Vol. 9, pp. 38-43 (2009)
Journal of Agricultural Physics
http://www.agrophysics.in

Effect of Monsoon Rain on Quality of Groundwater 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 semiarid tracts of the country where it is inevitable and compulsive for the farmers to use the available resources despite of doubtful quality. The Gohana Block, Haryana, India, has been selected to discuss the impact of monsoon on groundwater quality for irrigation in the region where agriculture is the main livelihood of the people and groundwater the main source of irrigation. To study the impact of monsoon on groundwater quality, sixty groundwater samples were collected two times from the study area; first in June (premonsoon) and the second in November (postmonsoon) of 2006. The water samples were analyzed for pH, electrical conductivity (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 procedures. Specific irrigation water quality criteria like Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Mg/Ca ratio have been computed from the above chemical parameters. The premonsoon and post-monsoon data were compared to understand the effect of monsoon on groundwater quality. The comparison showed marginal improvement in groundwater quality after monsoon.

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

Introduction

Judicious management and monitoring of soil and water resources is imperative for enhancing and sustaining agricultural production in any region. The crop potential is fully expressed when necessary inputs are made available in optimum quantities and of good quality. Irrigation water quality plays an important role in influencing the agricultural sustainability particularly in arid and semiarid regions of the country, where it is inevitable for the farmers to use whatever resources even of doubtful quality are available. Unscientific water management practices have led to the rise in water table conditions in most of the canal command areas coupled with aggravation of soil salinity and sodicity problems 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 same is necessary.

In India about 50 per cent of the total cultivated area under irrigation is dependent upon groundwater and of this, about sixty per cent of irrigated food production depends on groundwater wells (Shah *et al.*, 2000; CWC, 2000). In the present study, the area, i.e. Gohana Block of Haryana state also uses mostly groundwater through shallow tube wells besides canal water for irrigation of crops. A large variations in EC, pH, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) of water samples collected from different aquifer zones upto 30 m depth from different sites of Gohana Block, which

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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 some discrete hydrochemical data are available for the region, seasonal variation of groundwater quality has never been studied so far. In this paper an attempt has been made to study the affect of monsoon on groundwater quality for irrigation.

Materials and Methods

The study was conducted at Gohana Block of Haryana state that covers 293 sq. km and lies between 28º57′12′′-29º11′24′′ N latitude and 76º48′39′′-76º50′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 213m to 227m above mean sea level. The gradient slope is generally from North-West to South-East corner. The topographic situation of the block influences leaching pattern in the soils. The 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 percent occurs during the south-west monsoon period (July-September). The average annual evapotranspiration is 1650 mm. The day temperature varies from 1ºC in winter to 45ºC in peak summer (Pattanaaik., 2006). Soils of Gohana block represent a typical alluvial profile of the Yamuna origin. As per USDA classification, the soils of Gohana belong to sandy loam to silty loam textural classes.

