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Effects of Monsoon on Groundwater Quality for Irrigation in Gohana Block of Haryana

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Abstract: Irrigation water quality plays an important role in influencing the agricultural sustainability particularly in arid and semi-arid tracts of the country where it is inevitable for the farmers to use the resources, even if of doubtful quality. The Gohana Block in Haryana, India, is selected to discuss the impact of monsoon on groundwater quality for irrigation where agriculture is the main livelihood of rural people and the groundwater is the main source of irrigation. To study the impact of monsoon on groundwater quality, sixty groundwater samples were collected from the study area; in June (pre-monsoon) and in November (post-monsoon) in 2006. The water samples were analyzed for pH, EC, major cations (sodium, potassium, calcium, and magnesium), major anions (bicarbonate, chloride, sulphate and nitrate) and heavy metals (arsenic, cadmium, lead and nickel) using standard procedure. Specific irrigation water quality criteria like Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Mg/Ca ratio were computed from the above chemical parameters. The comparison of pre-monson and post-monsoon data showed marginal improvement in groundwater quality after monsoon.

Key words: Groundwater quality, monsoon, EC, SAR, RSC, Mg/Ca ratio.

Judicious management and monitoring of soil and water, the two vital natural resources, is imperative for enhancing and sustaining the agricultural production of any region. The potential of a crop is fully expressed when inputs are optimum and of good quality. Irrigation water quality plays an important role in influencing the agricultural sustainability, particularly in arid and semi-arid tracts of the country where it is inevitable for the farmers to use the resources even of doubtful quality. Unscientific water management practices have led to rise in ground water table coupled with aggravation of salinity and sodicity problem in most of the command areas resulting in considerable reduction in crop productivity. To minimize the occurrence of groundwater salinity and its spread in a given area, periodical monitoring of the groundwater in the area is necessary.

In India about 50% of the total irrigated area is dependent on groundwater and, of this, about 60% of irrigated food production depends on irrigation from groundwater wells (Shah *et al.*, 2000; CWC, 2000). The Gohana Block of Haryana state also uses mostly groundwater through shallow tube wells besides canal water for irrigation of crops. Large variations in EC, pH, SAR and RSC of water samples collected from different aquifer zones upto 30 m depth at different sites of Gohana Block, which on an average were much above the prescribed limits, have been reported (Kamra *et al.*, 2000). The salinity of native ground water has resulted from the impervious to semi- pervious nature of geological formations, stagnancy of groundwater, and high evapotranspiration and aridity index (Tanwar, 1998). Though there are some discrete hydrochemical data, the seasonal variation of groundwater quality has not been studied so far in this area. In this paper an attempt has been made to study the effect of monsoon on quality of groundwater.

Materials and Methods

The study was conducted at Gohana Block of Haryana State that covers 293 sq. km area and lies between 280°57′12″-29°11′24″ N latitude and 76°48′39″-76°50′44″ E longitude. It comes under Survey of India toposheet Nos. 53C/12, 53D/13, 53D/9 and 53C/16. The block has an elevation ranging from 213 m to 227 m above mean sea level. The slope is generally from north-west to south-east. The topographic situation of the block influences leaching pattern. Climate of the area is subtropical, semi-arid with hot dry summer and cold winter with mean annual rainfall of 567 mm, out of which 80% occurs during the monsoon period (July-September). The average annual evapotranspiration is 1650 mm. The temperature varies from 1°C in winter to 45°C in extreme summer

