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Nitrate Contamination in Ground Water of Jaipur District, Rajasthan, India: It's Impact on Human Health: A Review

Rajni Agarwal

BIT Jaipur Campus Mesra Ranchi, India

Abstract: ***There is unavailability of surface water in Jaipur, Rajasthan, ground water plays an important role for drinking water. The 91% of drinking water of this state completed from underground source. Fluoride and nitrate in drinking water is the main problem in Rajasthan, Jaipur. Nitrate in ground water is mainly due to anthropogenic activities. The maximum nitrate value is found in ground water of various places. The removal of nitrate can be done by using membrane and absorption techniques. This paper presents a review, which focuses on the sources of nitrate in ground water, its impacts on health.***

Keywords: Ground water, nitrate, Jaipur, Contaminant, Impacts, Health

1. Introduction

Water contamination is a common problem to all over the world. These may be geological or anthropogenic (man-made) 1. One sixth of the world population suffers from the freshwater unavailability situation 2. Nitrate (MCL 10mg/L as Nitrogen) 3 contamination comes through fertilizers. It is found in sewage and wastes from human and/or farm animals and generally gets into drinking water from these activities 4. Excessive levels of nitrate in drinking water have caused serious illness because of nitrate conversion to nitrite in the body and interferes oxygen transport in the blood. The symptoms include shortness of breath and blueness of the skin 3, 4.

70-80% illness in India is due to water contamination. The formation of nitrates an integral part of the nitrogen cycle in our environment, in moderate amount, nitrate is a harmless constituent of food and water. Plants use nitrates from the soil to satisfy nutrient requirements and may accumulate nitrate in their leaves and stems. It may cause methaemoglobinemia, an illness found especially in infants. Nitrates form when microorganisms break down fertilizers, decaying plants, manures or other organic residues. Usually plants take up these nitrates, But sometimes rain or irrigation water can leach them into ground water1. Nitrate levels in ground water have been increased beyond its maximum contamination level due to increased and excessive use of nitrogenous fertilizers in agricultural sector, changes in land-use pattern from pasture to arable, and increased recycling of domestic waste water in low-land rivers1. A further concern is that nitrate can be converted by bacteria in the digestive tract into nitrosamines which are potentially carcinogenic5.

The World Health Organization (WHO) guideline value for maximum contaminant level of prescribed value for nitrate in drinking water is 50mg $No3^{-}$/L6 . The Bureau of Indian Standards (IS-10500:2009) prescribed value for nitrate in drinking water is 45 mg $No3^{-}$/L (BIS 2009) 7. The US Environmental Protection Agency (EPA) established a maximum contaminant level (MCL) of 10 mg N-$No3^{-}$/dm38.

The issue of rising nitrate concentration in ground water has become a subject of extensive research in India and abroad. The increasing levels of nitrate ion ($No3^{-}$) in drinking water, particularly in well water in rural locations; the main sources of this nitrate is domestic activities and runoff from agricultural lands into rivers and streams. The nitrates being soluble in water percolate through layers of soil into deeper layers of earth and ultimately find their way to under ground stores of water 9, 10.

In most of the areas recent anthropogenic impacts can be ruled out. Whereas nitrate pollution due to anthropogenic sources, can be managed and be reduced, natural nitrate sources generally can not be controlled and other means will have to be adopted for managing the nitrate content of the ground water in such areas. This research paper describes the sources of nitrate in ground water, associated hazards and provides guidance on the management of anthropogenic activities that cause nitrate pollution11,12.

Water Availability:

The total amount of water on the earth is about 1400 million cubic kilometers. Of this, 97.5% is sea water. About 75% of the remaining fresh water is locked up as ice caps and glaciers and further about 24% is locked underground as ground water. Ground water accounts for about 8×106 m3or 0.6% of earth's total water resources (Table – 1) 13,14.

