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Seasonally Variation of Nitrate Level Before and After Fertilizers Application in Ground Water of Sikar District (India)

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ABSTRACT

Geochemical processes are identified as controlling factors of groundwater chemistry, including chemical leaching and nitrate contaminations. These geochemical processes are analyzed using major physico-chemical parameters of ground water from Sikar district. The analysis indicated that nitrate, phosphorous and potassium concentrations in fertilizers consumed area (FCA) have been observed greater than none fertilizers consumed area (NCA). These increased level has been observed after fertilizers application in the FCA, thereby suggesting the need for prevent excessive fertilizer uses, soil conservation, balanced fertilization, uses of slow-release fertilizers and best management for manure storages. No appreciable changes in water quality parameters have been pointed out in NCA during same period of application.

Key words: variation, nitrate, fertilizer applications, graphical plots.

INTRODUCTION

The physical, chemical and bacterial characteristics of ground water determine its usefulness for domestic, industrial, municipal and agricultural applications [1, 4, 17, 19]. The changes in modern agricultural practice have allowed an increased production using fertilizers, herbicides and other pesticides. The traditional organic fertilizers are less toxic than inorganic or synthetic fertilizers [5, 6, 17, 20]. The effect of modern farming on biodiversity is a considerable threat to many organisms, including plants, insects and birds [3,13,14,18]. Agriculture is considered the prime source of nitrate contamination in groundwater. Excessive use of Chemicals (pesticides and herbicides) and fertilizers increase the risk of groundwater contamination [10,11,18]. All the surface water bodies contaminated with nitrate may affect the aquatic biodiversity. The role of animal wastes (manure), sewage and synthetic fertilizers are studied by nitrogen isotope method [7,8]. Another potential source of nitrate leaching to the groundwater that deals with farming is the storage of the manure (animal wastes). It results in excessive leaching of nitrates [9,14,16].

Nitrate is a big problem as a contaminant in drinking water due to its harmful biological effects. In infant bodies, the consumed nitrate through drinking water is reduced to nitrite. The nitrite oxidizes hemoglobin in blood into methemoglobin, which cannot transport oxygen. This leads to a disorder called methemoglobinemia and is widely known as the blue-baby syndrome. In adults, high concentrations can cause gastric problems [4,14]. High nitrate concentrations in drinking water are also toxic to livestock and can cause abortions in cattle. Nitrate in surface water bodies, e.g., rivers, lakes or estuaries, can cause deterioration of the quality of surface water, resulting in eutrophication, algal bloom and fish poisoning [14,20,21].

The main objective of the present research work is to study the distribution of nitrate with other parameters and point out the role of fertilizers in ground water of Sikar district.

Study Area

Sikar district (latitude, 27°21' to 28°12' N and longitude, 74°44' to 75°25' E) is situated in the north-eastern part of Rajasthan (Fig. 1) at an average height of 432.31 meter from mean sea level. The Sikar city is located at a distance of 350 Kilometer from national capital of India, New Delhi and 115 Kilometer from state capital of Rajasthan, Jaipur (pink city). There are no surface water sources and only the source of drinking and irrigation water is ground water. The water table varies from 30 Meter to 60 Meter. The recharging of ground water is very low due to scanty rainfall. This district is one of the most crops production areas in the state and undergoing rapid industrialization and urbanization, which has led to immense pressure on ground water resources and it ultimately results both the quality and quantity deterioration of ground water. For this purpose, 10 ground water samples are collected from different part of this district. 5 ground water samples out of 10 are collected from the fertilizers consumed area (FCA) for two times i.e. before fertilizer application (Nov. 2009) and after fertilizer application (Oct. 2010). Remaining 5 samples are collected from none fertilizers consumed area (NCA) for the same period (Fig. 1).