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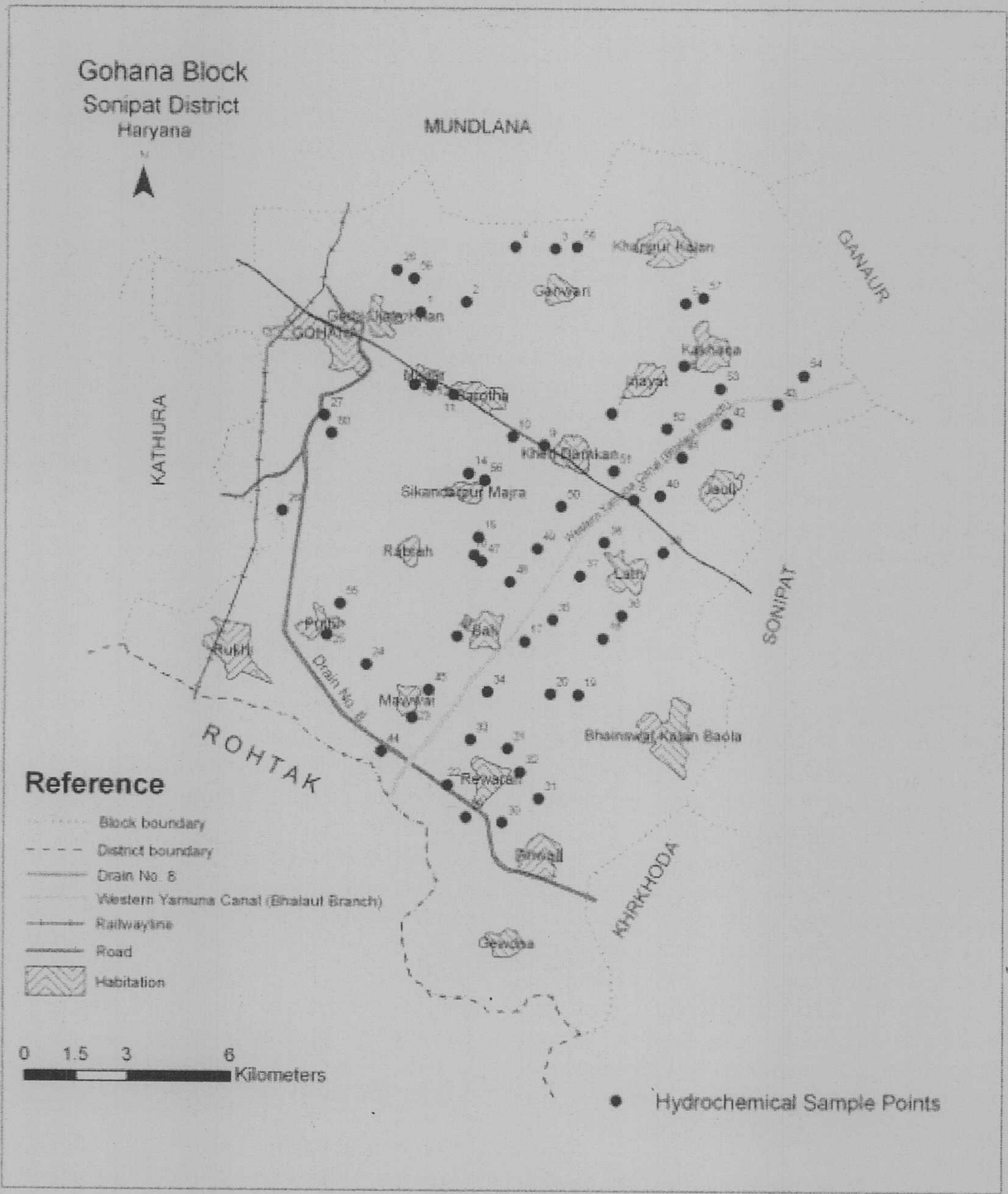

Fig. 1. Map of the study area indicating all hydrochemical Points/Locations.

(Pattanaaik., 2006). In the year 2006, the total rainfall was 306.2 mm out of which 109.4 mm occurred during pre-monsoon period and 196.8 mm occurred during post-monsoon period (http://www.imd.gov.in/). Depth to water level in the study area during pre-monsoon varies from 1.41-23.22 m while during post-monsoon it varies from 0.99-24.46 m (Marwaha, 2008). Soils of Gohana block represent a typical alluvial profile of Yamuna origin. As per USDA classification, the soils of Gohana belong to sandy loam to silty loam textural classes.

For hydrochemical investigation, water samples were collected twice from 60 tubewells of Gohana in pre-cleaned 500 ml plastic bottles covering almost all villages of the area. The first sampling was done in June 2006 (pre-monsoon) and the second one in November 2006 (post-monsoon). The sampling locations are shown in Fig. 1. Water samples were analyzed in the laboratory using the standard procedure.

The water samples were analyzed for pH (using glass electrode; Jackson, 1967), EC (conductivity

Table 1. Chemical characteristics of groundwater at Gohana Block, Haryana, during pre- and post-monsoon of 2006

