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Nitrate contamination in groundwater of some rural areas of Rajasthan, India

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ABSTRACT

Efforts were made to evaluate the level of nitrate in some agro-economy based rural habitations of northern Rajasthan, India. A total of 64 groundwater samples from 21 different villages/sub-villages of district Sri Ganganagar, India were collected and analyzed for nitrate (as NO_3^-), sulphate (as SO_4^{2-}) and few other parameters. NO_3^- level in groundwater was 7.10–82.0 mg l^{-1} for individual samples. But average NO_3^- for total samples was 60.6 ± 33.6 (SD) mg l^{-1}, which indicates the non-suitability of groundwater for drinking purposes, if BIS permissible limit (22.6 mg l^{-1}) is considered as reference level. SO_4^{2-} ranged form 28.6 to 660.3 mg l^{-1} in this area. The regression analysis indicates the difference sources for NO_3^- and SO_4^{2-} contamination in different regions rather than a common source. The point and non-point sources of NO_3^- and SO_4^{2-} in groundwater of this region may be N-fertilizer, sewerage, animal waste, organic manure, geology of sub-surface soil layers, pit latrines, etc. Results thus indicated that groundwater of this part of the State is severely polluted due to anthropogenic activities. The continuous consumption of such water may pose serious health hazardous in local residents.

1. Introduction

The chronic impact of chemical contamination of groundwater is more dreadful particularly in rural areas of developing world [1] where groundwater is the main assessable source for potable water. Groundwater can have some dissolved forms of chemicals, which may be unacceptable due to their chronic health effects, taste and aesthetic reasons [2]. Undesirable chemicals in groundwater may cause very serious health problems, whether the chemicals are naturally occurring or derived from source of pollution. The World Health Organization (WHO), a premier and most prestigious international health organization has published a guideline on the chemical safety of drinking water. According to the guideline there are two main criteria for identifying specific chemicals of concern to public health: high probability of consumer exposure from drinking water and, significant hazard to health [3]. Several chemicals, whether occurring naturally or due to anthropogenic activities, present different level of health hazardous in humans.

Nitrate contamination in groundwater is a common problem in many part of the world arising from diffuse reasons, e.g. intensive agriculture, unsewered sanitation in densely populated areas, or from point sources such as irrigation of land by sewage effluents. Nevertheless, the heavy use of nitrogenous fertilizers in cropping system is the largest contributor to anthropogenic nitrogen in groundwater worldwide. Nitrogenous fertilizer rapidly converts into NO_3^- form in soils, which is readily available to plants, but is highly soluble and hence easily leachable to deep soil layers. When quantity of nitrogen added to the soil exceeds the amount that the plants can use, the excess NO_3^- does not get much adsorbed by soil particles, leaches out from the root zone by water percolating through the soil profile and ultimately accumulates into the groundwater [4]. Since NO_3^- is the part of nitrogen cycle in nature and it represents the most oxidized chemical form of nitrogen found in the natural systems. Also, it is an essential part of building blocks of living organism, i.e. protein, genetic materials (DNA and RNA), vitamins, hormones and enzymes [5]. But human health consequences of exposure to high nitrate levels are of great concern. Greater NO_3^- intake reduces the oxygen-carrying capacity in the blood by binding to hemoglobin, causing a condition referred to as methemoglobinemia or "blue baby syndrome," which may cause mortality by asphyxiation especially in newly born infants. However, infants less than six months of age are at highest risk due to the presence of bacteria in their digestive systems that speed the binding process. Recent studies have revealed that nitrate can be endogenously reduced to nitrate, which can then undergo nitrosation reactions in the stomach with amines and amines to form a variety of *N*-nitroso compounds (NOC) [6], which are mainly carcinogens [7]. The continuous consumption of water containing high

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Table 1
Nitrate (as NO_3^-) contamination in some regions of India.

Sampling/study site	State	Range	Ref.
Ludhiana district	Punjab	0.31–13.3 mg l^{-1}	Bijay-Singh et al. [8]
Kanpur district (n = 297)	Uttar Pradesh	1.0–166 mg l^{-1}	Sankararamakrishnan et al. [2]
Hooghly district (n = 412)	West Bengal	0.01–4.56 μg ml^{-1}	Kundu et al. [4]
Nadia district (n = 342)	West Bengal	0.01–5.97 μg ml^{-1}	Kundu and Mandal [21]
Anantapur district (n = 48)	Andhra Pradesh	3.0–684 mg l^{-1}	Reddy et al. [5]
New Delhi (n = 95)	Delhi	0.04–98.3 mg l^{-1}	Data et al. [14]
Jaipur district (n = 5)	Rajasthan	26–459 mg l^{-1}	Gupta et al. [13]

Table 2
N based fertilizer consumption in Rajasthan.

N-based fertilizer	Tonnes			
	1996–1997	1997–1998	1998–1999	1999–2000
Urea	1057.38	1132.41	1007.69	1031.50
Ammonium sulphate	1.95	3.44	3.35	2.17
Calcium ammonium nitrate (CAN)	14.29	13.83	12.69	13.28
Di-ammonium phosphate (DAP)	246.77	322.75	330.79	453.18

Table 3
Livestock population and its contribution in total NPK production in Sri Ganganagar district.

