

Water Quality Study for Drinking Purposes Through the Mathematical Water Quality Index (WQI) of Canning Block, Coastal Belt in South 24 Parganas, West Bengal

D. K. Verma, P. K. Dhara, R. K. Kole, G. C. Hazra, S. K. Mandal, Pradeep Mishra, Viveka Nand

Received 23 December 2016 ; Accepted 27 January 2017 ; Published online 15 February 2017

Abstract Water quality is a very important role play in the coastal areas for the drinking purposes. Water quality is big issues in these areas due to the salinity, but for drinking purposes its's not much important. So thirty (30) ground and surface water samples were collected from difference sources, like shallow (Ground water), pond (Surface water), in pre-monsoon and post-monsoon. Use the standard analytical water quality method of APHA, for the water quality analysis we are analyse fifteen (15) different parameters, pH, COD, electrical conductivity (EC), chloride

(Cl⁻), carbonate (CO₃⁻), bicarbonate (HCO₃⁻), sulfate (SO₄⁻), nitrate (NO₃⁻), fluoride (F⁻), calcium (Ca⁺⁺), magnesium (Mg⁺⁺), sodium (Na⁺), potassium (K⁺), sodium adsorption ratio (SAR) and residual sodium carbonate (RSC). Using the thirteen (13) water quality parameters we were computed the water quality index (WQI). Analyzed shallow water samples in pre-monsoon were found 53.33% good, 33.33% poor, 6.66% very poor and 6.66% found unsuitable for drinking purposes, but after the monsoon we were found 86.66% of shallow water found good and 13.33 in poor category. Pond water samples were found in pre-monsoon 73.33% in good quality, 20.0% poor, 13.33% very poor and 6.66% for the unsuitable for the drinking purposes.

D. K. Verma*, P. K. Dhara
 Department of Soil and Water Conservation, BCKV, Mohanpur, Nadia, WB, India

R. K. Kole, S. K. Mandal
 Department of Agricultural Chemicals, BCKV, Mohanpur, Nadia, WB, India

G. C. Hazra
 Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur, Nadia, WB, India

P. Mishra
 Department of Statistics, BCKV, Mohanpur, Nadia, WB, India

V. Nand
 Department of Food Engineering, BCKV, Mohanpur, Nadia, WB, India
 e-mail: dkvermabckv@gmail.com

*Correspondence

Keywords Water quality index (WQI), Surface, Ground water.

Introduction

In coastal rural areas people generally use surface and sub-surface water for the drinking, irrigation and other domestic purposes. We are generally think that, the ground water is good for the drinking and irrigation purposes, but some coastal areas people also use pond water for the bathing and other domestic purposes. Coastal areas ground water was found rich to the salt concentration and it's not generally suitable for irrigation use [1]. If the pond water found

microbial contamination free then we also use for drinking purposes. Rain water is pure water it's collected in different pocket of land and we were use as for need.

In human health, water plays a very important role and quality of the water supplied is important in determining the health of individuals and the whole communities. The values of these parameters are harmful for human health if they occurred more than defined limits [2]. Therefore, the suitability of water sources for human consumption has been described in terms of WQI, which is one of the most effective ways to describe the quality of water. WQI utilizes the water quality data and helps in the modification of the policies, which are formulated by various environmental monitoring agencies. WQI provides a single value that expresses the overall water quality at a certain locations and time based on several water quality parameters. WQI convert the complex water quality data into information that is understandable and usable by the public [3]. The present study was carried out with an objective to assess the ground-water quality in Canning block of, South 24 Parganas, district, West Bengal using WQI.

Materials and Methods

Thirty (30) shallow and pond water samples were collected from different places in canning block in pre and post monsoon of the year 2011. Canning block lies between the 22.32°N 88.67°E in, South 24 Parganas, West Bengal. The groundwater samples were collected in one liter narrow mouth prewashed polyethylene bottles. The physico-chemical parameters, namely, pH, EC, Hardness, Ca^{+2} , Mg^{+2} , Na^+ , K^+ , CO_3^{-2} , HCO_3^- , Cl^- and F^- were analyzed in the laboratory as per the standard procedure. WQI was calculated using these twelve physico-chemical parameters [4], known as standard drinking water quality parameters. The weighted arithmetic index method has been used for the calculation of WQI of the water body. Further, quality rating or sub index (q_n) was calculated using the following equation:

$$q_n = 100 * \frac{(V_n - V_{io})}{(S_n - V_{io})}$$

(Where, n is the water quality parameters and quality rating or sub index (q_n) corresponding the n^{th} parameters is a number reflecting the relative value of this parameters in the polluted water with respect of this permissible value).

