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Short Note

A Study of Nitrate Contamination in Ground Water of Delhi, India

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Abstract: Fast urban growth, without proper arrangements of waste management, led to serious problems of contamination of ground water in many urban centres of India. Present study clearly indicates how uncollected and mismanaged waste contaminates the ground water. Taking nitrate as an indicator of groundwater pollution due to urban wastes in Delhi, a detailed survey of nitrate level in ground water was carried out in Delhi in order to assess the magnitude of problem in different areas of Delhi. Nitrate, which may cause methemoglobinemia or "blue baby" disease, is found much above the drinking water limits prescribed by WHO and Bureau of Indian Standards. 43% of the samples showed values higher than prescribed limit of 45 mg/l as per BIS: 10500-2004. Since, groundwater is source of drinking in many parts of the city as the municipal water supply is inadequate due to growing demand of drinking water, the dependence on ground water is inevitable. Thus, exposure of population to high nitrate cannot be ruled out. There is a need of detailed study on health impact of consuming high nitrate groundwater in different parts of the city.

Key words: Nitrate, ground water, methemoglobinemia.

Introduction

In a developing country like India, rapid urbanization has led to an alarming deterioration in the quality of civic life. The urban centres suffer from infrastructure differences, poor sanitation and solid waste disposal, pollution of water and natural courses, water logging etc. Water is tapped for domestic and industrial use from rivers, streams, wells and lakes. About 80% of the water supplied for domestic use passes out as waste water. In most of the cases, waste water is let out untreated and it either sinks into the ground as a potential source of pollutant of ground water or is discharged into the natural drainage system causing pollution in downstream areas. The large cities in India have grown faster than small cities, which led to an increase in their weight in the city size distribution of population. Delhi is one of the fastest growing cities in the country. With fast urban growth, unfortunately the waste management is lagging behind due to lack of resources, leading to a large part of wastes not being collected, transported and disposed. This is leading to its percolation in the ground and polluting it.

Nitrate (NO_3^-) and nitrite (NO_2^-) are naturally occurring inorganic ions that are part of the nitrogen cycle. Microbial action in soil or water decomposes wastes containing organic nitrogen into ammonia, which is then oxidized into nitrite and nitrate. Because nitrite is easily oxidized to nitrate, nitrate is the compound predominantly found in decomposed domestic wastes. Application of nitrogenous fertilizers (e.g. potassium nitrate and ammonium nitrate) or animal organic wastes can also raise the concentration of nitrate in water. Nitrate containing compounds in the soil are generally soluble and readily migrate with ground water. The atmospheric nitrogen gets ammonified by micro-organisms and leads to conversion to nitrites and nitrates through nitrification.

1. $NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$
2. $NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$

Nitrate is regulated in drinking water primarily because excess level can cause methemoglobinemia or "blue baby" disease. In vivo conversion of nitrates to nitrites significantly enhances nitrates' toxic potency. The major metabolic pathway for nitrate is conversion to nitrite, and then to ammonia. Approximately 5-10% of the total nitrate intake is converted to nitrite by bacteria in the saliva, stomach, and small intestine. The reaction is pH dependent, with no nitrate reduction occurring below pH 4 or above pH 9. This is the main reason why infants are more susceptible to nitrite toxicity from elevated nitrate/ nitrite ingestion. Another potential metabolic pathway is the reaction of nitrite with endogenous molecules to form N-nitroso compounds, which may have toxic or carcinogenic effects. Although nitrate level that affects infants do not pose a direct threat to older children and adults, it indicates the possible presence of other more serious residential or agricultural contaminants such as bacteria and pesticides. Natural water naturally contains less than 4.5 milligram of nitrate per litre and is not a major source of exposure. Higher levels indicate that water has been contaminated. Bureau of Indian Standard has prescribed maximum contaminant limit of nitrate 45 mg/l as NO_3 beyond this limit is likely to cause toxicity and health problems. Hence it is essential to monitor the nitrate contents in water especially for potable purpose.

Hemoglobin molecules contain iron within a porphyrin heme structure. The iron in hemoglobin is normally found in the Fe^{++} state. The iron moiety of hemoglobin can be oxidized to the Fe^{+++} state to form methemoglobin. Once it is formed, the molecule loses its ability to carry molecular oxygen. Because red blood cells are bathed in oxygen, a certain amount of physiologic methemoglobin formation occurs continuously. Several endogenous reduction systems exist to maintain methemoglobin in the reduced state. In normal individual only about 1% of total hemoglobin is methemoglobin at any given time.

Methemoglobinemia can be reduced back to hemoglobin by both spontaneous (NADH-dependent and to a lesser degree by NADPH-dependent) methemoglobin reductase enzymes. Maternal exposure to environmental nitrates and nitrites may increase the risk of pregnancy complications such as anemia, threatened abortion/ premature labour, or preeclampsia. Some study results have raised concern about the cancer-causing potential of nitrates and nitrites used as preservatives and colour-enhancing agents in meats. Nitrates can react with amino acids to form nitrosamines, which have been reported to cause cancer in animals. Elevated risk of non-Hodgkin's lymphoma and cancers of the esophagus, nasopharynx, bladder, and prostate have been reported.

