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Study on Quality - Related Constraints for Drinking and Irrigation in Ground Water of Sundarbans

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The objective of this study was to identify the groundwater potential zones in Sundarbans for drinking and irrigation purposes by assessing the impact of ground water contamination with saline water. The analytical results show the scattered distribution of groundwater quality in Sundarbans. Most of water samples were characterised within the desirable limits of individual parameters according to Bureau of Indian Standards (BIS, 2012) guidelines. On comparison with WHO standards Water Quality Index (WQI) in relation to drinking water quality, most of the samples in Sundarbans were found suitable (good category) for drinking purposes except those from the blocks of Gosaba and Patharpratima which was categorized as 'poor'. The United States Salinity (USSL) diagram shows that the groundwater is free from sodium hazards *i.e.*, 'low sodium water' but the salinity hazard was categorized as 'high salinity water' throughout the study area. Along with concentration of salt *i.e.*, TDS, the ionic ratios of Mg^{2+}/Ca^{2+}, Na^+/Cl^- & $Cl^-/(HCO_3^- + CO_3^{2-})$ were used to identify the intrusion of saline water in the Sundarbans and the sequence of blocks from high to low degree of contamination were in the following order: Gosaba > Patharpratima > Namkhana > Sagar > Kakdeep > Mathurapur I > Mathurapur II > Kultali > Basanti > Canning I > Canning II > Joynagar I > Joynagar II.

(***Key words:*** *Ground water quality, Saline water intrusion, Salinity hazard, Sundarban, Water quality index*)

Quality of ground water is one of the most important issues owing to the suitability of water for various purposes especially for drinking and irrigation in the Sundarbans. The water sources of coastal Sundarbans exhibit a complex distribution of fresh water and salt water having varying degrees of salinity. Majority of the water resources in Sundarbans are saline in nature and its harmful effects on soil and plant were reported (Ayers and Westcott 1985; Burman *et al*., 2009; Si, 2012, 2013 and 2016). Degradation of groundwater quality in coastal region generally occurs due to natural processes such as saline water intrusion, evaporation and interaction of groundwater with soil formed by marine sedimentation, etc. (Fetter, 1994; Langevin *et al*., 2007; Todd, 1980). Over-exploitation of ground water from coastal region accelerates the progress of sea water towards the land, which in turn affects the quality of ground water with respect to drinking and irrigation purposes and have been reported in the different parts of coastal India (Umrikar *et al*., 2011; Sahoo and Mohapatra 2010; Umaran and Ramu, 2015). Therefore, there has been a tremendous increase in demand for fresh water due to groundwater contamination in coastal area besides population growth and intense agricultural activities. The objective of our study was to identify the groundwater potential zones in Sundarbans for drinking and irrigation purpose by assessing the impact of saline water contamination on ground water quality which would be useful for deciding the strategy of water use for drinking and irrigation purposes in near future.

MATERIALS AND METHODS

Indian part of Sundarbans which lies between 88° 10′ E - 89° 51′ E longitude and 21° 31′ N - 22° 40′ N latitude is bordered by Ganga River in the west, Matla and Gosaba rivers in the east, Bay of Bengal in the south. The study area is characterized by small rivers, tidal creeks and low-lying wet plains. The details of the sites from where water samples were collected *i.e.*, name of the village, gram panchayat (GP) and block along with latitude and longitude are given in Table 1.

Ground water samples were collected in each village from 3 tube wells of three different layers A (600-800 ft), B (800-1000 ft), C (>1000ft) in each block, during summer (March-April) 2015-16. The pH, electrical conductivity (EC) and total dissolved solids (TDS)

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Table 1. *Details of the sampling locations and depth of water layer with sample code*