q_n = quality rating for n^{th} water quality parameters, V_n = estimated value of thenth parameters at a given sampling station, S_n = standard permissible value of the n^{th} parameters, V_{10} = ideal value of the n^{th} parameters in pure water. (i.e. 0 for all other parameters except the parameters pH and dissolved oxygen (7.0 and 14.y mg/L respectively).

Unit weight was calculated by a value inversely proportional to the standard recommended valve S_n of the corresponding parameters.

$$K_n = \frac{K}{S_n}$$

K_n = unit weight for the n^{th} parameters, S_n = standard value for the n^{th} parameters, K = constant for proportionality.

The overall water quality index was calculated by aggregating the water quality rating with the unit

$$\text{weight linearity : WQI} = \frac{\sum q_n W_n}{\sum W_n}$$

WQI level and water quality status was explained as shown in the Table 1.

Results and Discussion

Physico-chemicals property of water collected from different places

pH of a water is an important indicator of water quality and the extent of pollution in the surrounding area. The collected water samples were neutral to alkaline in nature ; the range of the pH values of shallow tube well in pre monsoon is 7.34–8.38 and 7.14–7.64 in post monsoon (Table 2). The pH of pond water samples had varies in range differences of 7.13–8.41 and 6.93–8.21 in pre and post monsoon respectively.

Table 1. Represent the water quality index (WQI) level and status of water quality.

WQI Range	Water quality status
0–25	Excellent
26–50	Good
51–75	Poor
76–100	Very poor
> 100	Unsuitable for drinking

Electrical conductivity is important parameters for the identification the suitability of water for irrigation purposes. These study areas are found under the coastal belt so effects of salinity appear there. (Fig. 1). The range of EC values of shallow tub well in pre and post monsoon is $0.82\text{--}2.88\text{ ds}^{-1}\text{ m}$ and $0.39\text{--}2.14\text{ ds}^{-1}\text{ m}$ respectively (Table 2). The range differences of electrical conductivity of pond water samples varies is $0.71\text{--}2.17\text{ ds}^{-1}\text{ m}$ in pre-monsoon and $0.35\text{--}1.12\text{ ds}^{-1}\text{ m}$ (Table 2) was found in after monsoon. Most of samples in both water sources in pre-monsoon were found unsuitable for irrigation purposes, but after monsoon increase the suitability of water for irrigation. The changes in different physico-chemicals parameters a decreasing trend observed after the monsoon which indicate that the pH, salinity and concentration of ions of fresh ground water zone has decrease over the four month [5].

COD concentration in water quality represents the total amount of oxygen which is required to oxidize all the organic matter in a sample to CO_2 and H_2O [3]. In the present study, the COD ranged of the shallow tub well in pre-monsoon is $1.20\text{--}5.60$ and $0.8\text{--}3.2\text{ mg/L}$, after the monsoon (Table 2). Pond water samples were found the excess compare to the shallow water. Pond water samples were varies COD between the range of $22.90\text{--}78.10\text{ mg/L}$, (Table 2) in pre-monsoon and $12.8\text{--}54.82\text{ mg/L}$, after the monsoon (Table 2). Excess of COD in water samples indicate the availability of organic matter in water [6].

Chloride (Cl^-) is an important parameters in water its represent the intensity of salt concentration it is essential to plants in very low amount, it can cause toxicity to sensitive crops at high concentrations effect on plant growth. The Cl^- concentration below 70 mg/L is generally safe for all plants. The range of Cl^-

in shallow tube well varies between $383.21\text{--}2699.16\text{ mg/L}$ in pre-monsoon and $149.95\text{--}2399.26\text{ mg/L}$ in after monsoon (Table 2). Pond water was found the range difference of Cl^- concentration in pre monsoon is $949.71\text{--}2424.25\text{ mg/L}$ and $674.79\text{--}2174.33\text{ mg/L}$ (Table 2) in post monsoon [7].