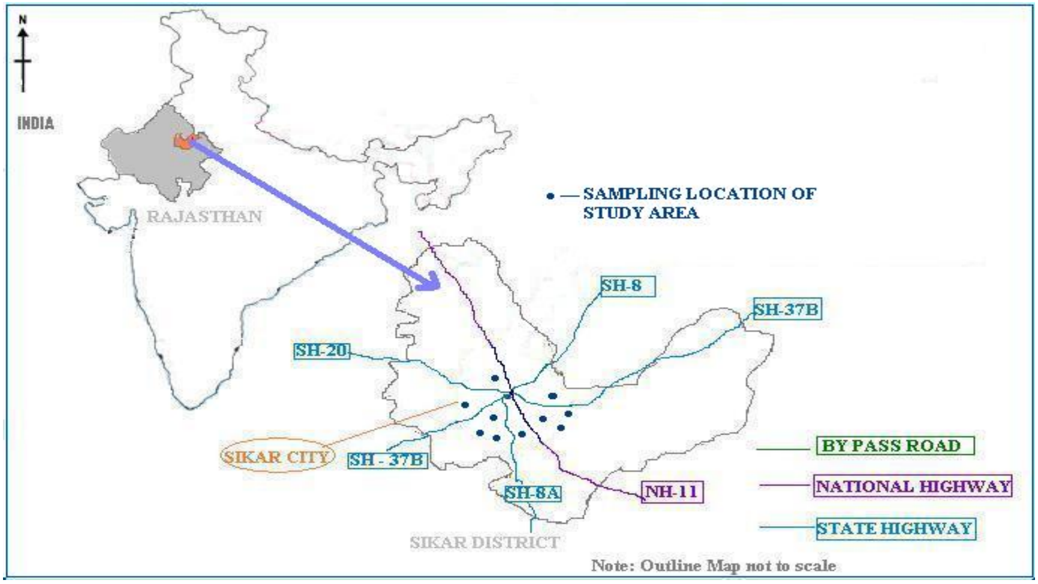

Fig.1: Study area, showing the sampling locations in Sikar district

MATERIAL AND METHODS

The present research work is based on 10ground water samples collected from tube-well in cleaned and screw capped polythene bottles. These water samples are collected after pumping the water for 10 minutes. The water samples are analyzed for various physico-chemical parameters using standards methods recommended by American Public Health Association[2]. The parameters i.e. EC (electrical conductivity), pH and TDS (total dissolved solids) are determined at the same day of sampling using Water Analyzer (Systronic-371). Argentometric method with K_2CrO_4

indicator is used to determine chloride concentration. With the help of double beam UV-VIS Spectrophotometer (Systronic-2201), phosphate, nitrate and sulfate concentration are determined using ammonium molybdate, brucine and turbidimetric methods respectively. Estimation of sodium, potassium and calcium are carried out by Flame-Photometric method (Systronic-128, compressor-126).

RESULT AND DISCUSSION

The respective values of all water quality parameters are summarized in Table 1 and Table 2 from FCA and NCA respectively. All the results are compared with standards permissible limit recommended by the World Health Organization (WHO) and Indian Council of Medical Research (ICMR).

Table 1: Ground water quality parameters from fertilizers consumed area (FCA) of Sikar

	Before fertilizers (BF) application						**After fertilizers (AF) application**					
S.No.	**BF-1**	**BF-2**	**BF-3**	**BF-4**	**BF-5**	**Avg.**	**AF-1**	**AF-2**	**AF-3**	**AF-4**	**AF-5**	**Avg.**
pH	8.03	7.62	7.80	7.24	8.25	7.79	8.09	7.58	7.67	7.45	8.16	7.79
EC	1200	2100	901	1960	746	1381	1220	2090	960	1990	732	1398
TDS	650	1170	493	1090	404	761	660	1150	512	1110	402	766
Ca^{+2}	56.91	64.93	55.31	68.13	48.90	58.84	54.63	64.62	58.54	67.96	51.11	59.37
Na^{+}	90.39	176.87	51.29	118.22	89.72	105.30	91.74	177.99	49.76	121.61	84.92	105.24
K^{+}	1.15	2.42	0.87	1.52	1.24	1.44	3.67	5.34	2.11	1.99	2.53	3.13
Cl^{-}	149.99	406.07	69.69	340.14	84.03	209.98	147.56	396.87	70.15	345.47	86.33	209.28
SO_4^{-2}	5.25	141.25	21.50	64.75	28.00	52.15	7.67	139.56	20.89	64.13	30.25	52.50
NO_3^{-}	93.2	80.8	39.6	115.6	60.0	77.8	116.9	108.7	62.9	157.2	112.5	116.8
PO_4^{-3}	0.78	0.64	0.81	1.24	1.05	0.90	0.88	0.70	1.14	1.25	1.21	1.04

Table 2: Ground water quality parameters from none fertilizers consumed area (NCA) of Sikar