Location No.	Location Block, Grampachayat & Village	Latitude °N	Longitude °E	Depth of water layer (ft)	Sample Code
1	Sagar Rudranagar Rudranagar	88.1034200	22.7294177	600-680(A) 800-880(B) >1000(C)	1_A 1_A 1_C
2	Namkhana Shibrampur Rajnagar	88.2515795	21.6712561	600-680(A) 800-880(B) >1000(C)	2_A 2_B 2_C
3	Patharpratima Ramganga Gayadham	88.3796634	21.8681692	600-680(A) 800-880(B) >1000(C)	3_A 3_B 3_C
4	Kakdwip Sri Ramkrishna Kakdwip	88.1847331	21.8699336	600-680(A) 800-880(B) >1000(C)	4_A 4_B 4_C
5	Mathurapur I Mathurapur Purba Chak Madhusudanpur	88.3926122	22.1134093	600-680(A) 800-880(B) >1000(C)	5_A 5_B 5_C
6	Mathurapur II Nandakumarpur Nandakumarpur	88.4152347	21.9474090	600-680(A) 800-880(B) >1000(C)	6_A 6_B 6_C
7	Joynagar I Dhosa Chandaneswar Dhosa Chandaneswar	88.5419701	22.2525638	600-680(A) 800-880(B) >1000(C)	7_A 7_B 7_C
8	Jounagar II Mayda Chandipur	88.4455595	22.1881994	600-680(A) 800-880(B) >1000(C)	8_A 8_B 8_C
9	Kultali Dakshin Durgapur Deulbari	88.5755207	22.0178259	600-680(A) 800-880(B) >1000(C)	9_A 9_B 9_C
10	Canning I Taldi (E) Madya Rajapur	88.6072511	22.3414261	600-680(A) 800-880(B) >1000(C)	10_A 10_B 10_C
11	Canning II Narayanpur Narayanpur	88.5613758	22.3964238	600-680(A) 800-880(B) >1000(C)	11_A 11_B 11_C
12	Basanti Ranighar Jatishpur	88.6941285	22.1294906	600-680(A) 800-880(B) >1000(C)	12_A 12_B 12_C
13	Gosaba Jatirampur Rangabelia	88.8478328	22.1582642	600-680(A) 800-880(B) >1000(C)	13_A 13_B **13_C**

of the collected groundwater samples were measured using digital meters in laboratory. The instruments were calibrated as per the manufacturer guidelines. Ca^{2+} and Mg^{2+} were estimated by EDTA titration. Total alkalinity (HCO_3^- $+CO_3^{2-}$) was determined by using acid titrimetric method and Na^+ concentration was estimated using flame photometer. Cl^- concentration was measured using argentometric ($AgNO_3$) titration. Spectrophotometer was employed to determine the SO_4^{2-} concentration. Arsenic (As) and iron (Fe) were estimated by using a atomic absorption spectrometer. The standard procedures that were given by Richards (1954) were followed in the laboratory to carry out the above analyses. The water samples were assessed for its suitability to drinking as per the Bureau of Indian Standards (BIS, 2012) guidelines. To assess the overall quality of the ground water samples a water quality index (Ganeshkumar and Jaideep, 2012) was followed. The calculation formula of water quality index (WQI) is given below.

$$WQI=\sum [W_r \times \{(C_i/S_i) \times 100\}] \quad \ldots (1)$$

Where, W_r is the relative weight of each parameter and calculation of relative weight (W_r) values of each parameter is

$$W_r = W_i / \sum_{1}^{n} W_i \quad \ldots(2)$$

Where, W_i is the weight of each parameter and n is the number of parameters.

C_i is the concentration of each chemical parameter in each water sample in mg L^{-1} and S_i is the WHO standard of drinking water for chemical parameter in mg L^{-1}.

Sodium adsorption ratio (SAR) of the water samples were determined by the following relation:

$$SAR = Na / \sqrt{[(Ca + Mg) / 2]} \quad \ldots(3)$$

where, the concentrations are expressed in me L^{-1} .

The United States Salinity (USSL) diagram was also used to assess the sodium and salinity hazard of the water samples.

RESULTS AND DISCUSSIONS

The experimental results of pH, TDS, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, SO_4^{2-}, (HCO_3^- $+CO_3^{2-}$), Fe, As, WQI, EC and SAR of three layers of ground water in Sundarbans are presented in Table 2. In our study, the standards were derived from Bureau of Indian Standards (BIS, 2012) guidelines to assess the drinking water quality of the ground water (Table 3). The pH of ground water samples in Sundarbans ranged from 7.77-8.45 with an average of 8.11 which shows that the most of the ground water samples were slightly alkaline in nature and lie within the accepted limit of BIS standards. Total dissolved solids (TDS) in the ground water varied between 490 to 800 mg L^{-1} with a mean of 621.15 and exceeded the desirable limit of 500 mg L^{-1} of BIS standards (Table 3). The saline water seepage from nearby sea, estuaries may be the reason for variation of TDS in the ground water samples (Jameel and Hussain, 2012).

