ABSTRACT

Water is an essential commodity of life on the earth. It plays a very important role in agricultural development. Agricultural activity impacts the water quality through the movement of chemical fertilizers and other poisonous materials from the agricultural fields to deep aquifers through surface runoff and deep percolation. The important source and cause of agricultural pollution are irrigational return flows and use of nitrogenous fertilizers in which nitrate is the basic component. High concentrations of Nitrate in water may cause methemoglobinemia, and have been cited as a risk factor in developing gastric and intestinal cancer. One of the most important negative effect of intensive use of nitrogenous fertilizer use is water eutrophication. Nitrates in the irrigational water serves as a nutrient to plants and crops. As per the guidelines of Ayers and Westcot (1994), nitrate content ranging from 22.5 to 135 mg/L causes slight to moderate toxicity and above 135 mg/L, nitrate concentration causes severe restriction on irrigational use. Due to the impact of fertilizers on human and environment, it is quite necessary to reduce the nitrate concentrations to safe levels.

Keywords: Water quality, Nitrates, Fertilizer.

INTRODUCTION

In order to achieve self capability in food grains, the farmers are using high doses of nitrogenous fertilizers along with insecticides, pesticides, fungicides and other chemicals in agricultural fields. As per the annual publication of the department of fertilizers under the ministry of chemicals and fertilizers (Indian Fertilizer Scenario 2014), the use of nitrogenous fertilizers in the country has been increased by more than 50 percent since 2000. India is the second premier consumer of nitrogen in the world after China. According to the Food and Agriculture Organisation, India's annual utilization of nitrogen is 16.48 million tones. The rising rate of nitrogen fertilizers have directly or indirectly effect the environment and causing nitrate pollution and thus demean the water quality. At the same time the farmers are using unscientific methods of farming such as flood irrigation, resulted water pollution through return irrigational flows.

Source of nitrogen and nitrate

Nitrogen is an crucial plant nutrient and it is the most copious element in the atmosphere, composing almost 80% of the air. Gaseous nitrogen can be found in many forms, the major ones consisting of N₂, N₂O, NO, NO₂, NH₃. Few of these gases readily react with rain water to generate nitrate and ammonium ions in solution. These ions can become part of the soil layer composition, or groundwater solution. Nitrate is the most common pollutant as dissolved nitrogen in groundwater. However, it can be found in the form of nitrite (NO₂⁻), nitrogen (N₂), nitrogen oxide (N₂O) and organic nitrogen. Nitrate that leaves the atmosphere can be transformed back into elemental nitrogen, through the process of denitrification. This often takes place...
in the soil through the activity of bacteria that reduce the nitrate. Ammonium can undergo the process of nitrification, which is an oxidation reaction, that converts it to nitrate. Through this mechanism, the nitrogen in the ammonium ion is released back into the atmosphere. After the conversion from elemental into nitrogenous ions in solutions of rainwater, the nitrogen in these compounds can be exhausted back to the atmosphere. \( N_2 \) is an “unreactive” form of nitrogen that plants and animals cannot access directly. In order for organisms to draw on this nitrogen to support their growth, the nitrogen must be “fixed” – that is, converted from the unreactive \( N_2 \) form to a reactive form such as nitrate (\( NO_3^- \)) or ammonia (\( NH_3 \)). In an environment absent of human influence, this conversion occurs only through fixation by plant- and soil-associated bacteria and lightning strikes. Human processes have doubled the global rate at which reactive nitrogen is produced. This change has led to an increase in the sources of reactive nitrogen that contribute to environmental pollution.

Nitrogen fertilizers or manures used on a sandy soil are more prone to leaching to groundwater than nitrogen used on a clay soil. Water moves rapidly through sandy or other coarse-textured soils. Nitrogen loss to the groundwater from clay soils is smaller than those for the coarse-textured soils. Clay soils do not specially retain nitrates. Water movement through clay soils is very slow and small. Water does not pass easily through clay soils so nitrates, which only move with water, do not leach to groundwater. Pore space in clay soils is often filled with water. Water-filled pores of clay soils lack oxygen. Lacking oxygen, a group of soil bacteria, called facultative anaerobes, substitute nitrates for oxygen for respiration. The nitrate concentration in groundwater is influenced by rainfall, where the amounts of rainfall are low, the concentration tends to be high because the diluting effect is reduced.

**Agricultural water pollution**

Nitrate contamination is a long-term problem and remedial action is necessary. One man’s food is other man’s poison, this proverb stands in good concurrence for fertilizers. Nitrogen is an essential plant nutrient, some plants fix atmospheric nitrogen but modern farming practice involves the addition of nitrogen in the form of manure, sewage sludge and chemical fertilizers. The accumulation of soluble forms of nitrogen, particularly nitrate, in water can be detrimental since high concentrations of nitrate in river water encourage eutrophication, and concentrations in drinking water must be limited for health reasons. The rate of movement of water, and hence of nitrate, from the soil zone to the saturated zone is influenced by the depth of the water table, that is the thickness of the unsaturated zone, and the properties and nature of the aquifer. Water can pass quickly through fractured rocks, at rates of some tens of metres per days.

The important sources and causes of agricultural pollution are Irrigational return flows, fertilizers and soil amendments, Use of Pesticides and Insecticides, Spills and surface discharge, stockpiles, Septic Tanks and Cesspools. These human-derived sources of reactive nitrogen include airborne emissions from fossil fuel combustion by vehicles and electric utilities, fertilizer production that results in runoff from farms as well as suburban and urban lands, and imported food that produces nitrogen-rich effluent leached from septic tanks and discharged from wastewater treatment plants.