Table 1: Inventory of water at the earth's surface

S. No.	*Reservoir*	*Volume (cubic kmx1,000,000)*	*Percent of Total*
1	Oceans	1370	97.25
2	Icecaps and Glaciers	29	2.05
3	Ground water	9.5	0.68
4	Lakes	0.13	0.01
5	Soil Moisture	0.07	0.01
6	Atmosphere	0.01	0
7	Streams and Rivers	0	0
8	Biosphere	0	0

Water Quality

A healthy environment is that in which the water quality supports a rich and varied community of organism and protects public health (15-18). It is a big issue today because of tremendous growth of the Nation's population and urban expansion and development. Rural areas can also contribute to water quality problems (14). People are primarily concerned with domestic water problems related to colour, odour, taste and safety to family health as well as the cost of soap, detergents, softening or other treatments required for improving the water quality (13).

2. Nitrate Contamination in Ground Water of India and Jaipur District, Rajasthan

In India, over 85 percent of drinking water sources have been based on ground water aquifers. In our country the percentage of water used for various applications is 93 percent in agriculture, 4 percent in industry and only 3 percent in domestic purpose. The waste generated by anthropogenic activities has not only polluted the environment as a whole but had a particular detrimental effect on the quality of aquatio envison too. Leachates from compost pits, animal refuse of garbage dumping grounds nutrient enriched return irrigation flows seepage from septic tanks, seepage of sewage etc. has adversely affected the ground water quality in several parts of India. The rate of generation of wastewater in India during 1981 was estimated to be 74,529 million liters/day i.e. about 27 km3 annually, which poses a perennial danger to the potable ground water resource (19).

Ground water is readily available drinking water source for many parts of India. Due to various factors including climate change, the semi-arid zones of the country are highly influenced by nitrate concentration. This contamination is largely controlled by the application of nitrogenous fertilizers and manures, waste water disposal, oxidation of nitrogenous human and animal excreta [20]. Nitrate contamination is predominant in the states of India such as Punjab, West Bengal, Andhra Pradesh, Tamil Nadu and Delhi, which have a major incidence of nitrate contamination. Humans, animals and ecology are equally affected by nitrate contamination in water [21]. A study of Krishna delta in southern India indicates that ground water of north krishna delta is more polluted with nitrate than the southern part. The possible sources for the high nitrate level in ground water were identified as excessive utilization of nitrogenous fertilizers for agricultural purpose [22].

Ground water is vulnerable to contamination by chemicals, including nitrate that can pass through soil to the water table. Nitrate comes from nitrogen supplied primarily by inorganic fertilizer and animal manure [23, 24]. Additionally, airborne nitrogen compounds emitted by industry and automobiles are deposited on the land in precipitation, gases, and dry particles (Puckett, 1994). Nitrate is soluble in water, can easily leach through soil, and can persist in shallow ground water for decades [24]. The concentration of nitrate in Dharapuram, South India, ranged from 10 to 415 mg/L. The analysis showed that 43% samples satisfied the standard of nitrate, i.e. 45 mg/L (BIS 1992) and 50 mg/L (WHO 2011). The alarming fact is that more than 34% of the samples have a nitrate concentration higher than 100 mg/L. the major sources of NO_3^- in ground water are non-point pollution such as fertilizers, used for agricultural, open dumping of animal wastes and poor sanitation facilities[25]. The statistical summary of the results of nitrate showed that the 88% of the samples had nitrate concentration above the maximum permissible limit of 45 mg/L as prescribed by BIS (1992). The elevated nitrate concentrations in the samples of the ground water are due to the intensive use of fertilizers in the study area. Leaching of nitrate to ground water is mainly due to excessive application of N-fertilizer, the absence of proper soil and water management practices, septic tanks, improper disposal of domestic wastes [26].

The progressive enrichment of nitrate ions, possibly from the point source pollution as per the results obtained from Andhra Pradesh and Rajasthan, respectively. The major factors controlling the spatial variation of nitrate are fertilizers application rate, crop rotation, fertilizer utilization efficiency of sown crops, irrigation art, soil texture and local redo-climate variability [27]. 5 to 300 mgs/L Nitrate was reported from Gangapur city, Rajasthan, posing serious health impacts [28].