Nitrate concentration of in shallow water found in the ranged of $0.5\text{--}5.7\text{ mg/L}$ in pre-monsoon and $0.32\text{--}3.70$ after the monsoon. In pond water samples were found the nitrate in range of $0.5\text{--}4.80$ (Table 2) in pre monsoon and $0.31\text{--}3.40\text{ mg/L}$ (Table 2) after the monsoon. Nitrogenous materials are rare in the geological record ; therefore, occurrence of nitrate in groundwater is an anthropogenic pollutant contributed by nitrogenous fertilizers, industrial effluents, human and animal wastes through biochemical activity of nitrifying bacteria, such as *Nitrosomonas* and *Nitrobacter*. All sources of nitrogen are potential sources of nitrate. The nitrate concentration in groundwater and surface water is normally low for all the samples. Groundwater levels are higher compare to the pond samples water. This include leaching of organic and inorganic fertilizers from agricultural land by infiltration and percolation of rainwater, irrigation water, animal waste, leakage from sewers [7].

Fluoride content in shallow tube was found in range of $0.25\text{--}1.25\text{ ppm}$ in pre-monsoon and $0.21\text{--}0.82$ after monsoon. In pond water a sample fluoride varies in range of $0.12\text{--}0.71\text{ ppm}$, but after monsoon is reduces in range of $0.10\text{--}0.69\text{ ppm}$. Fluoride is essential for teeth if its under the permissible limit $< 1.5\text{ ppm}$ [2], but excess of permissible limit the causes the fluorosis in human body. Water for irrigation purposes is no prescribed standards are suggested by world health organisation [8].

Sulfur is essential nutrient for the crop growth and it's also in oil seed crops sulfur increase the oil content and improves the quality of oil. In water sulfur converted into sulfate form. Sulfate (SO_4^-) content in shallow tube in pre-monsoon was found ranging from the $6.7\text{--}31.2\text{ mg/L}$ and $5.7\text{--}28.30\text{ mg/L}$ (Table 2) after the monsoon. In pond water samples SO_4^- content in pre-monsoon varies from $21.7\text{--}122.7\text{ mg/L}$, but after the monsoon sulfate content found the range $3.5\text{--}17.9\text{ mg/L}$ (Table 2).

Table 2. Physico-chemicals property of shallow tube well and pond water samples.

Parameters	Range	Shallow tube well				
		Pre-monsoon Mean	SD	Range	Post-monsoon Mean	SD
pH	7.34-8.38	8.2807	0.3274	7.14-7.64	7.3680	0.1423
Ec (dsm ⁻¹)	0.82-2.88	1.559	0.719	0.39-2.14	0.997	0.511
Turbidity (NTU)	0.70-3.10	1.773	0.811	1.1-4.1	2.335	0.822
COD (mg/L)	1.20-5.60	2.687	1.089	0.8-3.2	1.927	0.682
Cl ⁻ (mg/L)	383.21-2699.16	1172	578	149.95-2399.26	931	613
CO ₃ ⁻ (mg/L)	0.00-0.137	0.0346	0.0506	0.00-0.04	0.01268	0.01254
HCO ₃ ⁻ (mg/L)	0.015-386	0.0688	0.0980	0.006-0.040	0.02277	0.01011
F ⁻ (mg/L)	0.25-1.22	0.5086	0.2819	0.21-0.82	0.4273	0.2105
NO ₃ ⁻ (mg/L)	0.5-5.7	1.785	1.378	0.32-3.70	1.317	0.943
SO ₄ ⁻ (mg/L)	6.7-31.2	8.00	16.54	5.7-28.30	14.29	7.25
Hardness (mg/L)	94.0-368.7	229.2	103.4	42.0-286.0	171.2	90.5
Ca ⁺⁺ (mg/L)	18.7-69.7	36.91	15.83	10.4-37.7	20.79	7.80
Mg ⁺⁺ (mg/L)	15.06-84.61	46.93	26.31	3.06-65.09	36.70	22.35
Na ⁺ (mg/L)	2.5-28.1	11.43	7.08	4.3-17.5	9.80	4.01
K ⁺ (mg/L)	0.4-7.3	3.727	2.091	0.31-6.3	3.177	1.828
SAR	0.31-3.75	1.524	0.955	0.9-2.4	1.563	0.482
RSC	(39.3)-(-21.27)	-83.73	25.64	(-84.3)-(-23.0)	-57.45	22.26

Table 2. Continued.