Materials and Methods

The samples of ground water have been collected as per the guidelines laid in the book "Standard Methods" for Examination of Water and Wastewater from different localities of Central and its allied South Delhi's area. Samples are collected once from the area mentioned. The samples were preserved in icebox and transported to the laboratory in Delhi within 3 to 5 hours of collection. The samples were analyzed as per UV method prescribed in "Standard Methods for Water and Wastewater". An Ultraviolet (UV) Spectrophotometric Screening technique/method that measures the absorbance of NO_3^- (ion) at 220 nm is suitable for determining nitrate contents in uncontaminated water (low in organic matter).

Findings

Nitrate content level findings are based on one time sampling. It is observed that 43% of the groundwater samples collected from central and its allied South Delhi were found nitrate contaminated above 45 mg/l, the tolerance limit prescribed by BIS: 10500-2003. 17% of the samples were found contaminated above 100 mg/l of nitrate, a limit prescribed by BIS as maximum permissible if alternate source of water is not available (BIS: 10500-1991). However, as per new standard BIS: 10500-2003 drinking water containing nitrate content above 45 mg/l cannot be considered fit for drinking purpose in any condition.

The most polluted areas in respect of nitrate contamination are: Pandav Nagar (103.3 mg/l), Lodhi Road (104.1 mg/l), M.D. National Stadium (111.45 mg/l), Kotla Mubarkpur (117.38 mg/l), Paharganj (172.22 mg/l), Sunder Nagar (146.0 mg/l), Das Ghara (190.12 mg/l), Jangpura (188.73 mg/l), Defence Colony (225.0 mg/l), Kirti Nagar (195.0 mg/l), Darya Ganj (328.2 mg/l) and Lodhi Colony (400 mg/l). Average nitrate level in ground water of these areas was found to be above 100 mg/l, which is above the maximum tolerance limit of potable water as prescribed by BIS. During 2003, Central Pollution Control Board, New Delhi conducted similar study and found nitrate levels in ground water much higher than prescribed limit of 45 mg/L in areas like Moti Nagar II (101.1 mg/l), Wazirpur I (125.2 mg/l), and Azadpur (103.8 mg/l), Moti Nagar-I (94.3 mg/l), Roop Nagar (64.74 mg/l), Mall Road (83.0 mg/l) and Timarpur (67.5 mg/l). The localities which showed nitrate levels above tolerance limit of 45.0 mg/l but under maximum permissible limit of 100 mg/l: Jawahar Lal Nehru Stadium (48.53 mg/l), Andrews Ganj (50.8 mg/l), Inderpuri (53.8 mg/l), Keshavpuram (54.6 mg/l), Air Force station (65.0 mg/l), Karampura (70.4 mg/l), Anand Prabat (72.55 mg/l), Ranjeet Nagar (72.6 mg/l), Regarpura (79.3 mg/l), Baljeet Nagar (85.2 mg/l), Sunlight Colony (88.54 mg/l), West Patel Nagar (90.8 mg/l), Naraina Vihar (92.4 mg/l) , Todapur (99.0 mg/l) and Lahori Gate (90.04 mg/l).

The maximum nitrate level in ground water of some of the above said localities are at: Asaf Ali Road Darya Ganj (820.6 mg/l), Block 35/35 West Patel Nagar (242.2 mg/l), Road No. 20 Baljeet Nagar (158.9 mg/l), DJB BPS-UGR-2.09 MLD Kirti Nagar (195.0 mg/l), Community Centre Pandav Nagar (156.3 mg/l), E-Block Inderpuri (76.0 mg/l), Bore well No 355 Todapur (130.0 mg/l), B/W No. 354 Das Ghara (460.9 mg/l), C-Block Naraina Vihar (385.0 mg/l), D-Block New Ranjeet Nagar (171.20 mg/l), Petrol Pump Sunder Nagar (146.0 mg/l), Q-Block near Railway Phatak Jangpura (289.0 mg/l), Bore well No. 129 Sunlight Colony (148.0 mg/L), CGO Complex Lodhi Road (160 mg/l), CPWD Market Aliganj Lodhi Colony (400 mg/l), Bapu Park Kotla Mubarakpur (268.5 mg/l), S.N. Park Fazil Road Lahori Gate (220.0 mg/l) and Pratap Street Paharganj (1210.8 mg/l).