The chloride in ground water originates from seawater intrusion in coastal area (Aghazadeh *et al*., 2011; O′Brien and Majewski, 1975) and in the present study its value in Sundarbans was found to range from 130.20 to 295.5 mg L^{-1} with average value of 168.96. Majority of the water samples lie within desirable limit in respect to chloride concentration as per BIS standards and only a few samples crossed the acceptable limit (Table 3). The Na concentration in groundwater lied beyond the permissible limit except in few localities where the Na^+ content was between the acceptable and permissible limit. The concentration of Ca^{2+}, SO_4^{2-}, Fe and As were within the desirable limit of BIS standard, whereas the concentration of Mg^{2+} and total alkalinity (HCO_3^- + CO_3^{2-}) exceeded the desirable limit (Table 3). The heterogeneous distribution of elements in the Sundarbans might be due to hydrological influence of seawater, drying on low rainfall and high evapotranspiration, overexploitation of groundwater resources, etc. (Ballukraya and Ravi, 1995; Chidambaram *et al*., 2008; Swarna Latha, P. and Nageswara Rao, 2012; Subba Rao, 2008).

The computed water quality index (WQI) was classified as excellent (WQI <50), good (WQI = 50-100), poor (WQI = 100-200), very poor (WQI = 200-300) and unsuitable (WQI >300) for drinking purpose. In the Sundarbans only two different categories of water quality with respect to the WQI were observed. According to WQI classification, the ground water samples of all localities has been classified as 'good' and those from the blocks Patharpratima and Gosaba were of 'poor' quality for water depth below 600 ft in this region.

Table 2. *Water quality parameters, index and ionic ratios of the groundwater samples in Sundarbans*

