	41
30	28	38

Table I: Nitrate concentrations in groundwater during pre and post-monsoon seasons

S L N O	Source	No of samples	Range of Nitrate concentration, mg/L		Mean concentration of Nitrate (mg/L)	
			Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
a	Open well	04	210-394	224-418	281.0	307.3
c	Hand pump	09	06-266	06-292	85.33	96.77
c	Borewell	17	04-280	08-284	49.24	55.94

Table 2: Range of Nitrate concentrations and their mean values in groundwater samples

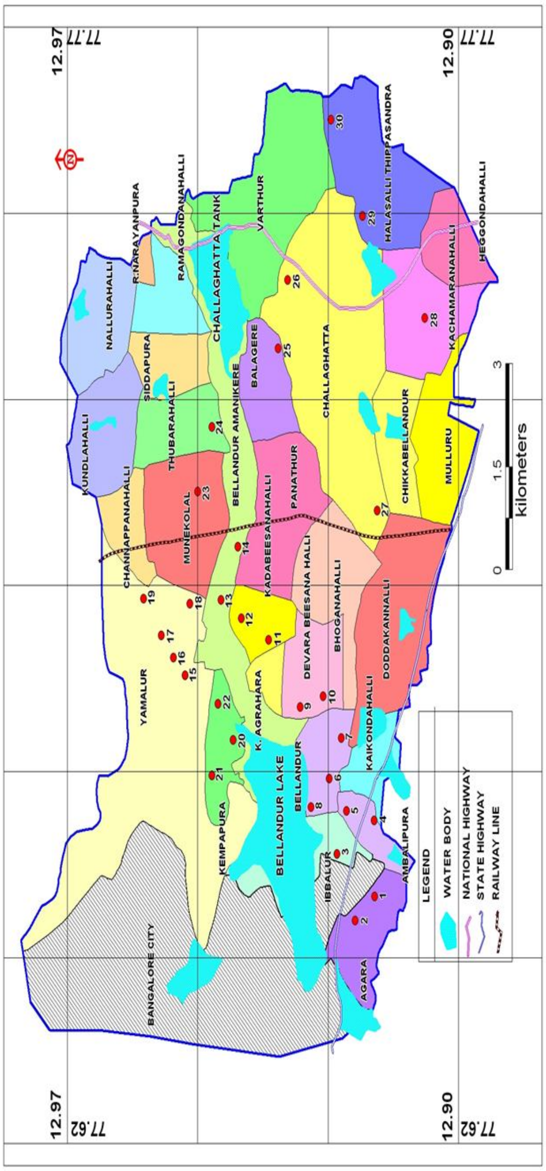

Fig 1: Location map of Bellandur area showing the sampling stations

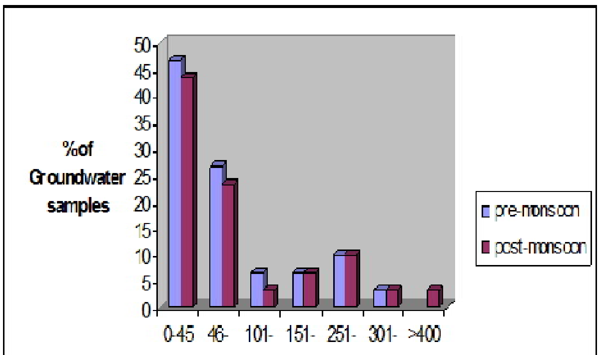

Fig. 2: Sample percentage based on different ranges of nitrate concentration

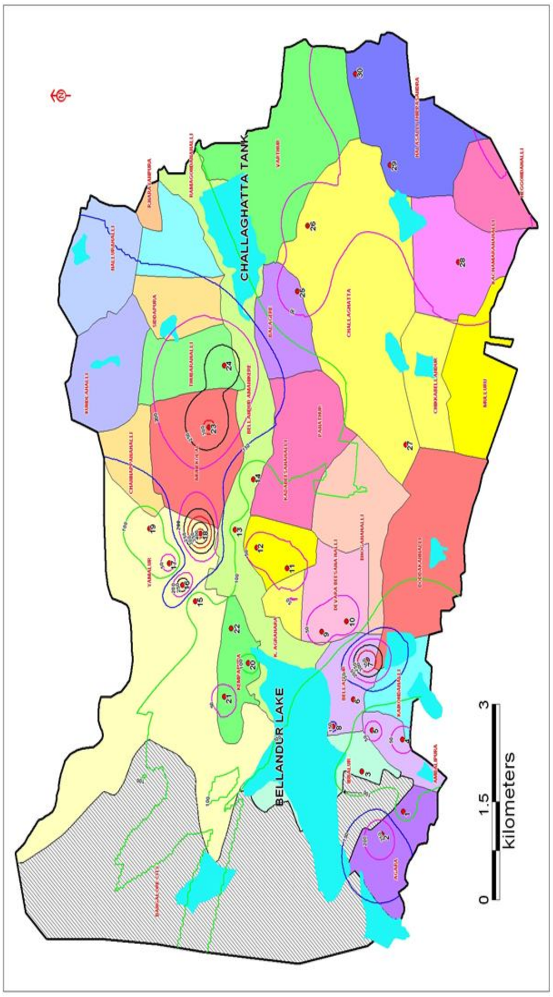

Fig. 3: Nitrate contours for the groundwaters of Bellandur industrial area during post-monsoon

RECOMMENDATIONS

(i) High nitrate levels often are associated with poorly constructed or improperly located wells. New wells may be located uphill and at least 100 feet away from feedlots, septic systems, barnyards and chemical storage facilities. Abandoned wells must be properly sealed or capped.

(ii) Non-point sources of water pollution (fields, lawns) must be managed to limit the loss of excess water and plant nutrients. Fertilizer and irrigation applications must be matched to precise crop uptake needs in order to minimize nitrate contamination of groundwater.

(iii) Leaching of nitrate from the inorganic fertilizers can be minimized by controlled use of nitrogenous fertilizers.

(iv) While it may be technically possible to treat nitrate contaminated groundwater, it can be difficult, expensive and not totally effective. For this reason, prevention is the best way to ensure clean water. Water treatments include distillation, reverse osmosis, ion exchange or blending.

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