Parameters	Range	Pond				
		Pre-monsoon Mean	SD	Range	Post-monsoon Mean	SD
pH	7.13-8.41	8.087	0.408	6.93-8.21	7.727	0.439
Ec (dsm ⁻¹)	0.71-2.17	1.239	0.432	0.35-1.12	0.624	0.212
Turbidity (NTU)	32.87-50.63	42.06	5.29	41.73-91.41	62.88	15.42
COD (mg/L)	22.90-78.10	43.76	16.95	12.8-54.82	31.00	12.94
Cl ⁻ (mg/L)	949.71-2424.25	1432	407	674.79-2174.33	1136	428
CO ₃ ⁻ (mg/L)	0.00-0.0060	0.00201	0.00202	0.0-0.05	0.01-670	0.01415
HCO ₃ ⁻ (mg/L)	0.015-0.051	0.03592	0.01082	0.009-0.073	0.03646	0.01750
F ⁻ (mg/L)	0.12-0.71	0.3518	0.1546	0.10-0.69	0.2953	0.1552
NO ₃ ⁻ (mg/L)	0.5-4.80	2.427	1.189	0.31-3.40	1.909	0.979
SO ₄ ⁻ (mg/L)	21.7-122.7	52.06	27.35	3.5-17.39	43.31	22.15
Hardness (mg/L)	83.3-392.2	246.7	96.3	62.0-322.0	181.1	86.0
Ca ⁺⁺ (mg/L)	16.8-62.5	29.49	11.43	13.6-30.5	20.20	5.18
Mg ⁺⁺ (mg/L)	16.23-85.33	53.01	22.74	11.41-71.14	39.25	20.36
Na ⁺ (mg/L)	4.9-17.3	10.100	3.848	3.2-12.8	7.920	2.776
K ⁺ (mg/L)	0.4-7.2	3.227	2.162	0.2-6.5	2.700	1.934
SAR	0.72-2.23	1.372	0.498	0.60-2.0	1.297	0.476
RSC	(-132.21)-(-33.01)	-82.46	27.55	(-101.5)-(-25.9)	-59.40	23.21

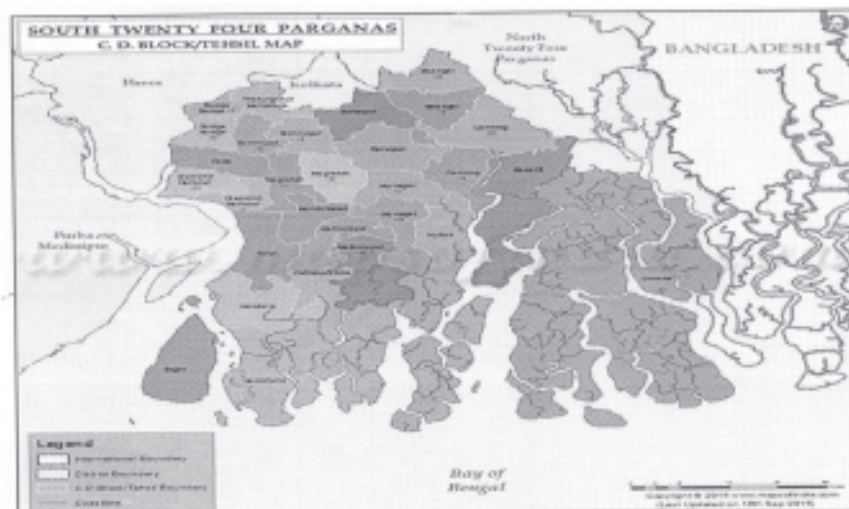


Fig. 1. Map of the selected study area.

Table 3. WQI of different ground and surface water samples collected in pre-monsoon and post-monsoon, 2011.

