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Research Article

ISSN : 2455-1953

JGSR
Journal of Geosciences Research
Vol. 10, No.1, January, 2025, pp. 7-13

Incidence of Brackishness in Ground Water from Bore Wells Drilled in Deeper Aquifers in Parts of Kozhikode District, Kerala, Southern India

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Abstract

Seasonal salinity along river mouths is generally observed in the coastal tracts of Kerala at places. The problem is felt during summer season with the incursion of sea water along river mouths, which imparts brackishness to the adjoining phreatic aquifer systems along the coastal tracts of Kerala. This process is reversible through seasons; during the rainy season, the aquifer freshens up and by summer it becomes brackish. However, the reports of brackish water in bore wells tapping deeper crystalline formations are quite rare in Kerala. This paper discusses the comparison of hydro chemical characteristics of bore wells tapping fresh water to those of having relatively high TDS. Major hydrochemistry of the water samples was studied and in Hill Piper diagram 88% of the samples fall in the field of Ca^{2+}- HCO_3^- type facies. The ionic abundance can be expressed as Ca^{2+}>Mg^{+}>Na^{2+} for cations and for the anions as HCO_3^->Cl^- > SO_4^{2-} and the EC values range from 82 - 292 µS/cm. The remaining 12 percentage of the samples are found to have relatively high TDS and falls in the field of Na^+- Ca^+- Cl^- type and the brackishness of the bore well water could be partly attributed to the inflow of saline water to the deep fractured aquifer systems through lineaments connected to brackish surface water body/sea. Besides, the phreatic aquifers in the area are copiously fresh and EC values are generally below 500µS/cm. Out of the three wells with brackishness, EC values of two wells were found to above 10000µS/cm (Ramanattukara and Kannore) whereas at Paleri it is 1765 µS/cm. It is revealed that majority (88%) of the ground water samples are highly suitable for agricultural purposes with all types of soil except those of the Ramanattukara, Kannore and at Paleri exploratory bore well samples.

Keywords: Litholog, Hydrogeology, Hydrochemistry, Mixing, Deeper Aquifer, Kozhikode

Introduction

The awareness among the public about the importance of groundwater has increased during recent years. The need for groundwater is being felt in all sectors because of the shortage of surface water resources to mitigate the growing needs of the population. Recently the problems pertaining to decline in water table, contamination of groundwater, seawater intrusions *etc.* are being reported from many places. The change in rainfall pattern in recent years and the increased utilization of ground water has caused concern among the public that water may become a scarce commodity in the future (Central Ground Water Board, CGWB, 2021). As ground water forms an important component of the total water supply (*e.g.* about 90% in rural areas and 30% in urban areas of India), the aquifers are often under stress, resulting in lowering of the water table and drying up wells in many places (Gopinath and Jesiya, 2015). Bloomfield *et al.* (2020) analysed variation of salinity in the deep ground water reservoirs of Great Britain (GB) by using well-depths, TDS data and found that fresh groundwater at depth possesses spatial coherence and is related with relatively deep sedimentary basins. Sreedevi *et al.* (2021) examined the role of climatic water balance under climatological parameters of hydrology and variation in hydrochemistry used to assess the salinity change in the crystalline aquifers of South India. Abul Qasim *et al.* (2022) studied salinization of coastal alluvial plains of Gujarat based on $^{87}Sr/^{86}Sr$ in ground water and negating evaporation as the major salinization process. Marjorie *et al.* (2023) analysed brackishness of crystalline aquifers of semi-arid hinterland of Ceará to give reason on the salinization processes based on hydrgeochemical, isotopic and multi-tracer dating monitoring, where saline water with sodium-chloride hydrochemical facies and found that the area became saltier due to leaching of salts either in surface waters or the unsaturated zone. The similar salinity studies were carried out by several researchers (Fisher and Mullican, 1997, Greene *et al.*, 2016; Liu and Wang, 2018; Krishan *et al.*, 2020; Reddy, 2023). Some studies have revealed that shown that most of the ground water was unsuitable for agricultural purposes due to the higher concentration of sodium (Pophare and Dewalkar, 2007) and revealed that the salt tolerant cropping and groundwater quality management strategies are

(Received : 03 June 2024 ; Revised Form Accepted : 01 December 2024)
https://doi.org/10.56153/g19088-024-0209-63