Livestock	Total population[a]	Tones nutrient $year^{-1}$ [b]		
		N	P	K
Cattle	70,1805	35,090.25	10	7,018,050
Pigs	3,865	46.38	4	15,460
Sheep	33,8962	3,389.62	2	677,924
Goats	268,853	2,688.53	2	537,706
Horses	1,058	47.61	8	8,464
Poultry	132,113	792.678	0.19	25,101.47
Total[c]	1,622,516			

[a] Census 2001 [16].
[b] Based on nutrient production rate as calculated by Sheldrick et al. [29].
[c] Including all other livestock populations.

nitrate may cause several health hazardous in animals, e.g. gastrointestinal cancer, Alzheimer disease, vascular dementia, absorptive, secretive functional disorders of the intestinal mucosa, multiple sclerosis, Non-Hodgkin's lymphoma, hypertrophy of thyroid, etc.

In developing countries like India NO_3^- enrichment in groundwater has been appearing as a major threat in few intensively

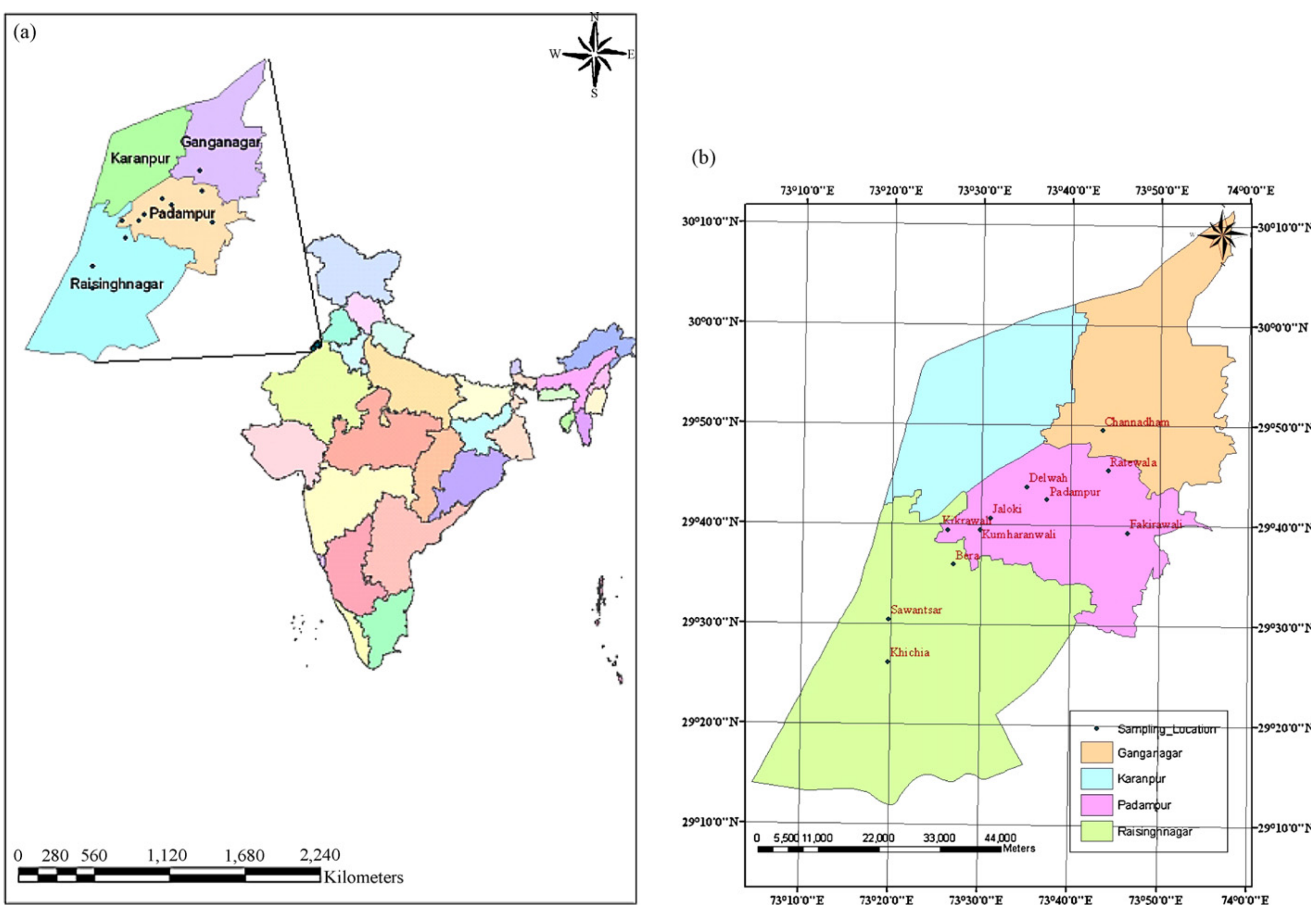

Fig. 1. (a) Location map of study area in India and (b) sampling location in the study area.