Sl. No.	Source of water	Pre-monsoon		Post-monsoon		Water quality status
		WQI	Water quality status	Source of water	WQI	
1	Shallow	46.72	Good	Shallow	28.74	Good
2	Shallow	49.59	Good	Shallow	38.46	Good
3	Shallow	31.75	Good	Shallow	26.97	Good
4	Shallow	77.09	Very poor	Shallow	38.95	Good
5	Shallow	44.04	Good	Shallow	37.62	Good
6	Shallow	45.58	Good	Shallow	32.12	Good
7	Shallow	28.95	Good	Shallow	26.12	Good
8	Shallow	60.57	Poor	Shallow	57.15	Good
9	Shallow	57.21	Poor	Shallow	48.71	Good
10	Shallow	55.13	Poor	Shallow	48.21	Good
11	Shallow	63.40	Poor	Shallow	61.36	Poor
12	Shallow	111.53	Unsuitable	Shallow	62.04	Poor
13	Shallow	65.72	Poor	Shallow	49.36	Good
14	Shallow	44.43	Good	Shallow	32.25	Good
15	Shallow	45.77	Good	Shallow	40.77	Good
16	Pond	34.71	Good	Pond	34.35	Good
17	Pond	69.56	Poor	Pond	43.01	Good
18	Pond	49.08	Good	Pond	47.76	Good
19	Pond	93.83	Very poor	Pond	91.82	Very poor
20	Pond	33.93	Good	Pond	32.79	Good
21	Pond	49.05	Good	Pond	46.00	Good
22	Pond	30.76	Good	Pond	30.45	Good
23	Pond	35.86	Good	Pond	32.39	Good

Table 3. Continued.

Sl. No.	Pre-monsoon			Post-monsoon		
	Source of water	WQI	Water quality status	Source of water	WQI	Water quality status
24	Pond	38.04	Good	Pond	35.71	Good
25	Pond	65.94	Poor	Pond	58.11	Poor
26	Pond	208.27	Unsuitable	Pond	49.44	Good
27	Pond	75.93	Very poor	Pond	69.82	Poor
28	Pond	52.86	Poor	Pond	51.74	Poor
29	Pond	48.33	Good	Pond	46.78	Good
30	Pond	50.00	Good	Pond	44.89	Good

The calcium and magnesium in waters are generally used to classify the suitability of water. Calcium and magnesium are directly related to hardness of the water and these ions are the most abundant elements in the surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulfate and chloride [7]. The range of the Ca^{++} in shallow tube well observed in pre monsoon is 18.7–69.7 mg/L and post monsoon is 16.8–62.5 mg/L (Table 2). Pond water samples carried calcium content in the range of 16.8–62.5 mg/L in pre monsoon and 13.6–30.5 mg/L after the monsoon (Table 2). Magnesium (Mg^{++}) in shallow tube well were varies in pre-monsoon ranging from the 15.06–84.61 mg/L. (Table 2) and 3.06–65.09 mg/L (Table 2) after the post monsoon. In pond water samples in pre-monsoon were found the range between the 16.23–85.33 mg/L and 11.41–71.14 mg/L (Table 2) after the post monsoon. Magnesium is a dominant element found in the both of water sampler in pre and post-monsoon and its responsible factor for the water quality [9].

Sodium content in shallow tube found in pre-

monsoon ranges from 2.5–28.1 mg/L and 4.3–17.5 mg/L (Table 2) after the post-monsoon. In pre-monsoon pond water samples sodium content varies in the ranging from 4.9–17.3 mg/L and after the post-monsoon sodium content found range from 3.22–12.8 mg/L (Table 2). Sodium content was found the under the permissible limit both of water sources in pre and post monsoon [10].

Potassium (K^+) is primary nutrients for the crop and its more quantity require for the crop growth and development but quality of irrigation water its permissible, highest desirable or maximum permissible limit was not set by FAO, BIS and WHO. Potassium content in shallow tube well found in pre-monsoon ranges from 0.4–7.3 mg/L and 0.31–6.3 mg/L (Table 2) after the monsoon. In pond water samples potassium found ranges from 0.4–7.2 mg/L in pre-monsoon and 0.2–6.5 mg/L (Table 2) after the monsoon respectively [11].

An important chemical parameter for judging the degree of suitability of water for irrigation is sodium

Table 4. Rank distribution of the water samples collected in pre and post monsoon season.