The anthropogenic sources most often cause the amount of nitrate to rise to a dangerous level. Waste materials and Septic tank are the anthropogenic sources of nitrate contamination of groundwater. Many local sources of potential nitrate contamination of groundwater exist such as sites used for disposal of human and animal sewage; industrial wastes related to food processing and sites where handling and accidental spills of nitrogenous materials may accumulate. When natural sources contribute a high concentration of nitrate to the groundwater it is usually as a result of anthropogenic disturbance. Natural forests conserve nitrogen but human disturbances can lead to nitrate pollution of the groundwater.

The agricultural water pollution results due to return irrigational flows, due to excessive irrigation and fertilizer use or in case of non irrigated lands it may occur due to excessive use of fertilizers and infiltration of rain water in such agricultural fields. The use of pesticides and insecticides also results water pollution through infiltration. Nitrate contamination is a long-term problem and remedial
action is necessary. The cost of chemical treatment to remove it from groundwater is significant and disposal of water products from the process can also be difficult. An alternative course is to reduce the contamination at the source – the amount leaching from the soils, which mainly occurs in the autumn and winter when the soil is fully saturated.

The average nitrate content in rain water reported by Handa, (1983) is less than 0.5 ppm. in India. Karanth, (1987) states that the unpolluted groundwater contain less than 5 ppm of nitrate. The higher content of nitrate in groundwater is associated with contamination from different sources.

Impact of nitrates on human health, environment and agriculture

As per the guide lines of WHO (2006) and ISI (2004), the nitrate in potable water should not exceed 50 ppm and 45 ppm respectively. The toxicological effects of nitrate noted in three stages. The primary toxic effect of nitrate concentrations in drinking water of 50 mg NO$_3$ - /L exceeds the value of the bowel in adults, digestive and urinary systems, inflammation is seen. Secondary toxicity, high nitrate concentration in drinking water caused disease in infants as methamoglobinemia, commonly called ‘blue baby syndrome’. A further concern is that nitrate can be converted, by bacteria in the digestive tract, into nitrosamines which are potentially carcinogenic. Strong carcinogenic effects of these compound has been identified in recent studies.

One of the most important negative effects of intensive fertilizer use is water eutrophication. Increased amounts of nitrogen and phosphorous compounds in water as a result of the increase in the amount of higher aquatic plants and algae formation and degradation of water quality and water environment in the event of life is defined as eutrophication. The accumulation of soluble forms of nitrogen, particularly nitrate, in water can be detrimental since high concentrations in river water encourage eutrophication, and concentrations in drinking water must be limited for health reasons. The rate of movement of water, and hence of nitrate, from the soil zone to the saturated zone is influenced by the depth of the water table, that is the thickness of the unsaturated zone, and the properties and nature of the aquifer.

Nitrates in the irrigational water serves as a nutrient to plants and crops. Ayers and Westcot, (1994) proposed a modified water quality guidelines to assess the agricultural water quality on the basis of Salinity, Water Infiltration, Specific ion capacity and Miscellaneous effects. Each of the water quality problems has been further classified into None restriction category, Slight to moderate restriction category and Severe restriction category on the basis of degree of restriction on their use. As per the guide lines of Ayers and Westcot (1994), nitrate content upto 22.5 mg/L causes no toxic effect, nitrate concentration ranging from 22.5 to 135 mg/L causes slight to moderate toxicity and above 135 mg/L. nitrate concentration causes severe restriction on irrigational use.

As per Neena Arora (2011), Excessive use of nitrogen fertilizers are going to be contaminate the water bodies thus it affects the fish fauna and causing health hazards for human beings and animals. 25 to 30% decrease in protein content have been reported in corn, maize, gram and wheat crops when grown in soils fertilized with NPK fertilizers. Excessive and imbalanced use of chemical fertilizers has adversely affected the soil causing decreasing in organic carbon, reduction in microbial flora of soil, increasing acidity and alkalinity and hardening of soil.

An epidemiological study in Rajasthan revealed severe methaemoglobinemia (7–27% of Hb) in all age groups of the population, especially in < 1 year age group (Gupta et al., 2000). Malik (2000), however, reported that of the total 822 groundwater samples from Punjab and Haryana, 3.3% had NO$_3$–N in the 0–10 mg/L range, 15% with 10–20 mg /L, and 58% contained > 22 mg/L. Nitrate pollution of groundwater is a serious problem in Karnataka. Nitrate problem has also been reported from Andhra Pradesh (Rao, 1998), Tamil Nadu, and Maharashtra.

CONCLUSIONS

On the basis of the study it can be concluded that the nitrate pollution in India is a very serious problem and it is likely to grow high dimension with the passage of time and continuous use of nitrogenous fertilizers. As the nitrate pollution becomes the global problem, it is quite necessary to
reduce the use of nitrogenous fertilizers by adapting the latest irrigation technology and switch over to traditional methods of organic farming for better green revolution.

In order to overcome the problem the following suggestions can be made:

- High nitrate water may be used as as substitute of nitrogenous fertilizers which helps in the abatement of nitrate pollution and also minimize the use of nitrogenous fertilizers.
- The scale of the problem can also be reduced by better land management including reducing the use of artificial fertilizers and carefully managing the disposal of farm wastes.
- Farmers desire to take more productions , they use unscientific irrigational methods and use high doses of chemical fertilizers so the farmers should be trained and provide them proper knowledge of irrigation techniques, advised to rotate the crops and use the proper does of fertilizers.
- The shallow groundwater having the nitrate concentration in between 30to 40mg/l should be regularly monitored and should not use for sensitive crop irrigation.
- Motivate the farmers to use organic manures in place of chemical fertilizers for better agricultural development.

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