Nitrate in water is due to domestic activities and agricultural runoff which dissolved in rain water leaches in the wells. The presence of nitrate in drinking water has adverse effects on health above 50 mg/L. The nitrate content in the study area varied in the range 3.8 mg/L to 72.4 mg/L and found below permissible limit of ISI, except few samples [29].Nitrate was found in all ground water samples with a great variation. It was recorded in the range of 3.70 to 82.11 mg/l, 0.34 to 50.70 mg/l and 0.50 to 278.68 mg/l in IGNP, Bhakra and Gang canal command area, respectively with mean values of 21.54, 13.65 and 13.41 mg/l. Canal water was also contaminated with nitrate content and it was reported as 21.60 mg/l, 0.32 mg/l and 0.34 mg/l in IGNP, Bhakra and Gang canal command, respectively. Max. value of nitrate in ground water was found in the sample from Bhagwansar-Chunavad- 31GG in Gang canal command area [30].

A total of 10,6019 sq km area (about 30%) of Rajasthan comes under saline ground water out of this 88675 sq. km area falls in Western Rajasthan of Ganganagar, Barmer, Bikaner, Churu and Jaisalmer districts. Districts like Jhunjhunu, Sikar, Churu and Barmer exhibits in 50% of samples of nitrate content in ground water more than 100 mg/lt. The high nitrate content is due to the available sandy soil which contributes its part to the trouble with nitrates since the most substances including nitrate do not get absorbed by sand [31]. According to Singh et. al. Nitrate and other parameters were estimated in drinking water and results were found to be quite nutritious except high nitrate [32]. In a research paper, A general survey and physico - chemical characterization of drinking water of Nawalgarh town (Rajasthan) was found that high level of nitrate in samples and it is due to improper drainage system. Which will create health problems in future. So the drainage system should be improved [24]. Major part of Western Rajasthan falls under high nitrate category and most part of Bhilwara – Rajsamand - Udaipur – Dungarpur belt has high nitrate concentration are found widely distributed all over. Low to moderate concentrations of nitrate are found in the areas around Jhalawar and scattered areas in rest of eastern Rajasthan. Maximum value of nitrate in Rajasthan has been observed as 1392 mg/lt in Chittarurgarh district [33]. Nitrate and other parameters were determined in the 50 villages of Bassi Tehsil, Jaipur and found that nitrate concentration in sampling sites ranges from 9 to 224 mg/lt in ground water samples, with lowest value 9 mg/lt in village Baseri and highest value 224 mg/lt in village Hanumanpura. Nitrate in ground water is mainly due to the intensive use of fertilizers. Leaching of nitrate to ground water is due to excessive application of N-fertilizers, the absence of proper soil and water management practices, septic tanks, improper disposal of domestic wastes. High nitrate levels found in drinking water have been proven to be the cause for numerous methaemoglobinaemia, alzheimer's disease, vascular dementia, multiple sclerosis in human beings, nitrate contamination leads to Eutrophication of water bodies [34].

3. Impacts of Nitrate on Human Health

According to the report of center for health effects of environmental contamination, the nitrate in the environment is a risk factor for human health. The high level of nitrate in food and drinking water was from nitrogen containing fertilizers and was identified as the environmental health concern (24, 35).

Ingestion of nitrate in drinking water by infants can cause low oxygen levels in the blood, a potentially fatal condition [35]. For this reason, the U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) of 10 milligrams per liter (mg/l) nitrate as nitrogen [21]. A high concentration of nitrates (>45 mg/L) may cause methaemoglobinemia, gastric cancer and birth defects [23]. The nitrate in drinking water has health effects so before using drinking water in this area must be treated [29]. In a study, abnormal level of nitrate in the ground water of Jaipur was found mainly in populated areas, which causes serious health hazards to the human [36].

4. Conclusion

The author concluded that the water samples were highly polluted and unfit for drinking and other purposes. The major sources of nitrate pollution in ground water were excessive use of nitrogenous fertilizer, organic waste and sewage. Nitrate pollution has become one of the key environment issues because of its implications on human and animal health. Based on the literature review, it is recommended that water should be used for drinking purpose after suitable treatment technology to prevent adverse health effects.

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