	Before fertilizers (BF) application						**After fertilizers (AF) application**					
S.No.	**BF-6**	**BF-7**	**BF-8**	**BF-9**	**BF-10**	**Avg.**	**AF-6**	**AF-7**	**AF-8**	**AF-9**	**AF-10**	**Avg.**
pH	7.86	7.94	7.88	8.09	7.57	7.87	7.77	7.94	7.91	8.11	7.55	7.86
EC	862	892	1260	881	1470	1073	856	899	1273	875	1486	1078
TDS	497	485	690	485	760	583	491	487	711	479	774	588
Ca^{+2}	44.89	32.06	49.70	32.87	67.33	45.37	45.13	34.32	45.65	33.61	67.57	45.26
Na^{+}	50.57	83.26	138.69	94.99	110.86	95.67	51.51	82.76	140.05	93.79	110.21	95.67
K^{+}	1.11	1.61	1.75	1.08	1.06	1.32	1.08	1.60	1.81	0.98	1.13	1.32
Cl^{-}	53.76	87.93	197.85	81.95	262.13	136.72	55.54	83.09	202.36	81.56	261.00	136.71
SO_4^{-2}	14.75	50.50	71.00	39.25	51.25	45.35	15.67	49.99	75.25	40.71	49.02	46.13
NO_3^{-}	7.6	18.2	56.4	41.4	72.6	39.2	7.1	19.7	58.6	39.5	72.9	39.6
PO_4^{-3}	ND	0.12	0.46	ND	0.07	0.22	ND	0.11	0.42	0.04	0.13	0.17

Fertilizers Consumed Area (FCA)

The mean hydrogen ion concentration (pH) of the ground water is same (7.79) during before fertilizers application (BFA) and after fertilizers application (AFA) (Table 1). These values are within the permissible limit prescribed by ICMR (as 7.0-8.5) and WHO (as 6.5-9.5). The mean value of EC and TDS are more after fertilizers application (AFA) than before fertilizers application (BFA). The average values of calcium, sodium, chloride and sulfate concentrations are approximately equal during BFA and AFA and these concentrations are under the permissible limit prescribed by WHO and ICMR. The mean potassium contents were found 1.44 and 3.13 mgL^{-1} during BFA and AFA respectively. The increased mean value of potassium concentration was 1.69 mgL^{-1}. The value of phosphorous is also increased during AFA as compare to the period of BFA. The observed mean nitrate concentrations were 77.8 and 116.8 mgL^{-1}

during BFA and AFA respectively. All the samples have crossed the permissible limit prescribed by WHO (50 mgL^{-1} as NO_3^-) during AFA (Table 1). The increased mean value of nitrate (39.0 mgL^{-1} or 50%) level in the study area is due to heavy recharge of nitrate concentration in the period of 11 months. In the rainy season of this period, there was a heaviest rain in the last decade. This heaviest rain has increased the ground water level from 0.2 to 1 meter. Dilution of ground water and leaching of ions from different rocks has played a major role to maintain the concentration of above mentioned water quality parameters in the study area. But, the increased contents of potassium, nitrate and phosphorous are due to some anthropogenic activities like consuming more urea, NPK (nitrogen, phosphorous, potassium), animal wastes etc. for irrigation purpose. The sources of nitrate pollution are mainly point sources (i.e. poultry farms, cattle shed and leakage from septic tanks etc.) and non point sources like nitrogenous fertilizers etc. [14,15,18]. The ground water pollution due to nitrate in Sikar district is due to non-point sources.

None Fertilizers Consumed Area (NCA)

The average value of pH, EC, TDS, Ca^{+2}, Na^+, K^+, Cl^-, SO_4^{-2}, NO_3^- and PO_4^{-3} in the area of NCA were observed with approximately equal concentration during BFA and AFA (Table 2). The nitrate mean concentrations were observed as 39.2 and 39.6 mgL^{-1} during before and after fertilizers applications respectively. No appreciable changes in the concentration of these parameters were observed, because this area was uncultivated, free from the point and none point sources of nitrate contamination.

