Nitrate Pollution and its Remediation

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1. Introduction

Groundwater, due to its relative purity, enjoys a privileged place as a potable water source world wide. Among the selected chemical threats to groundwater in the world, nitrate (NO\textsubscript{3}\textsuperscript{-}) is listed as second most common pollutant of groundwater next to pesticides (Spalding and Exner 1993; Bachmat 1994). Out of the total earth surface water almost 95\% is in ocean, seas, ice caps, glaciers or buried deep under ground leaving only a small fraction i.e. 5\% as fresh water, suitable for human consumption. Out of this small 5\% of fresh water, approximately 68\% is groundwater. It is thus very important to protect the groundwater resources from pollutants which threaten its quality. If not taken care of, it may pose serious problems for human and animal life and whole environment (Babiker et al. 2004).

Nitrate pollution usually originates from diffused sources, like intensive agriculture and unsewered sanitation or point sources, such as irrigation of land by sewage effluent (Bouchard et al. 1992; Eckhardt and Stackelberg 1995; McLay et al. 2001). Nitrate pollution of groundwater caused by agricultural activities has been encountered in almost all regions of the World (Dillon et al. 1991; Bernhard et al. 1992; Spalding and Exner 1993; Lagerstedt et al. 1994; Zhang et al. 1996; Levallois et al. 1998; Hudak 2000). It may also originate from industrial effluents, including paper and munitions manufacturing (Nitrate in News), septic tanks and human and animal wastes, due to biochemical activity of nitrifying bacteria. In groundwater recharge areas with large portions of agricultural land, the nitrate concentration of well water has shown rising trend in many countries within last two three decades. Nitrate leaching from agricultural land must be considered as a non-point source for nitrate pollution of the groundwater (Strebel et al. 1989). High levels of nitrate can leach through soils that have received heavy application of Manure. Water from farm ponds, road ditches or other surface depressions, which collect drainage from poultry houses, feedlots, heavily fertilized fields, septic tanks, or manure lagoons may
contain high concentration of nitrate. Nitrate is one of the potential contaminants of groundwater, because it is soluble and moves readily with soil water (Salameh Al-Jamal et al. 1997). Hack-ten Broeke et al. (1996) defined the term ‘nitrate leaching risk’ as the number of days during the year with a NO$_3^-$ N concentration exceeding a predefined threshold value, for which the EC-directive for drinking water is used (i.e. 50 mg/l nitrate). Nitrate leaching potential is defined as the downward soil water flux from the root zone, possibly causing solute leaching (Hack-ten Broeke et al. 1993). In terrestrial ecosystems, nitrate is subjected to mass flow and leaching.

Groundwater with nitrate concentration exceeding the threshold of 3 mg/l Nitrate Nitrogen (NO$_3^-$ N) or 15 mg/l NO$_3^-$ is considered contaminated due to human activities (so called human affected value (Burkart and Kolpin 1993; EcKhardt and Stackelberg 1995; Agrawal et al. 1999). However, the maximum acceptable concentration of nitrate for potable water according to World Health Organisation (WHO) is 11.3 mg/l NO$_3^-$ N or 50 mg/l NO$_3^-$ (Strebel et al. 1989; Power and Schepers 1989). The current limits have been modified to 10 mg/l NO$_3^-$ N for drinking water which is equivalent to about 45 mg/l of nitrate (Agrawal et al. 1999). Hygienic and toxicological considerations are the decisive reasons for assessing the standard, particularly the risk of methemoglobinemia on infants and of carcinogenic effects of nitrosamino compounds possibly formed (Selenka 1985).

Recent studies in Australian arid zones have shown that bacteria associated with certain soil termites can cause considerable nitrate pollution of shallow groundwater under flash desert precipitation events (Barnes et al. 1992). No such information has yet been gathered from Indian arid zones. Also, denitrification of nitrate leads to production of nitrous oxide causing problem of global warming. In addition, the loss of nitrate from the field has to be considered as the loss of a resource of whose production is linked to the consumption of energy (ca. 47 MJ/ kg N fertilizer) and the emission of atmospherically active substances. On the average, 2500 g CO$_2$, 10 g N$_2$O and 1 g CH$_4$ are emitted to produce 1 kg of N fertilizer (Kaltschmitt 1997).

2. Methods for Estimation of Nitrate Pollution

In order to find out the extent of nitrate pollution, it is essential to have methods for estimating nitrate contamination of the sites. A number of approaches have been used. Thus, traditionally NO$_3^-$ N leaching has been determined using lysimeteres where the drainage water is collected and NO$_3^-$ N content measured (Chapman et al. 1949; Owens 1960; Pratt and Chapman 1961), however, it is expensive method. Pratt et al. (1978) described a cheaper method where the ratio of chloride in the irrigation water, corrected for plant uptake, the chloride below the root zone is used to estimate leaching fraction (LF). The LF, seasonal evapotranspiration and NO$_3^-$ N concentration below the root zone are combined