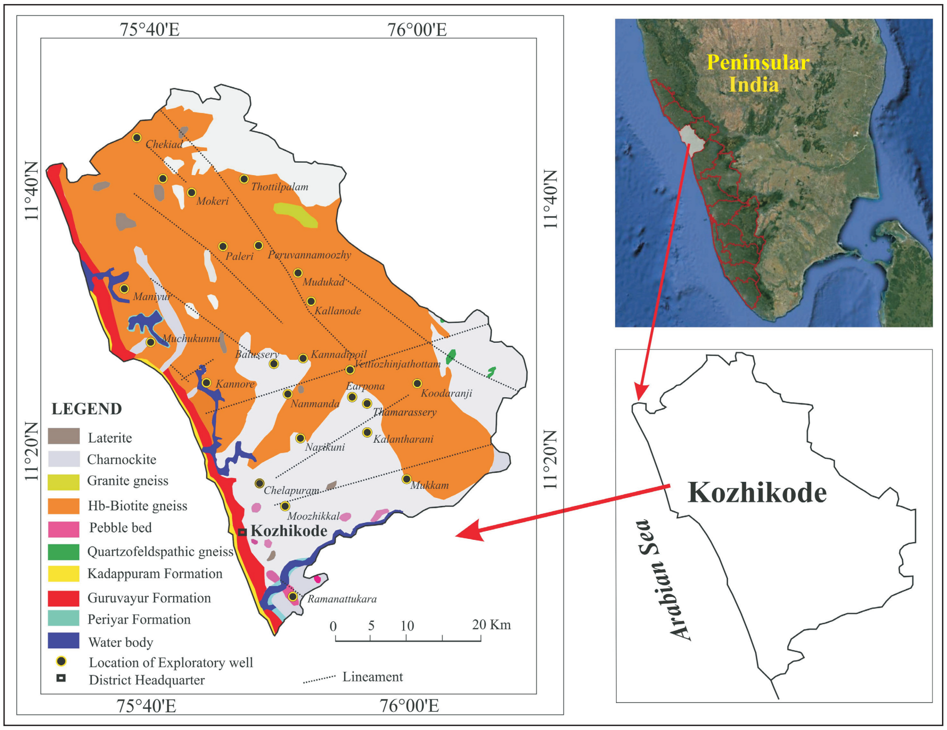

Fig.1. Location and Geology of the study area

required for the sustainability of water (Ingewar *et al.*, 2021). The geospatial techniques may be used as one of the tools to appraise suitability of groundwater for drinking and agricultural uses (Chatterjee *et al.*, 2022).

Phreatic aquifers adjoining tidal river mouths and oceans are often thought of as more prone to salinity; however, drilling activity carried out by CGWB turned the table upside down with the reporting of brackish water in deep fractured aquifers also. The present study discusses the comparison of major ion hydrochemistry of groundwater from bore wells drilled by CGWB in Kozhikode district with special emphasis on the incidence of salinity in deep fractured aquifer systems.

Geological Setting

The district of Kozhikode is one of the coastal districts of Kerala state which lies between latitudes N 11º06' and 11º48' and longitudes E 75º32' and 76 º09' (Fig.1). The district falls in parts of Survey of India toposheets 58 A and 49 M with an aerial extent of 2345 km^2. The district receives annual rainfall of 3236 mm (Anjali and Ashna, 2015). The district is drained by Kuttyadi, Korapuzha, Chaliyar, Mahe, Kallayi and Kadalundi rivers. The total population of the district as per census, 2011 is 30.89 lakhs. The population density of the district *i.e.,* 1318 persons per km^2 is greater than the State average (860 persons per km^2).

The physiographic zones of the district include coastal low land in the west (< 7.6 m), mid land (7.6 to 76 m) and high lands (above 76 m) occupies the hilly-terrain of the Western Ghats. A major part of the district has a cover of Laterites, which is underlain by crystalline rocks of the Archaean age. The regional geological setting of the district is compiled (Table 1).