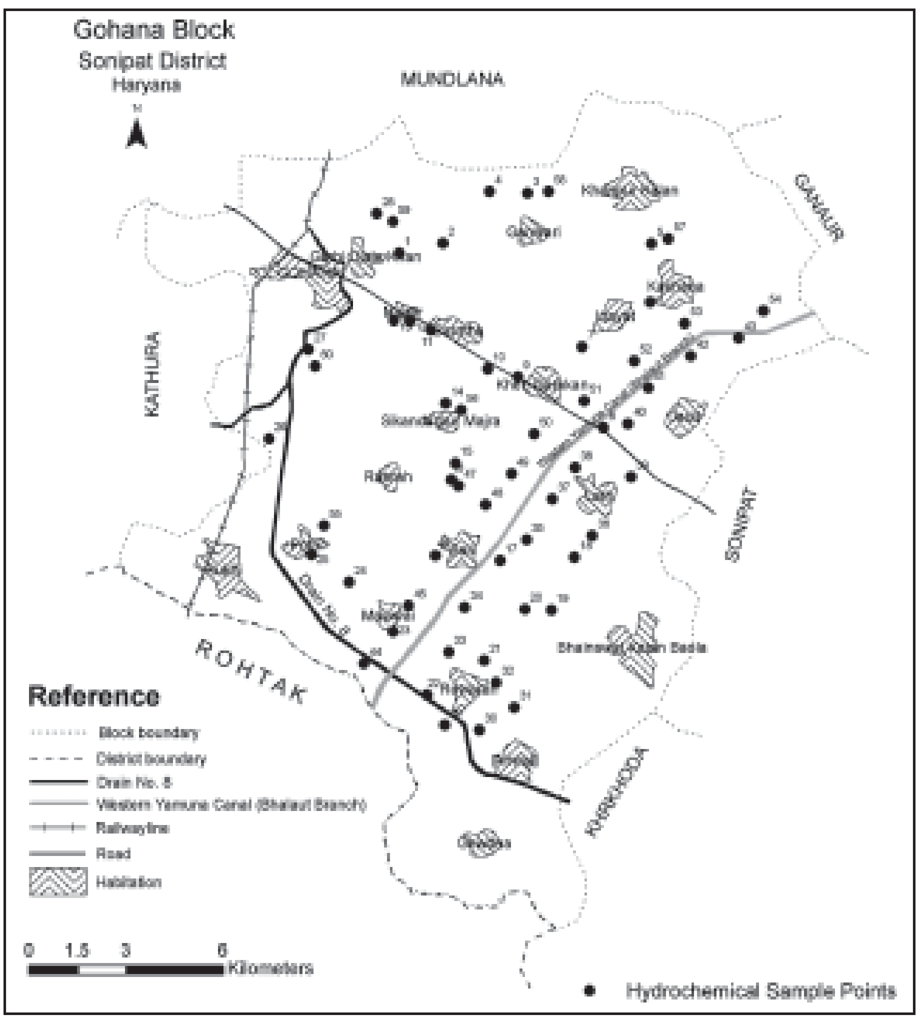

Fig. 1. Map of the study area indicating all hydrochemical Points/Locations

Table 1. Methods employed for Hydro chemical investigation

S No.	Particulars	Methods
1	EC	Glass electrode pH meter (Jackson, 1967)
2	pH	Conductivity bridge method (Richard, 1954)
3	CO_3^{--}, HCO_3^-	Titration method (Hesse, 1971)
4	Cl^-	Mohr's Titration method (Hesse, 1971)
5	SO_4^{--}	Turbidity method (Chesnin and Yien, 1950)
6	Na^+, K^+	Flame photometer (Richard, 1954)
7	Ca^{++}, Mg^{++}	EDTA Titration method (Richard, 1954)
8	NO_3^{--}	Kjeldahl method (Subbiah & Asija, 1956)

For hydrochemical investigation, water samples were collected twice from 60 tube-wells of Gohana in clean 500 ml plastic bottles covering almost all villages of the study area. The first sampling was done in June, 2006 (premonsoon) and the second one in November, 2006 (postmonsoon). The sampling locations are shown in Figure 1. Water samples collected as above were subjected to chemical analysis in the laboratory using the standard procedures (Table 1).