Village Name	EC		SAR		RSC		Mg/Ca	
	Jun 2006	Nov 2006	Jun 2006	Nov 2006	Jun 2006	Nov 2006	Jun 2006	Nov 2006
Garhi Ujale Khan-A	1.0	0.9	6.06	5.73	-0.22	-0.10	2.54	2.33
Namda Khan	1.3	1.1	4.05	3.55	-0.75	-1.32	1.64	1.81
Gamri-A	2.8	2.1	8.20	6.46	-3.70	-3.80	0.96	1.20
Gamri-B	1.9	1.5	4.91	4.66	-5.00	-3.80	1.42	2.90
Khanpur Kalan-A	1.0	0.7	3.23	2.84	-1.88	-1.99	2.15	2.07
Kakhana-A	5.8	5.1	18.12	16.99	1.44	0.80	2.16	1.95
Niat-A	6.3	5.8	14.19	13.14	-6.94	-10.10	1.21	1.09
Jauli-A	1.2	0.9	7.36	6.15	1.05	0.90	2.37	1.75
Garhi	4.4	3.8	12.39	9.65	-3.90	-5.10	1.40	1.51
Barota-A	1.0	0.7	5.29	3.97	0.02	-0.23	2.30	2.11
Barota-B	7.2	6.6	15.86	14.14	-12.18	-17.20	2.20	2.14
Nagar-A	6.3	5.9	12.62	13.76	-13.49	-12.90	2.09	1.87
Nagar-B	6.5	6.1	16.25	15.83	-8.40	-8.30	3.57	3.88
Sikandarpur Majra-A	1.3	1.0	7.89	7.48	0.22	0.08	1.28	1.19
Sikandarpur Majra-B	6.4	5.4	22.96	22.44	2.41	1.80	2.16	2.07
Rabrah-A	6.1	5.3	14.17	13.14	-7.29	-9.30	1.80	1.68
Bali-A	0.9	0.5	3.48	2.15	-0.10	0.50	2.58	2.09
Bali-B	8.9	8.5	16.03	15.63	-29.80	-26.90	1.80	1.71
Katwal-A	9.2	8.8	16.20	14.97	-24.40	-23.70	1.79	1.72
Katwal-B	8.5	7.8	18.23	16.85	-18.38	-17.39	1.65	1.46
Rewarah-A	8.1	7.3	18.13	16.77	-11.19	-10.67	1.75	1.57
Rewarah-B	3.6	3.4	10.85	9.47	-3.08	-2.50	0.99	0.97
Moi-A	5.9	5.6	36.10	35.01	2.05	2.40	2.64	2.33
Moi-B	5.0	4.0	11.30	10.02	-6.52	-9.30	1.33	1.52
Puthi-A	7.1	6.0	16.23	14.88	-16.48	-14.90	1.25	1.15
Mahra-A	7.6	6.8	18.19	15.39	-16.50	-18.20	1.16	1.06
Gohana-A	1.6	1.2	6.63	5.66	0.80	-0.20	1.41	1.10
Gohana-B	3.5	3.2	10.29	9.62	-3.52	-3.80	0.89	0.72
Rewarah-C	6.2	4.8	20.24	18.33	-6.31	-2.70	2.48	1.54
Anwali-A	10.3	9.7	27.80	26.66	-3.30	2.10	1.32	1.23
Anwali-B	12.4	11.2	26.40	24.13	-24.20	-18.22	1.16	1.07
Rewarah-D	11.8	10.5	26.22	24.86	-9.10	-9.10	1.40	1.35
Rewarah-E	3.3	2.7	11.20	7.26	-2.40	-1.30	1.80	1.71
Katwal-C	2.0	1.3	5.23	3.64	-2.94	-2.30	2.52	2.43
Bali-C	2.1	1.5	10.25	8.25	2.20	0.90	1.27	1.26
Lath-A	11.8	10.1	31.21	29.41	-3.20	1.60	1.42	1.30
Lath-B	2.9	2.0	10.40	7.45	0.74	1.00	1.48	1.11
Lath-C	1.8	1.3	8.62	7.92	1.30	1.20	1.62	1.22
Lath-D	10.5	10.3	28.10	27.45	0.80	2.02	2.42	1.09
Jauli-B	1.6	1.2	4.92	5.40	-1.47	-1.00	1.26	1.25
Jauli-C	1.4	1.1	7.57	8.08	1.00	0.70	3.11	2.33
Saragtha-A	2.2	1.6	5.74	5.29	-2.30	-2.80	2.37	2.33
Saragtha-B	2.0	1.4	5.32	4.20	-5.10	-3.90	2.85	2.81
Moi-C	6.0	5.1	19.35	18.24	-3.50	0.50	2.00	1.83

bridge; Richards, 1954), Na (flame photometry; Richards, 1954), K (flame photometry; Richards, 1954), Ca (EDTA titration method; Richards, 1954), Mg (EDTA titration method; Richards, 1954), Cl (Mohr's titration method using AgNO3; Hesse, 1971), HCO_3 (titration method; Hesse, 1971), CO_3 (titration method; Hesse, 1971), SO_4 (Turbidometric method, Chesnin and Yien, 1950) and NO_3 (UV method using colorimeter; Richards, 1954). Then the chemical characteristics (SAR, RSC and Mg/Ca) were calculated using the prescribed formula. In this paper only EC, SAR, RSC and Mg/Ca are given and discussed.