Methodology

The base map of the area and has been made by using MapInfo 11.5 techniques. The water samples from 24 exploratory borewells (Fig.1) were collected and analysed for major cations and anions. Chemical analyses were carried out at the Regional

Table 1: Regional Geological Setting of the study area (*Modified after* Soman, 1987)

Era	Age	Formation	Lithology
Quaternary	Recent	Alluvium	Coastal alluvium, river alluvium and valley fill deposits
	Sub-Recent	Laterite	Laterite derived from Tertiary and crystalline rock
Intrusive			Metagabbros and Dolerite
Precambrian	Archaean	Granite	Granite and granite gneisses
		Metaultramafite	
		Meta-Pyroxinite Garnetiferrous biotite gneiss +-sillimanite	
		Migmatites	Amphibolite/Hornblende biotite gneiss Biotite granite
		Charnockite/ gneiss	Magnetite quartzites Garnetiferrrous biotite gneiss (+ sillimanite and kyanite) Pyroxene granulite/charnockite

Laboratory of Central Ground Water Board, Kerala region. The collected samples from bore wells were analysed for Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, HCO_3^{-}, CO_3^{2-}, NO_3^{-} and F^{-} apart from determination of pH, EC, total dissolved solids (TDS) and temperature at the field. The georeferences and distance of exploratory water wells from the coastal line and that of chemical analysis data are compiled (Table 2-3). Of all the major ions in 92% (22 out of 24 samples) of the samples are well within the standards specified for drinking water and other purposes (BIS, 2012).

Results and Discussion

On the basis of exploratory, hydrochemical and other related data such as hydrogeology, hydrogeochemistry, and irrigation suitability pertaining to the study area have been discussed in brief.

Hydrogeology

Groundwater has been the principal source of water supply and irrigation in Kozhikode district. Weathered and fractured crystalline rocks, laterite and alluvium are the major hydrogeological formations occurring in the district. The midland terrain of Kozhikode is generally covered by porous laterite forming potential phreatic aquifers along topographic lows and valleys. The yield of dug wells in this formation ranges between 5 and $10m^3$ /day. The riverine and coastal alluvium both are mostly confined along the western part of the district consisting of sand, silt and clay and is developed through dug wells and filter-point wells with yield up to 30 m^3/day. The Tertiary formations occurring in the district are the Vaikom Beds and these occur below the alluvium and have been encountered at shallow depths along the narrow coastal strip of the district (CGWB,1992). The thickness and extent of tertiary beds is very limited with poor groundwater potential. Groundwater occurs under phreatic condition in weathered crystallines, laterites and alluvium and under confined to semi-confined conditions in deeper fractured crystalline formations. The major area of the district is occupied by the crystalline rocks of Charnockite and Hornblende biotite gneiss of migmatite group (Soman, 1987). The charnockites are more prominent in the southern extreme east and northeastern part of the district; whereas the hornblende biotite gneiss is prominent in the central, northern and eastern part of the district. The rocks have undergone a series of brittle deformations at the later stage, resulting in the formation of a number of lineaments and fractures (CGWB, 1992). The prominent lineament directions are NW-SE, NE-SW and E-W. The fractures in crystalline formations are found up to a depth of 200 m and the general depth of potential fractures is between 40 and 90 meter below ground level (mbgl) (CGWB, 2021). The yield of bore wells tapping fractured crystalline aquifers generally ranges between 12 to 540 litre per minute (lpm). In phreatic aquifers the depth to water level generally ranges between 1 to 10 mbgl and in deeper fractured aquifers it ranges from 2 to 13 mbgl (CGWB, 2021). Normally, ground water quality is good (except from Vaikom Formation due to inherent salinity) except for nitrate and iron above permissible limits in isolated pockets (CGWB, 2021). Localized issues of salinity are noticed in phreatic aquifers adjoining river mouths due to tidal effect and proximity to sea. The incidence of brackishness in bore wells are quite rare; however recent drilling activity by CGWB revealed the presence salinity in borewells tapping fractured crystallines. The two wells drilled, one each at Ramanattukara (located near the discharge area of Chaliyar River) in Kozhikode corporation and at Kannore (located near Korapuzha River where tidal effects are noticed) in Balusserry block turned out to be tapping saline groundwater. Two water bearing zones were identified at the depths of 105.5 to 106 m (discharge 0.73 lps) and 117.5 to 117 mbgl (3.63 lps) in Ramanattukara where Charnockite forms the principal aquifer. In, Kannore the potential fracture zones were encountered at 37.5 to 38 m (discharge 0.44 lps) and 50.00 to 50.50 (16.00 lps) m depths and hornblende biotite gneiss is the principal aquifer here. Another instance of relatively high TDS (though within the permissible limit as per BIS drinking water standards, 2012) is also noticed in a bore well water (1129 mg/l) at Paleri. Here, the well location is located along a lineament adjoining Kuttiyadi river. Lithologs along with discharge patterns for both the wells with TDS above permissible limits are given in Fig. 2 and the georeference and distance from the coastal line is compiled (Table 2).