Sample Code	pH	TDS (mg L^{-1})	Ca^{2+} (mg L^{-1})	Mg^{2+} (mg L^{-1})	Na^{+} (mg L^{-1})	Cl^{-} (mg L^{-1})	SO_4^{-2} (mg L^{-1})	Total alkalinity (mg L^{-1})	Fe (mg L^{-1})	As (mg L^{-1})	WQI	Mg^{2+}/Ca^{2+}	Na^{+}/Cl^{-}	Cl^{-}/ Total alkalinity
1_A	8.39	775.00	35.06	46.35	147.96	155.00	17.79	249.00	0.23	0.001	86.82	1.32	0.95	0.62
1_B	8.33	690.00	32.25	40.72	143.80	149.32	23.75	247.00	0.22	0.001	87.69	1.26	0.96	0.60
1_C	8.30	620.00	28.44	35.55	135.60	137.84	27.91	240.00	0.15	0.001	79.64	1.25	0.98	0.57
2_A	8.40	785.00	34.59	48.45	142.00	162.68	19.83	254.00	0.21	0.002	88.12	1.40	0.87	0.64
2_B	8.38	710.00	31.41	42.81	139.80	156.36	18.16	250.00	0.19	0.001	87.50	1.36	0.89	0.63
2_C	8.36	645.00	27.78	36.02	135.40	150.46	16.09	245.00	0.18	0.001	81.63	1.30	0.90	0.61
3_A	8.45	790.00	52.11	76.44	244.60	295.50	32.90	410.00	0.18	0.002	113.88	1.47	0.83	0.72
3_B	8.42	720.00	48.84	70.85	237.00	281.50	29.00	405.00	0.17	0.002	110.77	1.45	0.84	0.70
3_C	8.40	650.00	44.88	64.17	235.40	275.00	25.65	398.00	0.14	0.001	107.40	1.43	0.86	0.69
4_A	8.32	665.00	32.02	40.31	149.12	152.20	28.74	251.51	0.23	0.001	82.33	1.26	0.98	0.61
4_B	8.12	605.00	27.65	33.98	143.64	145.00	26.19	244.21	0.16	0.001	74.31	1.23	0.99	0.59
4_C	8.08	540.00	20.61	24.81	135.23	136.50	21.38	238.20	0.14	0.001	66.87	1.20	0.99	0.57
5_A	8.00	645.00	43.26	50.80	157.60	144.00	37.05	242.00	0.19	0.002	79.99	1.17	1.09	0.60
5_B	7.78	590.00	37.00	42.22	152.50	136.80	35.00	235.00	0.15	0.002	73.62	1.14	1.11	0.58
5_C	7.80	535.00	31.19	34.45	148.70	130.20	32.45	231.00	0.12	0.001	69.08	1.10	1.14	0.56
6_A	7.90	625.00	45.16	51.91	167.70	150.40	25.91	241.00	0.18	0.002	80.51	1.15	1.12	0.62
6_B	7.85	580.00	42.64	48.31	163.90	142.40	23.55	237.00	0.15	0.002	75.41	1.13	1.15	0.60
6_C	7.80	525.00	38.33	42.72	160.30	138.20	21.45	234.00	0.12	0.001	73.44	1.11	1.16	0.59
7_A	7.83	580.00	64.48	56.14	192.60	165.80	45.40	346.00	0.28	0.002	96.17	0.87	1.16	0.48
7_B	7.77	540.00	58.11	48.38	180.10	157.60	39.90	332.00	0.24	0.002	88.60	0.83	1.14	0.47
7_C	7.80	500.00	51.28	41.34	172.80	150.40	35.16	326.00	0.20	0.002	84.87	0.81	1.15	0.46
8_A	7.80	565.00	54.50	46.20	189.26	159.80	26.25	338.00	0.27	0.001	91.95	0.85	1.18	0.47
8_B	7.80	520.00	48.20	39.59	166.70	146.20	24.40	325.00	0.18	0.001	81.12	0.82	1.14	0.45
8_C	7.82	490.00	43.69	35.18	157.56	139.10	22.50	320.00	0.16	0.001	76.50	0.81	1.13	0.43
9_A	8.21	675.00	44.73	53.76	177.70	156.00	37.85	268.00	0.25	0.002	89.87	1.20	1.14	0.58
9_B	8.15	615.00	40.11	46.96	175.90	150.00	32.03	261.00	0.20	0.001	83.82	1.17	1.17	0.57
9_C	8.19	545.00	34.69	39.00	170.10	143.80	29.10	257.00	0.15	0.001	77.74	1.12	1.18	0.56
10_A	8.26	650.00	42.00	42.28	157.00	152.40	43.38	300.00	0.16	0.003	90.41	1.01	1.03	0.51
10_B	8.24	590.00	38.02	36.60	153.40	147.92	36.63	294.00	0.15	0.002	85.02	0.96	1.04	0.50
10_C	8.18	525.00	33.59	31.25	147.20	140.72	40.00	291.00	0.11	0.002	84.68	0.93	1.05	0.48
11_A	7.85	625.00	45.43	49.27	160.00	158.00	49.35	315.00	0.28	0.002	88.88	1.08	1.01	0.50
11_B	7.83	570.00	49.77	47.33	156.52	152.31	53.23	310.00	0.15	0.002	81.50	0.95	1.03	0.49
11_C	7.81	510.00	50.43	46.54	151.04	145.12	59.32	305.00	0.14	0.002	81.53	0.92	1.04	0.48
12_A	8.24	660.00	56.60	64.60	179.48	172.80	58.90	295.00	0.13	0.007	95.72	1.14	1.04	0.59
12_B	8.21	605.00	52.09	57.00	168.12	160.00	55.92	282.00	0.10	0.005	94.76	1.09	1.05	0.57
12_C	8.22	560.00	48.18	51.60	160.28	151.80	47.86	274.00	0.08	0.004	90.88	1.07	1.06	0.55
13_A	8.44	800.00	52.61	84.01	224.99	276.60	21.67	360.00	0.19	0.008	117.68	1.60	0.81	0.77
13_B	8.36	740.00	49.17	75.30	219.80	268.80	18.53	353.00	0.17	0.007	110.18	1.53	0.82	0.76
13_C	8.38	665.00	44.70	64.44	213.92	255.00	16.12	341.00	0.15	0.004	100.78	1.44	0.84	0.75