The water samples were analysed for pH, EC, Na, K, Ca, Mg, Cl, HCO_3, CO_3, SO_4, NO_3 and heavy metals such as As, Cd, Pb and Ni. Then the chemical characteristics (SAR, RSC and Mg/Ca) are calculated using the prescribed formula given under results and discussion. 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 value varied from 0.8 dSm^{-1} at Point No. 55 (Puthi-B) to 12.4 dSm^{-1} at Point No. 31 (Anwali-B) for premonsoon and 0.5 dSm^{-1} at Point No. 17 (Bali-A) to 11.2 dSm^{-1} at Point No. 31 (Anwali-B) for postmonsoon groundwater samples (Table 2). Out of 60 groundwater samples, 18 samples showed medium to high EC value (0.75-2.25 dSm^{-1}; Class C_3), 12 samples showed high EC value (2.25-5.00 dSm^{-1}; Class C_4) and 30 sample showed very high EC value (> 5.00 dSm^{-1}; Class C_5) according to USDA water quality rating for irrigation. Incase of postmonsoon, the number of samples coming under Class C_2 (EC: 0.25-0.75 dSm^{-1}), Class C_3 (EC: 0.75-2.25 dSm^{-1}), Class C_4 (EC: 2.25-5.00 dSm^{-1}) and Class C_5 (EC: >5.00 dSm^{-1}) are 4, 16, 13 and 27 respectively. It is now clear that the seasonal variations of EC value are marginal but the spatial variations of EC value are significant (Table 2). Marginal variations of EC value with respect to different time of sampling indicate that the dilution effect of water in the post monsoon is not very significant. Similar types of results have been observed by Biswal *et al.*, 2004, Kumaresan and Riyazuddin, 2005 and Laluraj and Gopinath, 2005. Low salinity water (Class C_1) can be used for irrigation for most of the crops on most soils. Medium salinity water (Class C_2) can be used where a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances with special practices of salinity control. Medium to high salinity water (Class C_3) is satisfactory for plants having moderate salt tolerance, on soils of moderate permeability with leaching. High salinity water (Class C_4) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and only plants with good salt tolerance should be selected. Very high salinity water (Class C_5) is not suitable for irrigation under normal conditions, but can be used occasionally, under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be in excess to provide considerable leaching and salt tolerant crops should be selected. Salinity problem occurs if the total quantity of salts in the irrigation water is high enough to result in salts accumulation in the crop

Table 2. Chemical characteristics of groundwater at Gohana Block, Haryana during pre- and post-monsoon