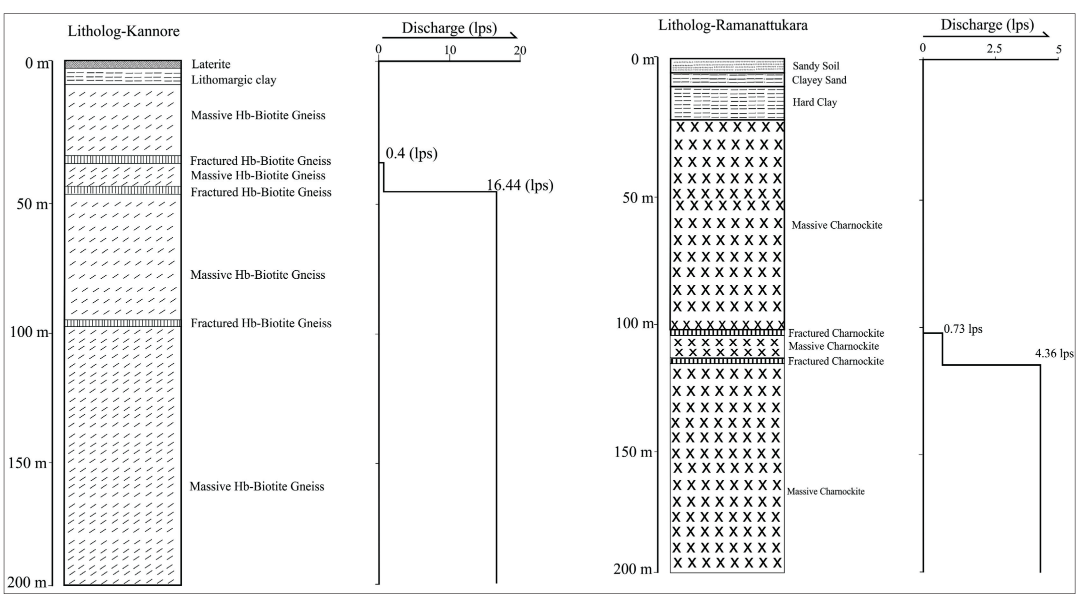

Fig.2. Litholog and discharge pattern of exploratory bore wells

Table 2: Georeference and the distance of Exploratory wells from the coastal line

S. No.	Location	Georeference Lat.	Georeference Long	Shortest Distance from coast, km	Shortest distance from near by water body, km
1	Kannore	11.44657	75.73951	6.10	0.39
2	Ramanattukara	11.17516	75.87731	6.01	0.10
3	Thamarasseri	11.4083	75.9361	24.58	
4	Chelakkad	11.6833	75.6833	14.50	
5	Kannadipoil	11.4639	75.8556	19.65	
6	Nanminda	11.4194	75.8361	14.34	
7	Kalaranthri	11.375	75.9361	21.62	
8	Chelapuram	11.3125	75.8	5.57	
9	Vettiozhinjathottam	11.45	75.9139	24.50	
10	Earpona	11.42077	75.92415	23.76	
11	Kallanode	11.53534	75.880254	29.76	
12	Koodaranji	11.345639	76.036842	31.78	
13	Moozhikkal	11.29819	75.83418	8.39	
14	Mukkam	11.32	75.9969444	26.74	
15	Narikunni	11.36649	75.851077	12.41	
16	Balussery EW	11.45786	75.8186	15.56	
17	Chekiad	11.74677	75.65413	14.29	
18	Maniyur Ew	11.55795	75.64078333	5.19	
19	Mokeri	11.67612	75.72255	18.68	
20	Muchukunnu	11.49305556	75.66638889	5.50	
21	Muthukad	11.58109	75.86171	29.48	
22	Peruvannamoozhi Ew	11.603481	75.812033	25.31	
23	Thottilpalam EW	11.686608	75.787243	26.45	
24	Paleri	11.6008	75.7556	19.37	0.02

Hydrogeochemistry

Hydrochemistry is a powerful tool in ascertaining the evolution of groundwater quality. In situ measurements of Electrical Conductivity (EC) of water samples from different locations in the district could indirectly indicate the level of mineralisation in the aquifer systems. Based on these observations water samples from 24 exploratory borewells (Fig.1; Table 3) were collected and analysed for major ions. In two wells at Ramanattukara and Kannore Parameter like TDS, Sodium, Chloride, Magnesium, Sulphate and Calcium are above permissible limits and is attributed by sea water mixing.

