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Seasonal Variation in Nitrate Levels of Groundwater in Coimbatore District, Tamil Nadu

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ABSTRACT

To study the influence of seasonal variation on the nitrate contamination of groundwater, water samples were collected during the pre and post-monsoon seasons from open wells, bore wells and hand pumps at different villages spread over in the 18 blocks of the Coimbatore district of Tamil Nadu. The water samples were analysed for pH, EC and NO_3-N content. Results indicated that the groundwater of different blocks of Coimbatore ranged from neutral to alkaline in reaction and saline in nature. The overall mean NO_3-N content of groundwater samples of different blocks varied from 5.20 to 9.52 mg L^{-1} with the overall mean value of 6.74 mg L^{-1} and it is below the critical level of 10.0 mg L^{-1}. The higher mean NO_3-N content was observed in groundwater samples collected from Gudimangalam block followed by Periyanaickenpalayam and Sultanpet blocks. The temporal variation in NO_3-N content of groundwater samples was observed, being higher in the post monsoon than in the pre monsoon season.

INTRODUCTION

Nitrate contamination in groundwater is a common problem in many parts of the world arising from diffuse reasons, viz., 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 (Fytianos & Christophoridis 2003). 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, and leaches out from the root zone by water percolating through the soil profile and ultimately accumulates into the groundwater (Kundu et al. 2008). 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 (Reddy et al. 2009). But human health consequences due to exposure to high nitrate levels are of great concern. Greater NO_3^- intake reduces the oxygen-carrying capacity in the blood by binding to haemoglobin, causing a condition referred to as methaemoglobinaemia or "blue baby syndrome," which may cause mortality by asphyxiation, especially in newly born infants (Wolfe & Patz 2002). However, infants less than six months of age are at highest risk due to the presence of bacteria in their digestive systems that speed up the binding process. The continuous consumption of water containing high nitrate may cause several health hazards in animals, e.g. gastrointestinal cancer, alzheimer disease, vascular dementia, absorptive and secretive functional disorders of the intestinal mucosa, multiple sclerosis, hypertrophy of thyroid, etc. Because of that, the US Environmental Protection Agency has established a maximum contaminant level (MCL) of 10 mg L^{-1} NO_3-N in groundwater (USEPA 2000). Studies on the effect of seasons on the level of nitrate in ground water are meagre. Hence, an attempt is made to assess the level of nitrate in groundwater among seasons in Coimbatore district.

MATERIALS AND METHODS

Background of the study area: The study area, Coimbatore district lies between 10°12' and 11°24' N and 76°36' and 77° 30' E. It is bounded by the Western Ghats, of which the Nilgiris on the north west and Anamalai on the south are the chief ranges that attain a height of over 2,400 m. In between the hill ranges lies the east-west trending pass known as Palghat gap. The rest of the district is an undulating plain sloping gradually from west (600 m) to east (150 m). On an average, the district gets 600 mm of rainfall in a year. The temperature varies from 18.6° to 35.7°. Regarding the soil types, more than 50 percent of the area comes under Irugur

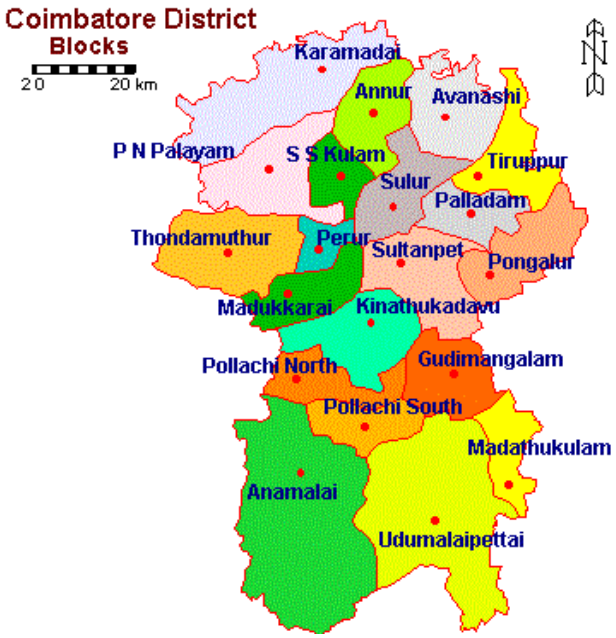

Fig. 1: Study area - Coimbatore district.

and Palladam series, which are poor in productivity. The soil is predominantly black soil, which is suitable for cotton crops. Red loam is also found in Avanashi and Coimbatore talukas. Major source of irrigation in this district is through wells. Important crops grown in the district are paddy, sorghum, ragi, maize, small millets, pulses, sugarcane, coconut and turmeric. Regarding the land use pattern, of the total geographical area 7.47 lakhs ha and 3.14 lakhs ha are under net sown area and gross cropped area while 0.19 lakh ha is sown more than once. Cropping intensity is 1.06.

