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Abstract

Disease burden, in relation to environmental risk factors is generally determined by establishing the number of people affected with each outcome. This can be then converted into disability-adjusted life years, accounting for the severity and duration of each health outcome. In relation to various risk factors; the disability or the diseased state may be attributed to exposure to poor quality water, improper sanitation and atmospheric pollution. Nitrogen is the major constituent of the atmosphere which occurs in many forms e.g. elemental nitrogen, nitrates and ammonia etc. According to WHO, if concentration of nitrates in our body exceeds more than 45 mg/l then it may cause various diseases such as Methemoglobinemia, Intestinal Cancer, Thyroid problems and various problems associated with the Reproductive system etc. The major source of increase in the concentration of nitrates is use of anthropogenic sources, nitrogen cycle, oxidation of lower nitrogen oxides to nitrates by microbial processes in the soil, photochemical oxidation in the stratosphere, chemical oxidation of ammonia, human and animal waste, industrial wastes, fertilizer processing industries, septic tanks and use of nitrogen rich fertilizers for agricultural purposes that leads to increase in nitrogen content in ground water by leaching etc. To achieve the safe nitrate levels, there are various options such as to change water sources, treatment of water(drinking water) using various processes such as reverse osmosis, ion exchange or biological denitrification etc. or by chemical reduction, by reducing the use of nitrogen rich fertilizers or by making dumps and using waste water treatment plants.

Introduction

Nitrogen is a major constituent of the earth's atmosphere and occurs in many different forms such as elemental nitrogen, nitrate and ammonia. Natural reactions of atmospheric forms of nitrogen with rainwater result in the formation of nitrate and ammonium ions1. High concentrations of nitrates in the body can cause methemoglobinemia, it is also cited as a risk factor in developing gastric an intestinal cancer, thyroid problems, reproductive problems, etc2.

While nitrate is a common nitrogenous compound formed during natural processes of the nitrogen cycle, anthropogenic sources (septic tanks, application of nitrogen-rich fertilizers and various other agricultural processes) have greatly increased the nitrate concentration, particularly in groundwater. The nitrate concentration of well water has shown rising trends in many countries within the last 30 years3. Methemoglobinemia is found prevalent in all age groups in areas of Rajasthan, with high nitrate concentrations in drinking water. Recurrent acute respiratory tract infections in some areas of Rajasthan have been attributed to high nitrate concentrations in drinking water4, 5.

Nitrate leaching from agricultural land must be considered as an important source for nitrate contamination of the groundwater. To reduce the nitrate load of groundwater it is very important to minimize the residual nitrate content in the root zone at harvest time; to preserve the nitrate during the main leaching period in the form of biologically fixed plant nitrogen within the Nitrogen cycle. Nitrate losses by microbial denitrification in the groundwater can play an important role. Quantitative understanding of the complex processes determining the final nitrate concentration of a groundwater is crucial. All agricultural and groundwater management measures should be applied to secure a sufficient water quality6.

A water source is said to be safe if it is free from any physical, chemical, bacteriological and biological contamination and conforms to the drinking water quality standards prescribed. The recommended standards acceptable and cause for rejection for drinking water in India by WHO and BIS are given as in the under given table:

Nitrates and their impacts

Nitrogen Cycle:

Nitrogen is the most abundant element in the atmosphere; composing nearly 80% of the air. Gaseous nitrogen can be found in many forms, the major ones consisting of N_2, N_2O, NO, NO_2 and NH_3. The two most important compounds that result from the reaction of these gases and rainwater are Nitrate (NO_3^-) and Ammonium ions (NH_4^+). Processes that lead to nitrate formation in the atmosphere are: reactions caused by lightning, photochemical oxidation in the stratosphere, chemical oxidation of ammonia, oxidation of lower nitrogen oxides to nitrates by microbial processes in the soil and the fossil fuel combustion. Various sources of Ammonia in the atmosphere are: fertilizer manufacturing, anaerobic decomposition of organic matter, bacterial decomposition of excreta and burning of coal. Ammonium can undergo the process of nitrification; an oxidation reaction that converts it to nitrate. These ions can become part of the soil composition or enter into the groundwater through various simple and complex processes7.

Nitrate that leaves the atmosphere can be converted back into elemental nitrogen, through the process of denitrification. This often takes place in the soil through the activity of bacteria that reduces the nitrates to its inert form8.

Major Sources of Nitrate Pollution:

There are number of sources of nitrate contamination of groundwater such as, human and animal waste, industrial wastes from food processing, fertilizer processing industries and septic tanks; the major source of nitrate pollution in the densely populated areas is the septic systems of that area.

Another major reason for the nitrate pollution may be taken as the disturbances in the natural systems due to the changes made by the mankind for its facilities; one example of this is the effect of forested areas on the leaching of nitrate to the groundwater. Natural, dense forests conserve nitrogen but cutting of such forests by the human causes lesser conservation of nitrogen, which in turn leads to nitrate pollution of the groundwater9, 10.

Another major source of nitrogen pollution of groundwater is the application of nitrogen-rich fertilizers to the agricultural land areas. The nitrogen provided to such areas in the form of fertilizers can be consumed in number of ways such as; it may be: taken up by plants; stored in soil; lost to atmosphere and it may be lost to groundwater11.