Hydrogeochemical facies of groundwater sample were classified by Piper (1944) using a trilinear diagram. In this diagram, the triangular fields are plotted independently with milliequivalent per litre (meq/L) values of cations (Ca^{2+}, Mg^{2+} and $Na^{+} + K^{+}$), weak acid (HCO_3) and strong acid (SO_4^{2-} and Cl^{-}). For recognizing the chemical character of groundwater in the study area, samples have been plotted in Piper trilinear diagram (Piper, 1944) using Aqua Chem software (Fig. 3). The data plot in the Piper diagram shows only 3 samples (Ramanattukara Paleri and Kannore; Sl. No 1, 2 and 24 in Table 3) fall in the field of Na^{+}- Ca^{2+}- Cl^{-} type and the remaining 22 (88%) bore well samples are in the field of Ca^{+}- HCO_3^{-} type. In the Piper diagram used for the present study, other than bore well samples collected, average values of sea water and also rain water samples collected from Kerala were also contrived for a lucid understanding of ground water quality evolution. The samples at Ramanattukara and Kannore where brackishness is noticed are found to fall nearby with proximity to the sea water in the Hill-Piper diagram. From the Piper diagram, it may be inferred that the brackish water in the two borewell samples at Ramanattukara and Kannore (where relatively high electrical conductivity is noticed) may be assumed to be attributed through sea water intrusion along fractures. The proximity of these two locations near to river mouths is also firms up the assumption (Singh and Ganesh, 1996; Rao and George, 1960).

To confirm the assumption and also to ascertain the extent of salinization in the groundwater, the samples were classified using the molar Cl^{-}/HCO_3^{-} ratios (Revelle, 1941). The Cl^{-}/HCO_3^{-} ratios

Table 3: Hydrochemistry of bore well samples, rainwater and sea water used for the current study

S. No.	Sample	EC# (TDS/ 0.64)	TDS	pH	Ca	Mg	Na	K	Cl	CO_3	HCO_3	SO_4	NO_3	Mol. Cl^{-}/ HCO_3
1	Kannore	13400	8576	6.9	874.9	256	1589	30.2	5282	0	102	581	0.8	88.98
2	Ramanattukara	10300	6592	7	708	322	1002	28	3988	0	133.4	314	0.8	51.37
3	Thamarasseri	269	172.16	7.97	25	14	9	2.4	9.9	0	134	0	12	0.13
4	Chelakkad	253	161.92	8.22	21	13	9.6	3.4	7.1	0	124	12	0	0.10
5	Kannadipoil	127	81.28	7.84	12	3.9	6.8	1.6	7.1	0	63	0	0.7	0.19
6	Nanminda	204	130.56	6.96	23	5.8	9	2.6	8.5	0	103	15	0	0.14
7	Kalaranthri	286	183.04	7.79	25	9.7	6.2	2.2	7.1	0	129	5	0	0.09
8	Chelapuram	82	52.48	7.31	5.6	2.9	3.2	1.1	9.9	0	29	0	0	0.59
9	Vettiozhinjathottam	207	132.48	7.48	31	4.9	6.8	1.9	5.7	0	134	0	0	0.07
10	Earpona	400	256	8.16	74	26.6	18	4	27.5	0	203	55	0.52	0.23
11	Kallanode	220	140.8	7.03	55	7.19	18.3	3.46	7.88	0	133	46	1.4	0.10
12	Koodaranji	290	185.6	7.1	35.1	17.1	36.6	6.3	49.1	0	127	29.5	0.32	0.66
13	Moozhikkal	270	172.8	7.71	48.5	16.9	17.2	8.67	5.33	0	165.1	39	0.72	0.06
14	Mukkam	500	320	7.3	50.8	29.2	35.03	6	65.7	0	196.9	21	1.9	0.57
15	Narikkuni	290	185.6	7.25	54.8	15.8	14.52	5.95	6.31	0	159	40.3	1.45	0.07
16	Balussery	210	134.4	8.32	32	16	13.6	2.8	4.5	0	107.6	3.4	0.23	0.07
17	Chekiad	300	192	8.35	30	11.7	21.98	5.84	12.4	21.3	135.4	42.7	0	0.16
18	Maniyur	240	153.6	8.36	29.9	23.87	10.5	5.51	5.6	5	128	4	0	0.08
19	Mokeri	330	211.2	8.12	132	19	15.6	3.9	5.7	0	190.6	3.3	1.4	0.05
20	Muchukunnu	580	371.2	7.99	20	36	27.4	7.1	93.7	3	137.2	8.06	0	1.17
21	Mudukkad	270	172.8	8.54	119	15	20	4.5	4.2	0	165.2	2.1	0.3	0.04
22	Peruvannamoozhi	96	61.44	7.88	8.9	7.5	13.9	5.9	10.2	0	61.5	17.8	3.4	0.28
23	Thottilpalam	102	65.28	8.32	73	8.6	7.6	3	3.8	0	41.3	4.8	0	0.16
24	Paleri	1764	1128.96	8.17	10	12	312	16	440	0	185	185	0.4	4.09
25	Sea Water	53906	34500	8.1	410	1350	10500	390	19000	0	142	2700	0	229.91
26	Rainwater	76	48.64	6.8	11.1	2.6	3	0.8	3	0	33.9	2.3	2.5	0.15