Collection of water samples: Water samples were collected from different sources viz., open well, bore well and hand pump located in crop field area (346 samples), habitation area (109 samples) and dairy/poultry farming areas (22 samples), at different villages spread over in the 18 blocks of the Coimbatore district of Tamil Nadu during the month of January, 2008 (Fig. 1). Due to the industrial influences, the samples were not collected from two blocks viz., Palladam and Tirupur. Sampling was done at a spatial distance of approximately 2 to 3 km away from each other areas. While sampling from agricultural fields, care was taken to select the sites having almost similar type of cropping systems over a large area around them for ascribing any possible effects of cropping system on the loading of NO_3-N in the aquifers beneath.

Analysis of water samples: The pH and EC values of the water samples were measured *in-situ* immediately after collection by using a portable pH meter and conductivity meter. The NO_3-N content was measured by forming a purple azo-dye out of a coupling reaction between a diazo compound of sulphanilamide and N-(1-napthyl)-ethylene diamine dihydrochloride and recording the colour intensity at 540 nm with the help of a Flow Injection Autoanalyzer (FIASTAR 5000, FOSS Analytical AB, Sweden) with a detection limit of 0.01 µg mL^{-1} NO_3-N following the method described by US EPA (1979). Means of three replicates, range and standard deviation were calculated for all the parameters analysed.

RESULTS AND DISCUSSION

pH of groundwater: In all the three seasons, a significant variation in the pH of groundwater samples collected from different blocks was observed (Fig. 2). Results showed that the groundwater of different blocks of Coimbatore is neutral to slightly alkaline in reaction. Irrespective of the seasons and blocks, there was an increasing trend from post monsoon 2006 to post monsoon 2007 and a slightly higher pH values were observed during post monsoon 2007.

EC of groundwater: The mean EC values of different blocks of Coimbatore district varied from 0.93 to 3.59 dS m^{-1}. Irrespective of the seasons, there was a significant variation in EC values of groundwater samples collected from different blocks (Fig. 3). Although the variation was minor, it was observed that there was always a higher value of EC of groundwater samples collected during post-monsoon seasons of 2006 and 2007 than that of samples collected during pre-monsoon season of 2007. It might be due to the dissolution of ion containing substances in soils during infiltration and percolation of rain water. Similar results were reported by Jain et al. (2013).

Nitrate-N content of groundwater: The season-wise and block-wise variation in NO_3-N content of groundwater samples is shown in Fig. 4. The mean NO_3-N values of different blocks varied from 4.45 to 12.21 mg L^{-1}. Irrespective of the seasons and blocks, a significant variation in the NO_3-N content of groundwater samples was observed. In general, higher NO_3-N content was recorded during the post monsoon season of 2006 and 2007.

Temporal variation in NO_3-N content of groundwater: About 150 sites were selected and were monitored for their seasonal variation in the Nitrate-N content. During pre and post monsoon season of 2007, water samples were collected and analysed for Nitrate-N content.

Temporal variation in the NO_3-N content of the representative aquifers of the selected sites are shown in Fig. 5. The temporal variation in NO_3-N content of groundwater samples was observed, being higher in post monsoon-2007

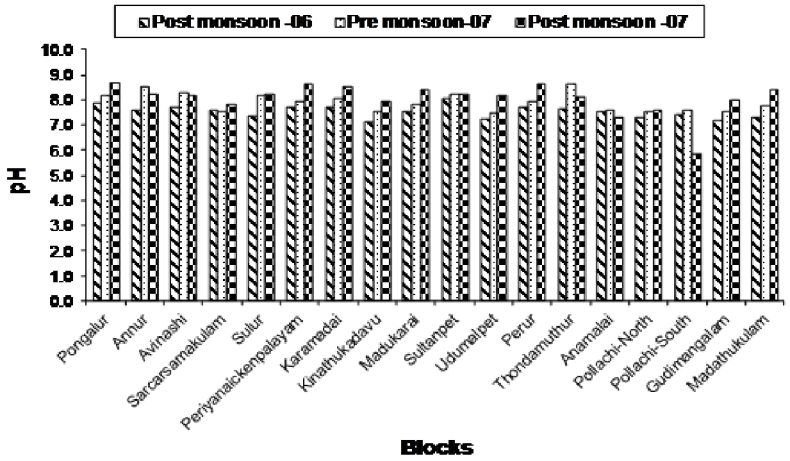

Fig. 2: Season-wise and block-wise variation in pH values of groundwater.