Table 3. *Status of ground water quality in Sundarbans as per BIS drinking water standards (2012)*

Sl. No.	Para meters	BIS (2012)		Samples below /within acceptable limit	Samples between acceptable and permissible limit	Samples beyond permissible limit
		Acceptable Limit	Permissible Limit			
1	pH	6.5-8.5	9.2	$1_A,1_B, 1_C,2_A,2_B,2_C,3_A,3_B,3_C, 4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B,13_C$	--------	--------
2	TDS (mg L^{-1})	500	1000	8_C	$1_A,1_B, 1_C,2_A,2_B,2_C,3_A,3_B,3_C, 4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B$	--------
3	Ca^{2+} (mg L^{-1})	75	200	$1_A,1_B, 1_C,2_A,2_B,2_C,3_A,3_B,3_C, 4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B,13_C$	--------	--------
4	Mg^{2+} (mg L^{-1})	30	100	4C	$1_A,1_B, 1_C,2_A,2_B,2_C,3_A,3_B,3_C, 4_A,4_B,5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B,13_C$	--------
5	Na^{+} (mg L^{-1})	100	150	-------	$1_A,1_B, 1_C,2_A,2_B,2_C, 4_A,4_B,4_C,5_C,10_C$	$3_A,3_B,3_C, 5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B,13_C$
6	Cl^{-} (mg L^{-1})	250	1000	$1_A,1_B, 1_C,2_A,2_B,2_C,4_A,4_B,4_C, 5_A,5_B,5_C,6_A,6_B,6_C,7_A,7_B,7_C, 8_A,8_B,8_C,9_A,9_B,9_C,10_A, 10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C$	$3_A,3_B,3_C, 13_A,13_B,13_C$	--------
7	Sulphate SO_4^{2-} (mg L^{-1})	200	400	$1_A,1_B, 1_C,2_A,2_B,2_C,3_A,3_B,3_C, 4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C, 7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C, 10_A,10_B,10_C,11_A,11_B,11_C, 12_A,12_B,12_C,13_A,13_B,13_C$	--------	--------

8	Total Alkalinity (HCO_3^- + CO_3^{2-}) (mg L^{-1})	200	600	--------	$1_A,1_B,1_C,2_A,2_B,2_C,3_A,3_B,3_C,4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C,7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C,10_A,10_B,10_C,11_A,11_B,11_C,12_A,12_B,12_C,13_A,13_B,13_C$	--------
9	Fe (mg L^{-1})	0.30	0.30	$1_A,1_B,1_C,2_A,2_B,2_C,3_A,3_B,3_C,4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C,7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C,10_A,10_B,10_C,11_A,11_B,11_C,12_A,12_B,12_C,13_A,13_B,13_C$	--------	--------
10	As (mg L^{-1})	0.01	0.05	$1_A,1_B,1_C,2_A,2_B,2_C,3_A,3_B,3_C,4_A,4_B,4_C,5_A,5_B,5_C,6_A,6_B,6_C,7_A,7_B,7_C,8_A,8_B,8_C,9_A,9_B,9_C,10_A,10_B,10_C,11_A,11_B,11_C,12_A,12_B,12_C,13_A,13_B,13_C$	--------	--------

SAR is one of the major factors that determine the suitability of ground water for irrigation purposes and high amount of dissolved salt in water affects plants growth and soil fertility. The total concentration of soluble salts in irrigation water can also be expressed in terms of specific conductance. A comparative SAR and EC studies are presented in Fig. 2. The salinity hazard classes from C_1 to C_4 and sodium hazard classes from S_1 to S_4 are used to express the nature of the water samples as excellent/good/doubtful and unsuitable for irrigation. In the present study, the ground water samples of Sundarbans were found to fall in the S_1 (SAR<10) and C_3 (EC = 0.75-2.25 dS m^{-1}) categories with reference to SAR and EC values, respectively (Fig. 2). From detailed analysis of SAR and EC on USSL diagram, all of samples are found under C_3S_1 (moderate category). Hence, there is no difficulty to use the water for irrigation purpose in soils without control of salinity and sodium contents. SAR classification confirms that the ground water at all locations is safe for irrigation purpose.