Results and Discussion

Electrical conductivity (EC)

EC is a measure of salinity hazard. Analysis of groundwater samples of Gohana Block showed EC ranged from 0.8 dS m^{-1} at Point No. 55 (Puthi-B) to 12.4 dS m^{-1} at Point No. 31 (Anwali-B) during pre-monsoon and 0.5 dS m^{-1} at Point No. 17 (Bali-A) to 11.2 dS m^{-1} at Point No. 31 (Anwali-B) during post-monsoon (Table 1). Out of 60 groundwater samples, 18 samples had medium to high EC values (0.75-2.25 dS m^{-1}; Class C_3), 12 samples had high EC values (2.25-5.00 dS m^{-1}; Class C_4) and 30 samples had very high EC values (>5.00 dS m^{-1}; Class C_5) according to USDA water quality rating for irrigation. Incase of post-monsoon, the number of samples coming under Class C_2 (EC: 0.25-0.75 dS m^{-1}), Class C_3 (EC: 0.75-2.25 dS m^{-1}), Class C_4 (EC: 2.25-5.00 dS m^{-1}) and Class C_5 (EC: >5.00 dS m^{-1}) are 4, 16, 13 and 27, respectively. Now it is clear that the seasonal variations of EC values are marginal, but the spatial variations of EC value are significant (Table 1). Marginal variations of EC with respect to different time of sampling indicate that the dilution effect of water in the post-monsoon was not very significant. Similar results were observed by Biswal *et al.* (2004), Kumaresan and Riyazuddin (2005) and Laluraj and Gopinath (2005).

Sodium adsorption ratio (SAR)

SAR is a measure of sodium hazard and is calculated by the formula $Na^+ / [(Ca^{++} + Mg^{++}) / 2]$ where concentration of cations are in me L^{-1}. SAR values of the groundwater collected from the area varied from 3.23 at Point No. 5 (Khanpur Kalan-A) to 36.10 at Point No. 23 (Moi-A) for pre-monsoon and 2.15 at Point No. 17 (Bali-A) to 35.01 at Point No. 23 (Moi-A) for post-monsoon groundwater samples (Table 1). According to USDA water quality rating for SAR, number of samples coming under low (<10; Class S_1), medium (10-18; Class S_2), high (18-26; Class S_3) and very high (>26; Class S_4) classes of SAR are 20, 25, 8 and 7 for pre-monsoon and 27, 22, 7 and 4 for post-monsoon samples, respectively (Table 1). The SAR of ground water of the study area also showed marginal improvement after monsoon which may be ascribed to the dilution effect of rainfall.

Residual sodium carbonate (RSC)

In waters having high concentration of bicarbonate, there is a tendency for calcium and magnesium to precipitate as the water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form sodium carbonate. RSC is a measure of bicarbonate hazard and is calculated by the formula [RSC = (CO_3-- = HCO_3-) – ($Ca^{++} + Mg^{++}$)] where concentrations of both cations and anions are in me L^{-1}. Out of 60 groundwater samples, 55 samples showed RSC value of 1.25 (Low) and 5 samples showed RSC value in between 1.25-2.50 (medium) for pre-monsoon and 54 samples showed RSC value of 1.25 (low) and 6 samples showed RSC value in between 1.25 to 2.50 (medium) for post-monsoon. No samples have unsafe RSC value (>2.5) (Table 1). There was little change in RSC value of groundwater between the study period (pre- and post-monsoon).

Magnesium calcium ratio (Mg/Ca)

Mg/Ca ranges from 3.57 at Point No. 13 (Nagar-B) to 0.90 at Point No. 53 (Kakhana-B) for pre-monsoon and 3.88 at Point No. 13 (Nagar-B) to 0.85 at Point No. 53 (Kakhana-B) for post-monsoon (Table 1). The number of samples coming under low (<1.5), Medium (1.5-3.0) and high (>3.0) Mg/Ca are 25, 31, and 4 for pre-monsoon samples and 27, 30 and 3 for post-monsoon samples. Like EC, SAR and RSC, Mg/Ca showed marginal change after monsoon in the study area indicating the recharge of groundwater after monsoon is very little effective in bringing out dilution for improvement in water quality.

Conclusions

Analysis of groundwater samples showed, out of 60 samples during pre-monsoon period the number of samples coming under Class C_3, Class C_4 and Class C_5 were 18, 12 and 30, respectively whereas during post-monsoon the number of samples coming under Class C_3, Class C_4 and

Class C_5 were 16, 13 and 27, respectively. During post-monsoon a new category of EC (Class S_2) appeared under which 4 samples came. Similarly the number of samples coming under Class S_1, Class S_2, Class S_3 and Class S_4 of SAR were 20, 25, 8 and 7 for pre-monsoon and 27, 22, 7 and 4 for post-monsoon samples, respectively. Like EC and SAR, the number of samples coming under low, medium and high class of Mg/Ca was 25, 31, and 4 for pre-monsoon period and 27, 30 and 3 for post-monsoon period. There was very little change in groundwater quality with respect to RSC. It is quite clear that there was marginal change in groundwater quality with respect to EC, SAR, RSC and Mg/Ca ratio which may be ascribed to dilution effect of water which is not much appreciable.

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