Graphically Representation of Physico-chemical Parameters

The nitrate ion (in mgL^{-1}) plotted against calcium (Fig. 2a), sodium (Fig. 2b) and potassium (Fig. 2c) has shown a rising correlation. Sodium and potassium have good linear correlation with nitrate (Fig. 3) suggesting a similar source of their origin during BFA. After a period of 11 months, nitrate has indicated a good linear correlation with potassium (Fig. 4) as compare to that of sodium, suggesting some anthropogenic activities during AFA. Results from these plot has been indicating a variation in the value of nitrate and potassium during BFA and

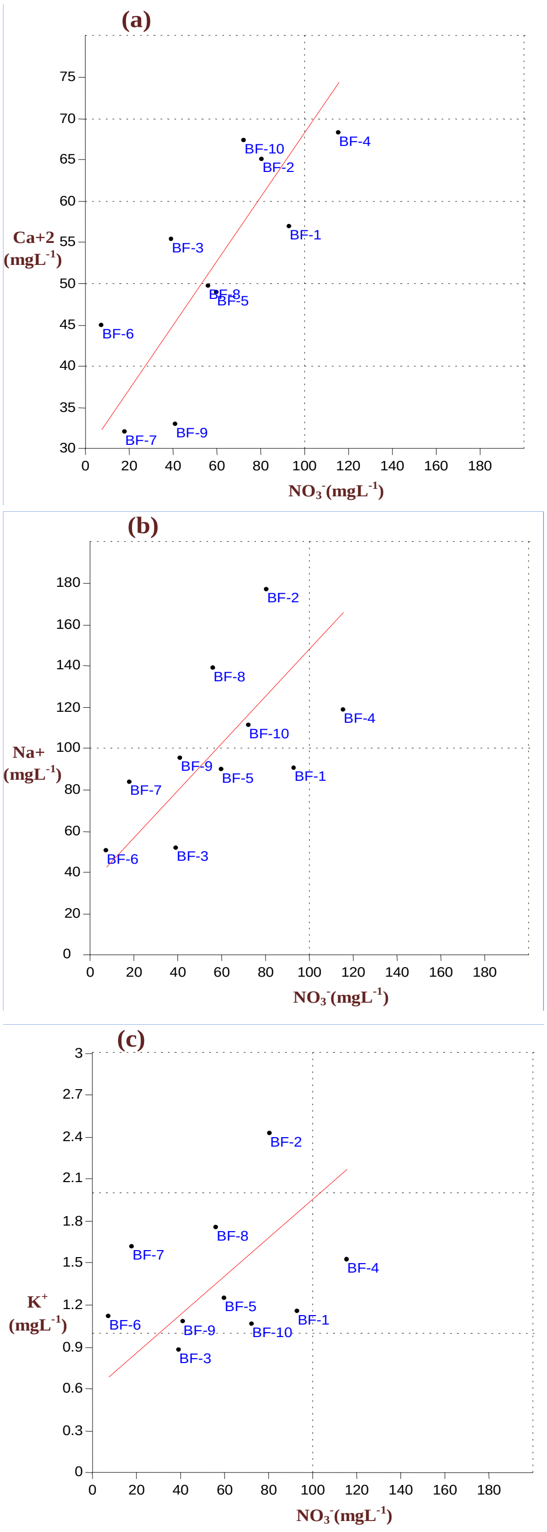

Fig 2: Plots (a, b and c), NO_3^- showing with Ca^{+2}, Na^+ and $K^+$the relation

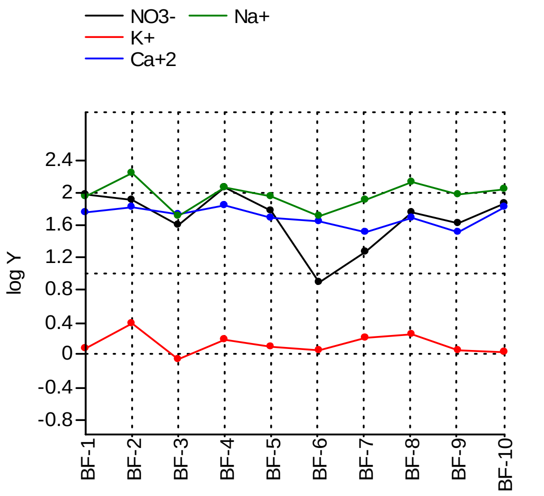

Fig 3: Linear plot indicating correlation between NO_3^-, Ca^{+2}, Na^+ and K^+ (in mgL^{-1}) BFA