The mixing trends between seawater and ground water can be understood from the molar ratio of Na^+/Cl^- which lies in between 0.86 and 1.00 (Vengosh and Rosenthal, 1994) and the Mg^{2+}/Ca^{2+} ratio > 0.9 (Hem, 1985). The molar ratio of Cl^-/(HCO_3^- +CO_3^{2-}) between 0.05 and 1.30 indicates slightly contaminated groundwater (Simpson, 1946) which might be due to the saline water ingress. A comparison of the ionic ratios of Mg^{2+}/Ca^{2+}, Na^+/Cl^- and Cl^-/(HCO_3^- +CO_3^{2-}) is shown in Fig. 2. The sequence of blocks based on degree of contamination from the analysis of graphical diagram of ionic ratios in the study area are in the following order; Gosaba (13) > Patharpratima (3) > Namkhana (2) > Sagar (1) > Kakdwip (4) > Mathurapur I (5) > Mathurapur II (6) > Kultali (9) > Basanti (12) > Canning I (10) > Canning II (11) > Joynagar I (7) > Joynagar II (8). Gosaba (13), Patharpratima (3), Namkhana (2) and Sagar (1) blocks have more saline groundwater due to sea and rivers flowing near the ground water station which have a direct relation with the chemical combinations of the ground water to a large extent (Li *et al*., 2005). Whereas Joynagar I (7), Joynagar II (8) and Canning II (11) blocks exhibited less salinity character owing to fresh water flowing in the rivers which percolate into the ground water and drastically change the ion concentrations in the ground water due to dilution effect (Jameel and Hussain, 2012).

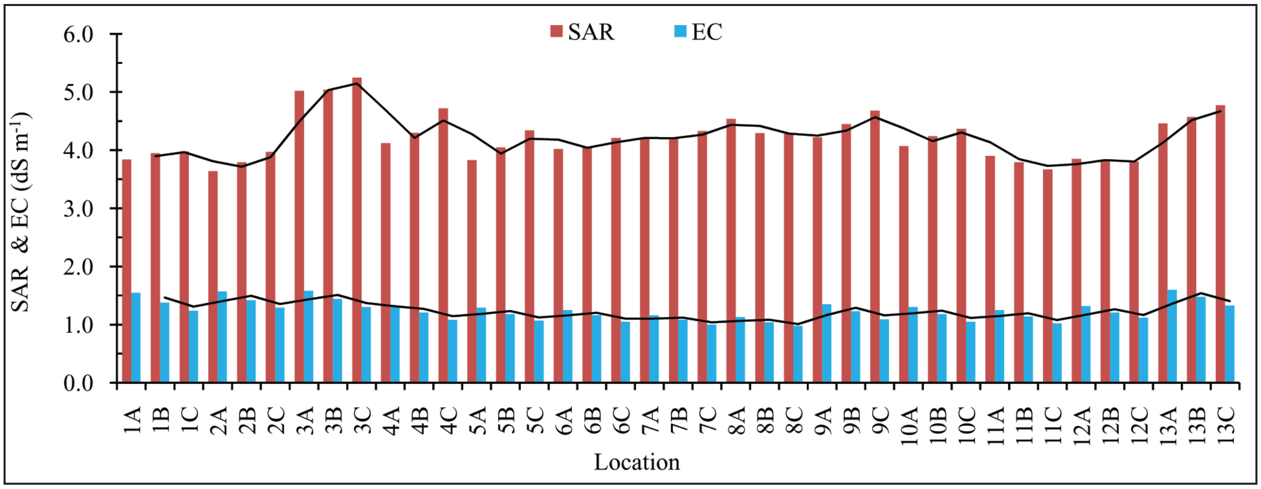

Fig. 1. *Variation of SAR and EC in groundwater sample across various locations in the Sundarbans, West Bengal*