Po. No.	Latitude (Y)	Longitude (X)	Village Name	EC		SAR		RSC		Mg / Ca	
				Jun	Nov	Jun	Nov	Jun	Nov	Jun	Nov
1	29.1429	76.7249	Garhi Ujale Khan-A	1.0	0.9	6.06	5.73	-0.22	-0.10	2.54	2.33
2	29.1456	76.7370	Namda Khan	1.3	1.1	4.05	3.55	-0.75	-1.32	1.64	1.81
3	29.1595	76.7606	Gamri-A	2.8	2.1	8.20	6.46	-3.70	-3.80	0.96	1.20
4	29.1600	76.7500	Gamri-B	1.9	1.5	4.91	4.66	-5.00	-3.80	1.42	2.90
5	29.1455	76.7951	Khanpur Kalan-A	1.0	0.7	3.23	2.84	-1.88	-1.99	2.15	2.07
6	29.1292	76.7947	Kakhana-A	5.8	5.1	18.12	16.99	1.44	0.80	2.16	1.95
7	29.1168	76.7758	Niat-A	6.3	5.8	14.19	13.14	-6.94	-10.10	1.21	1.09
8	29.0942	76.7817	Jauli-A	1.2	0.9	7.36	6.15	1.05	0.90	2.37	1.75
9	29.1084	76.7579	Garhi	4.4	3.8	12.39	9.65	-3.90	-5.10	1.40	1.51
10	29.1106	76.7495	Barota-A	1.0	0.7	5.29	3.97	0.02	-0.23	2.30	2.11
11	29.1214	76.7337	Barota-B	7.2	6.6	15.86	14.14	-12.18	-17.20	2.20	2.14
12	29.1238	76.7278	Nagar-A	6.3	5.9	12.62	13.76	-13.49	-12.90	2.09	1.87
13	29.1241	76.7234	Nagar-B	6.5	6.1	16.25	15.83	-8.40	-8.30	3.57	3.88
14	29.1010	76.7378	Sikandarpur Majra-A	1.3	1.0	7.89	7.48	0.22	0.08	1.28	1.19
15	29.0844	76.7405	Sikandarpur Majra-B	6.4	5.4	22.96	22.44	2.41	1.80	2.16	2.07
16	29.0797	76.7394	Rabrah-A	6.1	5.3	14.17	13.14	-7.29	-9.30	1.80	1.68
17	29.0572	76.7529	Bali-A	0.9	0.5	3.48	2.15	-0.10	0.50	2.58	2.09
18	29.0581	76.7737	Bali-B	8.9	8.5	16.03	15.63	-29.80	-26.90	1.80	1.71
19	29.0434	76.7672	Katwal-A	9.2	8.8	16.20	14.97	-24.40	-23.70	1.79	1.72
20	29.0437	76.7598	Katwal-B	8.5	7.8	18.23	16.85	-18.38	-17.39	1.65	1.46
21	29.0294	76.7485	Rewarah-A	8.1	7.3	18.13	16.77	-11.19	-10.67	1.75	1.57
22	29.0198	76.7326	Rewarah-B	3.6	3.4	10.85	9.47	-3.08	-2.50	0.99	0.97
23	29.0374	76.7231	Moi-A	5.9	5.6	36.10	35.01	2.05	2.40	2.64	2.33
24	29.0512	76.7109	Moi-B	5.0	4.0	11.30	10.02	-6.52	-9.30	1.33	1.52
25	29.0589	76.7004	Puthi-A	7.1	6.0	16.23	14.88	-16.48	-14.90	1.25	1.15
26	29.0912	76.6886	Mahra-A	7.6	6.8	18.19	15.39	-16.50	-18.20	1.16	1.06
27	29.1160	76.6996	Gohana-A	1.6	1.2	6.63	5.66	0.80	-0.20	1.41	1.10
28	29.1539	76.7186	Gohana-B	3.5	3.2	10.29	9.62	-3.52	-3.80	0.89	0.72
29	29.0114	76.7375	Rewarah-C	6.2	4.8	20.24	18.33	-6.31	-2.70	2.48	1.54
30	29.0100	76.7472	Anwali-A	10.3	9.7	27.80	26.66	-3.30	2.10	1.32	1.23
31	29.0164	76.7569	Anwali-B	12.4	11.2	26.40	24.13	-24.20	-18.22	1.16	1.07
32	29.0233	76.7519	Rewarah-D	11.8	10.5	26.22	24.86	-9.10	-9.10	1.40	1.35
33	29.0317	76.7386	Rewarah-E	3.3	2.7	11.20	7.26	-2.40	-1.30	1.80	1.71
34	29.0442	76.7431	Katwal-C	2.0	1.3	5.23	3.64	-2.94	-2.30	2.52	2.43
35	29.0631	76.7603	Bali-C	2.1	1.5	10.25	8.25	2.20	0.90	1.27	1.26
36	29.0642	76.7786	Lath-A	11.8	10.1	31.21	29.41	-3.20	1.60	1.42	1.30
37	29.0744	76.7675	Lath-B	2.9	2.0	10.40	7.45	0.74	1.00	1.48	1.11
38	29.0831	76.7739	Lath-C	1.8	1.3	8.62	7.92	1.30	1.20	1.62	1.22
39	29.0806	76.7894	Lath-D	10.5	10.3	28.10	27.45	0.80	2.02	2.42	1.09
40	29.0953	76.7886	Jauli-B	1.6	1.2	4.92	5.40	-1.47	-1.00	1.26	1.25
41	29.1053	76.7942	Jauli-C	1.4	1.1	7.57	8.08	1.00	0.70	3.11	2.33
42	29.1142	76.8061	Saragtha-A	2.2	1.6	5.74	5.29	-2.30	-2.80	2.37	2.33
43	29.1192	76.8194	Saragtha-B	2.0	1.4	5.32	4.20	-5.10	-3.90	2.85	2.81
44	29.0286	76.7150	Moi-C	6.0	5.1	19.35	18.24	-3.50	0.50	2.00	1.83
45	29.0447	76.7275	Moi-D	7.0	6.5	21.36	20.71	-2.70	-1.90	1.37	1.27
46	29.0586	76.7350	Bali-D	8.2	7.5	26.30	24.14	-3.44	-2.97	3.05	3.00
47	29.0781	76.7414	Rabrah-B	6.9	6.3	14.83	13.40	-16.74	-16.90	0.98	0.79
48	29.0728	76.7489	Rabrah-C	10.2	9.3	17.31	15.07	-20.30	-31.60	1.23	1.13
49	29.0814	76.7561	Lath-E	8.6	8.3	14.90	13.44	-23.19	-23.80	1.75	1.55