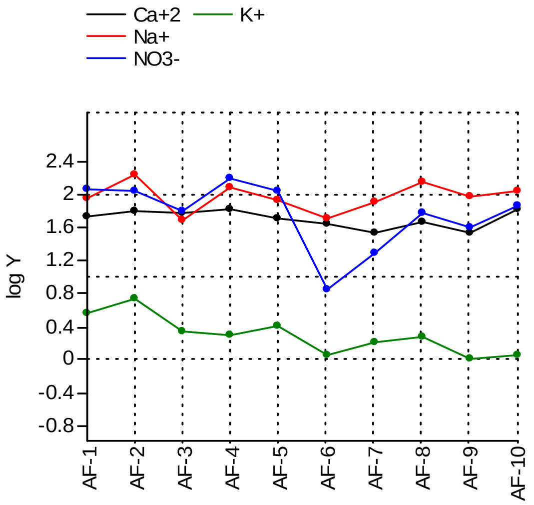

Fig 4: Linear plot indicating correlation between NO_3^-, Ca^{+2}, Na^+ and K^+ (in mgL^{-1}) AFA

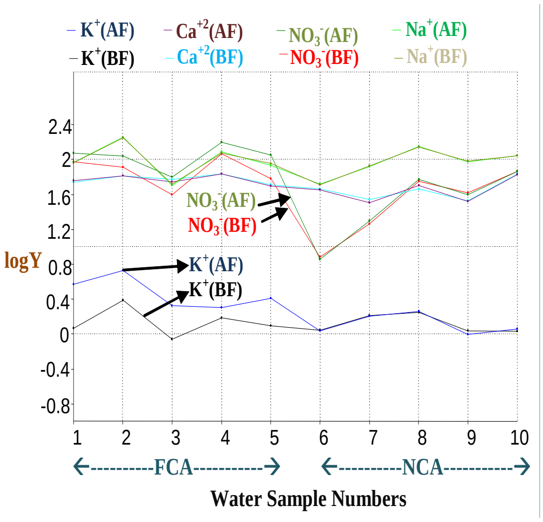

Fig 5: Comparative linear plots involving parameters before and after fertilizer application

AFA from the sample no 1 to 5. All the parameters from sample no 6 to 10 has shown a similar line during BFA and AFA (Fig. 5). These results are clearly signifying that the more variation mainly in nitrate and potassium has been observed in the particular ground water samples collected from FCA of Sikar district.

Nitrogen is a necessary element for plant growth and improved crop productions are well known with increased uses of synthetic nitrogen fertilizer and organic manures. Nitrate is very soluble and is the most usable form of nitrogen for plants. The plants absorb nitrate fertilizers through roots but compensation of nitrate is insignificant in the soil environment and excess nitrate is percolated into ground water [8,9,12,13]. However, increased uses of nitrogenous fertilizers have also led to increased nitrogen losses from agro ecosystems. The recovery of fertilizer's nitrogen in global crop yield is about 50% .The surplus may accumulate in soils, or be lost to air, ground water and surface water through various pathways. Nitrate is probably the most wide spread contaminant in groundwater.

Due to the biological effects of nitrate contamination, treatment and prevention methods must be considered to protect groundwater aquifers from nitrate leaching and high concentrations. Phyto-remediation is a concept that involves the use of plants to clean or stabilize contaminated environments. It is an eco-friendly technique to remediate ground water and surface water bodies [13,15]. Sub irrigation system can be used to reduce soil nitrate pollution along with drainage nitrate concentration [9].To maintain yield increases and minimize nitrate pollution of the ground waters, best management applications for N-fertilizer should be used. An excessive fertilizer application must be prevented. The practices include soil conservation, balanced fertilization, uses of slow-release fertilizers, more frequent N-top dressings at smaller rates during the rainy season and improving nutrient capture from soil by the genetic manipulation of crop plants.

CONCLUSION

The analysis revealed that the mean nitrate concentration in FCA were 77.8 and 116.8 mgL^{-1} while this concentration were observed in NCA as 39.2 and 39.6 mgL^{-1} during BFA and AFA respectively. The mean potassium and phosphorous contents has also increased from 1.44 to 3.13 mgL^{-1} and 0.90 to 1.04 mgL^{-1} in FCA during BFA and AFA respectively. No appreciable changes have been observed in the concentration of calcium, sodium, chloride, sulfate etc. in the study area. Dilution of ground water and leaching of ions from different rocks has played a major role to maintain the concentration of these parameters. The increased values of nitrate, potassium and phosphorous are due to some anthropogenic activities like consuming more urea, NPK (nitrogen, phosphorous, potassium), animal wastes etc. for irrigation purpose. To minimize nitrate pollution of the ground waters, Farmers are advised to prevent excessive fertilizer uses. The practices include soil conservation, balanced fertilization, uses of slow-release fertilizers and best management for manure storages.

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