#EC in micro mhos/cm at 25°C and all other values except pH in mg/L

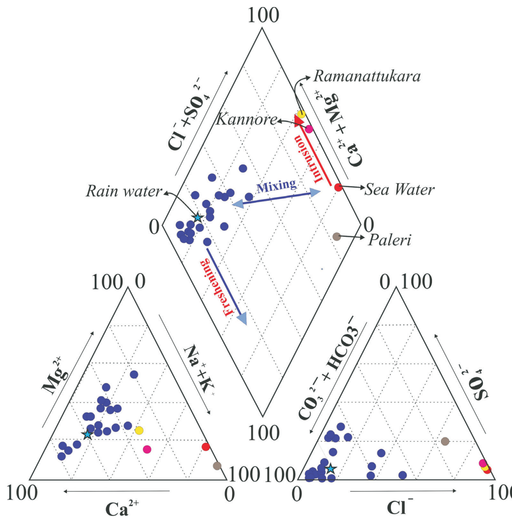

Fig.3. Hill Piper diagram illustrating hydrochemical chracteristics of groundwater

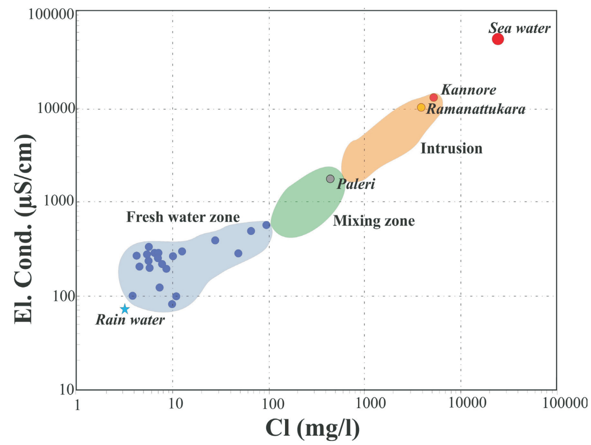

Fig.5. Plot of Chloride *vs.* EC showing normal groundwater conditions, salt water intrusion, and mixing between the two

computed for the bore well samples of the study area are given in Table 3. About 83 % of the groundwater samples in the study area had less than 0.5 Cl^-/HCO_3^- ratios are not affected by salinization. Three samples at Ramanattukara (29.90 as Cl^-/HCO_3^- ratio), Paleri (2.38) and Kannore (51.78) where the ratios are quite high is indicative of sea water intrusion. However, the values of Cl^-/HCO_3^- above 0.5 in some stations do not indicate the seawater intrusion (*e.g.,* Muchukunnu: 0.68 as ratio; Table 3). It may be due to some other localised issues such as anthropogenic pollution, source from uncontrolled agricultural practices *etc*.