Table 2 ***contd.***

50	29.0925	76.7625	Kheri Damkan-A	7.4	6.7	14.61	13.51	-16.70	-15.60	1.08	0.99
51	29.1017	76.7764	Kheri Damkan-B	5.7	4.5	16.19	13.14	-6.20	-2.40	3.14	2.59
52	29.1128	76.7903	Niat-B	2.7	2.4	7.91	6.69	-1.34	-0.10	2.65	3.45
53	29.1233	76.8044	Kakhana-B	4.3	3.8	13.51	12.44	-2.37	0.60	0.85	0.61
54	29.1267	76.8263	Saragtha-C	5.1	4.3	12.68	11.74	-3.90	-8.40	2.64	2.46
55	29.0670	76.7039	Puthi-B	0.8	0.6	3.38	2.72	0.10	0.30	1.18	1.06
56	29.0992	76.7421	Sikandarpur Majra-C	3.0	2.3	10.89	14.03	-0.57	1.50	1.86	1.76
57	29.1469	76.7998	Khanpur Kalan-B	1.0	0.9	5.04	3.40	-0.50	-0.70	1.52	1.37
58	29.1600	76.7664	Gamri-C	4.0	3.7	8.45	7.64	-9.90	-9.70	1.35	1.32
59	29.1517	76.7231	Garhi Ujale Khan-B	4.8	4.0	11.47	9.65	-6.80	-5.80	1.57	1.36
60	29.1114	76.7015	Gohana-C	7.7	7.0	14.10	12.96	-18.41	-16.52	2.00	1.73

root zone with consequent effect on yields. If excessive quantities of soluble salts get accumulated in the root zone, the plant will experience extra difficulty in extracting enough water for survival from the salty soil solution. Such reduced water uptake by the plant can result in slow or stunted growth and may also be seen by early wilting symptoms similar to those of drought.

Sodium Adsorption Ratio (SAR)

SAR is a measure of sodium hazard and is calcuted by the formula $Na^+ / [\sqrt{(Ca^{++} + Mg^{++})} / 2]$ 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 premonsoon and from 2.15 at Point No. 17 (Bali-A) to 35.01 at Point No. 23 (Moi-A) for postmonsoon groundwater samples (Table 2). According to USDA water quality rating for SAR, no. 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 premonsoon and 27, 22, 7 and 4 for postmonsoon samples respectively (Table 2). Low sodium water (Class S_1) can be used for irrigation on almost all types of soils with little danger of development of harmful levels of exchangeable sodium. Medium sodium water (Class S_2) in fine textured soils of high cation exchange capacity, especially under low leaching conditions, unless gypsum is present in the soil, presents appreciable sodium hazard, but may be used on coarse textured or organic soils which have good permeability. Very high sodium water (S_4) is generally unsatisfactory for irrigation purposes, except at low and perhaps medium soil salinity. Application of gypsum or other amendments may possibly render this water feasible. Application of gypsum also increases the crust conductivity property of soil. Recharge of groundwater after monsoon brought about some improvement in water quality with respect to SAR.