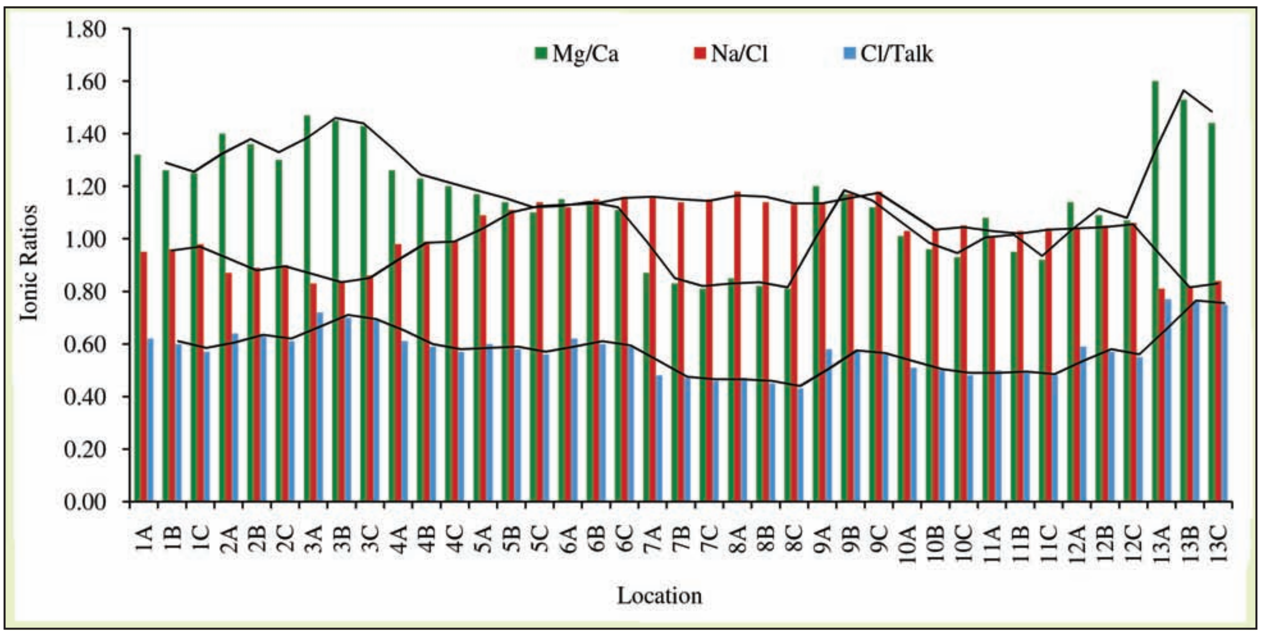

Fig. 2. *Ionic ratios as an indication of the degree of contamination of groundwater samples across various locations in the Sundarbans, West Bengal*

1 = Rudranagar, Sagar Block; 2 = Rajnagar, Namkhana Block; 3 = Gayadham, Patharpratima Block; 4 = Kakdwip, Kakdwip Block; 5 = Chak Madhusudanpur, Mathurapur I Block; 6 = Nandakumarpur, Mathurapur II Block; 7 = Dhosa Chandaneswar, Joynagar II Block; 8 = Chandipur, Joynagar I Block; 9 = Deulbari, Kultali Block; 10 = Madya Rajapur, Canning I Block; 11 = Narayanpur, Canning II Block; 12 = Ranigar, Basanti Block; 13 = Rangabelia, Gosaba Block; A = water layer depth 600-680 ft; B = water layer depth 800-880 ft; C = water layer depth >1000 ft

The present study mainly reflected the salinity contamination of ground water in Sundarbans. The ground water in Sundarbans are categorised as low SAR-high saline which reflects the salinity contamination for irrigation based on US salinity hazard diagram and water of all localities has been classified as 'Good' quality except Patharpratima and Gosaba which are 'Poor' quality for drinking purpose based on WQI. Based on the molar ratios of Mg/Ca, Na/Cl and Cl/Total alkalinity, it can be inferred that the ground water is under threat from salt water ingression and the intensity of ingression reduces on moving far away from saline sources. Further, it is suggested that the prevention of deterioration of ground water can be done by construction of lock/sluice gate at suitable places along the small rivers/channels to check the intrusion of saline water by tidal effect and also through digging of ponds in Sundarbans for rain water harvesting which would eventually improve ground water quality due to dilution effect.

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