The localities where ground water was found fit for drinking purpose in respect of nitrate contamination are: Sarai Kale Khan (0.33 mg/l), Race Course (0.74 mg/l), Indira Gandhi Stadium (1.78 mg/l), I.P. College (2 mg/l), Model Town (5.7 mg/l), Dev Nagar (7.3 mg/l), Lawrence Road (8.95 mg/l), New Rajender Nagar (9.2 mg/l), Inder Lok (10.3 mg/l), Jhandewalan (13.05 mg/l), Shastri Nagar (16.06 mg/l), East Patel Nagar (18.9 mg/l), Pusa (20.4 mg/l), Karol Bagh (20.95 mg/l), Mori Gate (21.59 mg/l), LNJP Hospital (23.8 mg/l), BSZ Marg (24 mg/l), Kingsway Camp (24 mg/l), Kashmere Gate (26.45 mg/l), Connaught Place area (32.1 mg/l), Ashok Vihar (32.74 mg/l), Old Rajender Nagar (34.2 mg/l), Chandni Chowk (36.68 mg/l), Chanakayapuri (37.5 mg/l), Rampura (39.5 mg/l), Naraina Village (44 mg/l), and Sat Nagar (44.1 mg/l). In above localities ground water is fit for drinking purpose in respect of nitrate contamination as per guidelines of Bureau of Indian Standard; however at some places in abovesaid localities ground water is contaminated above permissible limit prescribed for potable water. Some of these locations are: Julaha Mohalla Naraina Village (75.5 mg/l), Gaffar Market Karol Bagh (58.7 mg/l), DDA flats Shankar Road (56.2 mg/l), Ashoka Garden Ashok Vihar (94.0 mg/l), MCD School Sawan Park Ph-II Ashok Vihar, Jailer Wala Ward Ashok Vihar (83.0 mg/l) and Maqbara Lal Kuan Ballimaran Chandni Chowk (88.4 mg/l).

Discussion

It is observed that many areas in Delhi are highly contaminated with nitrate. The main source of nitrogen in soil is through interaction with the atmosphere, which is about 78% nitrogen by volume. Small amount of nitrate occur naturally in ground water as a result of atmospheric nitrogen contained in precipitation and minerals found in soils and rock. Most nitrate which enters ground water comes from anthropogenic (human derived) sources such as urban wastes not properly collected, transported, treated and disposed, atmospheric deposition of nitrous oxides associated with the combustion of coal, petrol and gas, land application of animal manure at farms, application of fertilizers to agricultural crops and urban yards. In Delhi, the major contribution of such high nitrate seems to come from un-collected urban wastes both sewage and garbage. Thus in order to ensure groundwater in Delhi safe for drinking with respect to nitrate, it is important to manage the waste properly. There should be enough resources, manpower and infrastructure to manage the garbage adequately.

Remedial Measures

If excessive nitrate-nitrogen is present in water supply, there are two choices: either switch on to an alternate water supply or use treatment to remove the nitrate-nitrogen.

1. Alternate Water Supply

This is most safe remedial measure, as the DJB supply is quite safe. If DJB supply is not available, it may be possible to obtain a satisfactory alternate water supply by drilling a new well in a different location or a deeper well in a different aquifer, especially if the nitrate contamination is from a point source such as sewage percolation, livestock or garbage dumps. If the water supply with high nitrate is coming from a shallow aquifer, there may be an uncontaminated, deeper aquifer protected by a clay layer that prevents the downward movement of the nitrate-contaminated water. A new well should be constructed so that surface contamination cannot enter the well. It should be located away from any potential sources of contamination, such as sewage drains, garbage dumps, septic systems, feedlots etc.

Another alternate source of water is bottled water that can be purchased in stores or direct from bottling companies. This alternate specially might be considered when the primary concern is water for infant, food and drinking. Delhi Jal Board and other agencies of government or government recognized are procuring bottled or packaged water which are quite safe for drinking purpose. One should be assured of the nitrate content, dissolved solids, and bacterial quality of any water purchased. In all cases, the purchased water must be handled and stored in a manner to prevent contamination.

2. Nitrate Removal by Treatment

Nitrate can be removed from drinking water by three methods: distillation, reverse osmosis, and ion exchange. Home treatment equipment using these processes is available from several manufacturers. Carbon adsorption filters, mechanical filters of various types, and standard water softeners don't remove nitrate-nitrogen. In the reverse osmosis process, pressure is applied to water to force it through a semi permeable membrane. As the water passes through, the membrane filters out most of the impurities. According to manufacturers literature, from 85 to 95 per cent of the nitrate can be removed with reverse osmosis. Actual removal rates may vary, depending on the initial quality of the water, the system pressure and water temperature.

Precautions

When laboratory tests determine that water contains more than 45 mg/l of nitrate as NO_3^- , the following action is recommended:

- Do not give the water to infants less than six months of age or use the water to prepare infant formula.
- Avoid drinking the water on a daily basis during pregnancy.
- Seek medical help immediately if the skin of an infant appears bluish or grey in colour. Sometimes the colour change is first noticed around the mouth, or on the hands and feet.
- Identify the nitrate source and take action to reduce contamination. Remedial actions may include reducing fertilizers use, improving manure handling methods, pumping septic tanks or upgrading wells.

Conclusion

Many areas in Delhi are found containing ground water much higher than the prescribed limit and hence a detailed study is required to see the health implication of consuming high nitrate containing water. Government should keep vigilance of health impacts and remedial measures. The water supplied by DJB is much better with respect to nitrate (Wazirabad Water Works 6 mg/l) and should be used in those areas infested with high nitrate.

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