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 saturated. As a result, the relative proportion of sodium in the water is increased in the form of sodium carbonate. RSC is therefore 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 premonsoon and 54 samples showed RSC value of < 1.25(Low) and 6 samples showed RSC value in between 1.25 to 2.50 (medium) after the postmonsoon. No sample was observed to have unsafe RSC value (> 2.5) (Table 2). There was almost no change in RSC values 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 premonsoon and 3.88 at Point No. 13 (Nagar-B) to 0.85 at Point No. 53 (Kakhana-B) for postmonsoon (Table 2). 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 premonsoon samples and 27, 30 and 3 for postmonsoon samples. Like RSC, Mg /Ca does not show any significant changes between pre and post monsoon season in the study area, indicating thereby that the recharge of groundwater after monsoon is not very effective in bringing out dilution for improvement in water quality in the Gohana block region. Another possibility may be that the source of ground water may be lying somewhere out side the region of study and contribution of rain water to ground water recharging may not be very significant.

Conclusions

Analysis of groundwater samples showed that out of 60 samples during premonsoon period the number of samples coming under Class C_3, Class C_4 and Class C_5 are 18, 12 and 30 respectively whereas during postmonsoon the number of samples coming under Class C_3, Class C_4 and Class C_5 are 16, 13 and 27 respectively. After monsoon period a new category of EC (Class S_2) appeared and only 4 samples came within it. Similarly the number of samples coming under Class S_1, Class S_2, Class S_3 and Class S_4 of SAR are 20, 25, 8 and 7 for premonsoon and 27, 22, 7 and 4 for postmonsoon samples respectively. Like EC and SAR, the number of samples coming under Low, Medium and High class of Mg/Ca are 25, 31, and 4 for premonsoon period and 27, 30 and 3 for the postmonsoon period. There was almost no change in groundwater quality with respect to RSC. It is quite clear that there is only a marginal change in groundwater quality with respect to EC, SAR and Mg/Ca ratio which may be ascribed to dilution effect of water which is not much appreciable.

References

Biswal, A., Singh, A.K., Tadi, S.G. and Chandrasekharan, H. 2004. Assessment of ground water quality at IARI farm, New Delhi. Journal of water management 12: 40-46.

Chesnin, L. and Yien, C.H. 1950. Turbidometric determination of available sulphates. *Proc. Soil Sci. Soc. Agric.*, **14**: 149-151.

CWC 2000. Water and Related Statistics, New Delhi.

Hesse, P.R. 1971. A textbook of soil chemical analysis. John Murray Publisher Ltd., 50 Albemarine Street, London, WIX4 BD.

Jackson, M.L. 1967. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kamra, S.K., Mongia, A.D., Singh, O.P. and Boonstra, J. 2000. Hydraulic and geo-chemical characterization of saline ground water aquifers through pumping test studies. *In: Proceedings of the international Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century (*Extended Summary). Vol. 2, Held at New Delhi, February 14-18, pp 534-535.

Kumaresan, M and Riyazuddin, P. 2005. Major ion chemistry of environmental samples around suburban of Chennai city. *Current Science.* **91**: 1668-1677.

Laluraj, C.M. and Gopinath, G. 2006. Assessment on seasonal variation of groundwater quality of pheratic aquifer – a river basin system. *Environmental Monitoring and Assessment* **117**: 45-57.

Richards, L.A. 1954. Diagnosis and improvement of saline-alakali soils. Agricultural Handbook, USDA, pp. 60.

Shah, T., Molden, D., Sakthivadivel, R. and Seckler, D. 2000. The global ground water situation: Overview of opportunity and challenges. International Water Management Institute, Colombo.

Tanwar, B.S. 1998. Inland salinity and challenges on water quality management in Haryana (India). *In: Proceedings of the International Specialised Conference on Water Quality and its Management.* Central Board of Irrigation and Power and National Committee of International Association on Water Quality, New Delhi, pp. 182-191.