There are number of reasons or factors that could lead to more of the nitrogen leaching to the groundwater. Some of them are summarized here under:

Nitrogen content

Nitrogen source

Irrigation practices

Soil texture

Obviously the more nitrogen rich fertilizers are used by the farmer, greater will be the chances of nitrate pollution of groundwater. Even if farmers cut down on nitrogen fertilizer, there will still be some nitrate leaching. Although sustainable practices may not eliminate nitrates, it might lower them to a safer level12, 13.

Problems Associated With High Nitrate Levels:

Nitrate incorporation in humans takes place via drinking water and food. The water used for drinking and cooking in the rural areas is high in nitrate content14. Although there have been studies performed attempting to link nitrate consumption to various illnesses, a few are stated here under:

Methemoglobinemia: Cases of Blue-Baby Syndrome usually occur in rural areas which rely on wells as their primary source of drinking water. Often these wells become contaminated when they are located close to cultivated fields, feedlots and septic tanks. Methemoglobinemia is the condition in the blood which causes Infant Cyanosis or Blue-Baby Syndrome. In the GIT of an infant certain bacteria converts the nitrate ion to nitrite ion, which then reacts with two molecules of hemoglobin to form methemoglobin; In acid mediums, such as the stomach, the reaction occurs quite rapidly. This altered form of blood protein (hemoglobin) prevents the blood cells from transporting oxygen, which leads to the oxygen deprivation in the infant; due to which infant often take on a blue or purple tinge in the lips and extremities, hence named as, Blue Baby Syndrome. Other signs of Methemoglobinemia are gastrointestinal disturbances, vomiting, diarrhea and relative absence of distress when severely cyanotic but irritable when mildly cyanotic.

Methemoglobinemia most often affects infants of less than six months in age; the primary reason is that infants possess much less oxidize-able hemoglobin than adults, so a greater percentage of their hemoglobin is converted to methemoglobin which greatly decreases the blood's ability to carry oxygen15-17.

Stomach and Gastrointestinal Cancer:

Scientists claim that nitrate represents a potential risk because of nitrosation reactions which, with appropriate substrates present in the body Nitrates form N-nitroso compounds which are strongly carcinogenic in animals. There is still no concrete evidence to support this theory of carcinogenicity of nitrates. This inconsistency suggests that nitrate alone cannot be the only cause of elevated regional gastric cancer mortality rates, but these could result from a number of other factors, such as high pesticide levels, presence of coli form bacteria and/or other groundwater contaminants18.

Thyroid Problems:

Histo-morphological changes in thyroid are observed due to 250 and 500 mg/l of Nitrates. Number of experimental studies or data suggests that Nitrates impairs thyroid function involving the hypothalamo–hypophysio–thyroid axis19, 20.

Reproductive Problems:

Few studies have been published regarding water nitrate and the outcomes of spontaneous abortions, stillbirths, premature birth, or intrauterine growth retardation. Results of these studies have been inconsistent, possibly indicating no true effect of water nitrate on reproductive outcomes at the levels evaluated in these studies. Alternatively, the inconsistencies may be due to the differing periods over which exposure was assessed, differing levels of water nitrate across studies, or differences in exposure to other cofactors21.

Treatment of Nitrate:

In case of high nitrate problem in subsurface waters, there are two options for achieving safe nitrate levels; first one is Non-Treatment Techniques that consist of blending drinking waters or changing water sources and the second alternate is the use of Treatment Processes, such as: Ion Exchange, Reverse Osmosis, Biological Denitrification and Chemical Reduction, to remove portions of the pollutant. However, the most important thing to be noted is that, neither of these methods is completely effective in removing all the nitrogen from the water. Treatment can remove some of the nitrate, but with varying efficiencies, much of which can depend on other substances found in the water22, 23.

Conclusion(s)

With regard to the nitrate problem in ground water the best way to avoid health risks is to reduce the fertilization of fields using nitrogen rich fertilizers. By using much lower amounts of fertilizers these crops may still be as productive as those produced under heavily fertilized soils, due to the healthier environment for the microbes. Furthermore, many of the above stated prevention methods can be used to reduce nitrate leaching from the soil into the groundwater. There should be proper checks on the water wastes from various industries contributing in the excessive nitrate composition in the waste water and such industries should be notified to install water treatment units for the removal of nitrates from the waste water before its disposal to the dumps.

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Illustrations

Illustration 1

Standards of Drinking Water

S. No.	Characteristics	Acceptable	Cause for rejection
1.	Turbidity (NTU)	1	10
2.	Color (Units on Platinum Cobalt Scale)	5	25
3.	Taste and Odor	Un objectionable	Objectionable
4.	pH	7.0 to 8.5	<6.5 or >9.2
5.	*Total dissolved solids (mg/l)	500	2000
6.	Total hardness (as CaCO3) (mg/l)	200	600
7.	Chlorides (as Cl) (mg/l)	200	1000
8.	Sulphates (as SO_4) (mg/l)	200	400
9.	Fluorides (as F) (mg/l)	1.0	1.5
10.	Nitrates (as NO_3) (mg/l)	45	>45
11.	Calcium (as Ca) (mg/l)	75	200
12.	Magnesium (as Mg) (mg/l)	30	150
13.	Iron (as Fe) (mg/l)	0.1	1.0
14.	Manganese (as Mn) (mg/l)	0.05	0.5
15.	Copper (Cu) (mg/l)	0.05	1.5
16.	Arsenic (mg/l)	0.05	>0.05

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