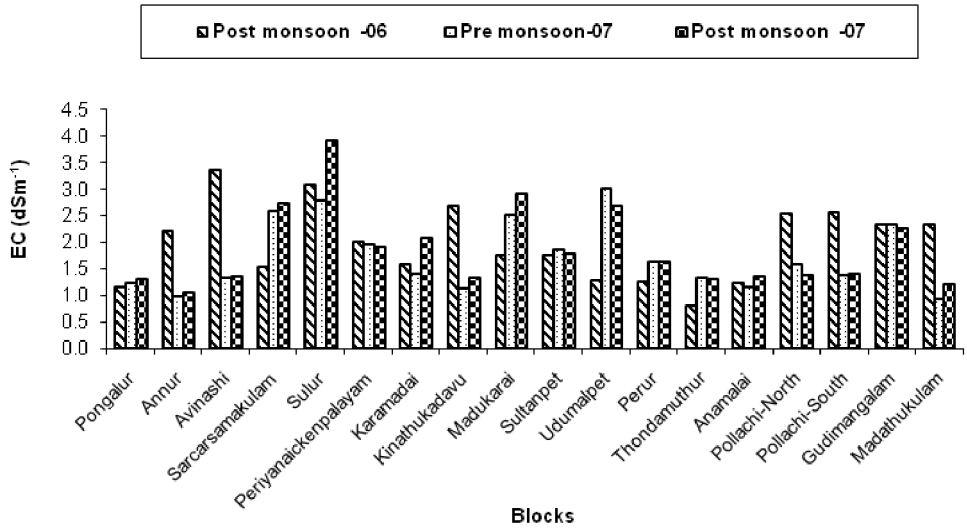

Fig. 3: Season-wise and block-wise variation in EC values of groundwater.

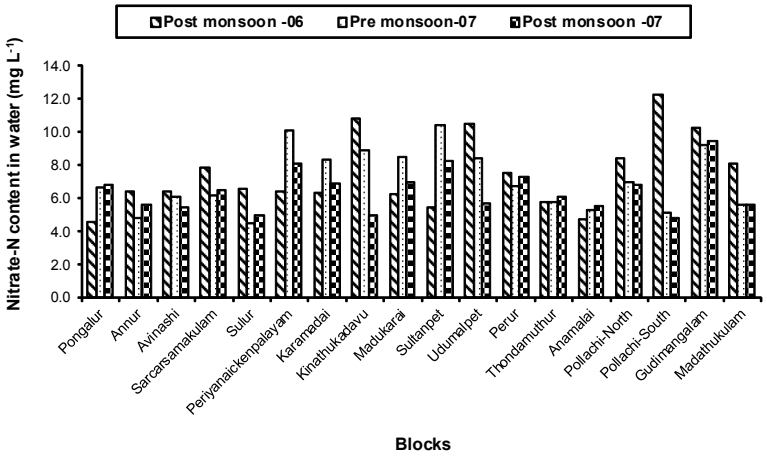

Fig. 4: Season-wise and block-wise variation in NO_3-N loading in groundwater.

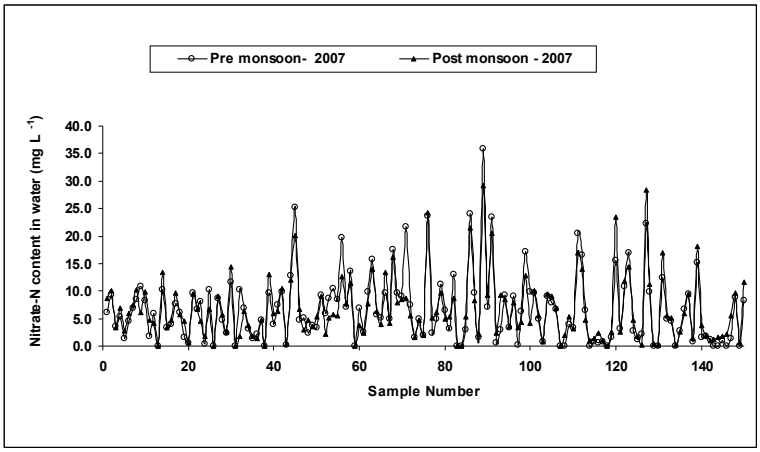

Fig. 5: Temporal variations of NO_3-N loading in groundwater samples.

than in pre monsoon -2007. It may be due to heavy leaching losses of applied fertilizer and residual N from soil to ground water aquifer due to monsoon rains. Similar trends of results were also observed by Rahaman et al. (2013) and Satpathy et al. (2011).

Results indicated that groundwater of different blocks of Coimbatore is neutral to alkaline in reaction and saline in nature. The overall mean NO_3-N content of groundwater samples of different blocks was 6.74 mg L^{-1} and it is below the critical level of 10.0 mg L^{-1}. The temporal variation in NO_3-N content of groundwater samples was observed, being higher in post monsoon-2007 than in pre monsoon -2007.

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