Source	Pre-monsoon		Source	Post-monsoon	
	Rank	Per cent (%)		Rank	Per cent (%)
Shallow	Good	53.33	Shallow	Good	86.66
	Poor	33.33		Poor	13.33
	Very poor	6.66		Very poor	
	Unsuitable	6.66		Unsuitable	
Pond	Good	60.00	Pond	Good	73.33
	Poor	20.0		Poor	20.00
	Very poor	13.33		Very poor	6.66
	Unsuitable	6.66		Unsuitable	

content or alkali hazard, which is expressed as the sodium adsorption ratio (SAR). The observed SAR values of shallow tube well in ranging from the 0.31–3.75 in pre-monsoon and 0.9–2.4 after post monsoon (Table 2). Pond water samples were found in the range of 0.72–2.23 before monsoon and 0.60–2.0 after the monsoon season (Table 2). The sodium hazard or SAR is expressed in terms of classification of irrigation water as low (S_1 : < 10), medium (S_2 : 10 to 18), high (S_3 : 18 to 26) and very high (S_4 : > 26). A high SAR value implies a hazard of sodium (alkali) replacing Ca^{2+} and Mg^{2+} in the soil through a cation exchange process that damages soil structure, mainly permeability and which ultimately affects the fertility status of the soil and reduces crop yield [3]. The RSC value of shallow tube well in pre-monsoon ranging from (39.3)–(–21.27) and (–84.3)–(–23.0) after the post-monsoon. Pond water samples were found RSC in range of (–132.21)–(–33.01) pre-monsoon and (–101.5)–(–25.9) after the post monsoon.

Water quality index (WQI) for drinking purposes

Calculated water quality of the different sources (shallow, pond) were found good condition according to the WQI. The water quality index shows the shallow tube well water in the pre monsoon were found 53.33% good, 33.33% poor, 6.66% very poor and 6.66% found unsuitable for drinking purposes, but after the monsoon we are found 86.66% of shallow water found good and 13.33% in poor category. Pond water samples were found in pre monsoon 73.33% in good quality, 20.0% poor, 13.33% very poor and 6.66% for the unsuitable for the drinking purposes (Table 3, 4).

Conclusion

The results and its interpretation with water quality index, result show the groundwater and pond water samples revealed that the shallow water of the studied area was more suitable in pre-monsoon and post-

monsoon compare to pond. The quality of pond water samples was required some safeguard for using the drinking purposes. Problems of water quality in these areas due to the high salinity and over loading of magnesium in water samples.

References

1. Gupta H, Nag A (2014) Physicochemical analysis of some water ponds in and around Santiniketan, West Bengal, India. *Int J Environ Sci* 4 : 676–682.
2. Mitran T, Mani PK, Singh DK, Tamang A, Basak A, Mandal B (2016) Assessment of hydro-chemical characteristics of ground water collected from the villages of coastal sundarban. *J Soil Sali and Water Qual* 8 : 51–58.
3. Etim EE, Odoh R, Itodo AU, Umoh SD, Lawal U (2013) Water quality index for the assessment of water quality from different sources in the Niger Delta Region of Nigeria. *Fronti In Sci* 3 : 89–95.
4. Ramakrishnaiah CR, Sadashivaiah C, Ranganna G (2009) Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India. *E-J Chem* 6 : 523–530.
5. Choudhury M, Rakshit A (2012) Chemical aspects of ground water quality in the shallow aquifers in selected districts of Eastern Uttar Pradesh. *Int J Agric Environ and Biotechnol* 5 : 345–351.
6. Rajiv P, Hasna AS, Kamaraj M, Rajeshwam S, Balgi R (2012) Comparative physicochemical and microbial analysis of various pond waters in Coimbatore District, Tamil Nadu, India. *Ann Biol Res* 3 : 3533–3540.
7. Shinde V, Tiwari KN, Singh M (2012) Assessment of land and water resources of mine affected watershed in India using Remote Sensing and GIS. *Int J Agric Environ Biotechnol* 5 : 333–344.
8. WHO (World Health Organization) (2012) Guidelines for drinking-water quality, 4th edn., ISBN 978 92 4 154815 1.
9. Gupta PK (2005) Methods in environmental analysis: Water, soil and air. Agrobios, Jodhpur, India, pp 1–127.
10. Vasanthavigar M, Srinivasamoorthy K, Vijayaragavan K, Rajiv Ganthi R, Chidambaram S, Anandhan P, Manivannan R, Vasudevan S (2010) Application of water quality index for groundwater quality assessment: Thirumanimuttar sub-basin, Tamilnadu, India. *Environ Monit Assess* 171 : 595–609.
11. Raju N, Ram JP, Dey S (2009) Groundwater quality in the Lower Varuna River Basin, Varanasi District, Uttar Pradesh. *J Geol Soc Ind* 73 : 178–192.