Another method to assess sea water intrusion is the Simpson Ratio, first described by Todd and Mays (2011), is the ratio of $Cl^-/(HCO_3^- + CO_3^-)$. Five classes were created to evaluate the level of contamination; good quality (<0.5), slightly contaminated (0.5-1.3), moderately contaminated (1.3-2.8), injuriously contaminated (2.8- 6.6), and highly contaminated (6.6-15.5) (Todd and Mays, 2011). The bivariate plot between molar ratio of Cl^-/HCO_3^- to Cl^- (mg/l) in groundwater evidently indicates the possibility of sea water intrusion (Fig. 4).

An alternative graphical approach is to plot Chloride vs. electrical conductivity (EC) (Washington State Department of Ecology, 2005). Fig. 5 shows three zones on a plot of Cl vs. EC: normal, mixed and sea water intrusion. Fig. 3 shows that groundwater samples with Cl exceeding 200 mg/L and EC exceeding ~1000 s/cm are most likely influenced by sea water intrusion. Groundwater samples that are characterized by Cl between 100-200 mg/L and EC between 600- 2000 s/cm represent a mixing between freshwater and saltwater. The plot of Chloride *vs.* EC (Fig. 5) evident that the sea water intrusion is there in bore wells at Kannore and Ramanattukara, whereas the well at Paleri falls in the mixing zone. About 21 wells out of 24 wells studied (87.5%) fall within the fresh water zone (Fig. 5).

To understand the extent of sea water mixing the molar Na/Cl ratio values of the water samples from the borewells in the study area is plotted against the chloride concentration (Fig. 5). The theoretical trends for mixing, freshening and intrusion are shown in the inset diagram (CGWB,1992). The size of loops of Na/Cl ratios depends on the ion exchange capacity of the aquifer material. It is seen that the ratio for most of the water samples is higher than in sea water freshwater mixture and that these fall in the field of freshening. However, the two bore well at Ramanattukara and Kannore with high chloride concentration and low Na/Cl mol ratio are found to fall near the field of sea water intrusion (Fig. 6).

Irrigation Suitability

To understand the irrigation suitability of the ground water samples, Wilcox diagram (Wilcox, 1955) is a useful representation

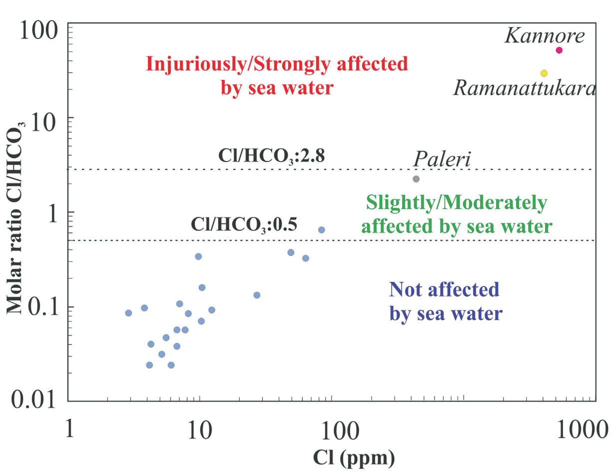

Fig.4. Relationship of mole ratio of Cl^-/HCO_3^- to Cl^- (mg/l) in bore well water

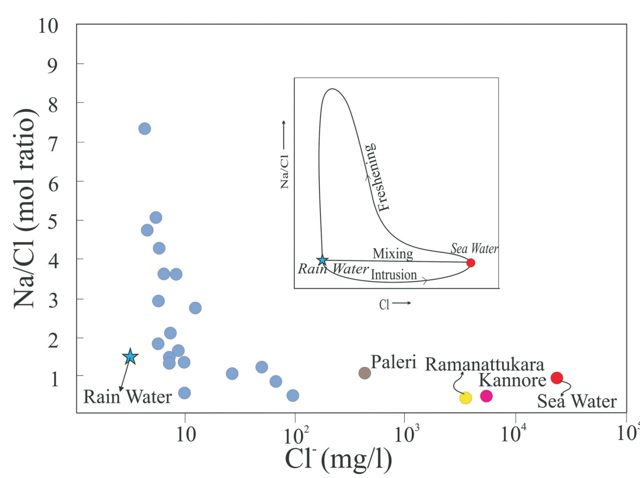

Fig.6. Cl *vs.* Na/Cl mol ratio indicating sea water intrusion

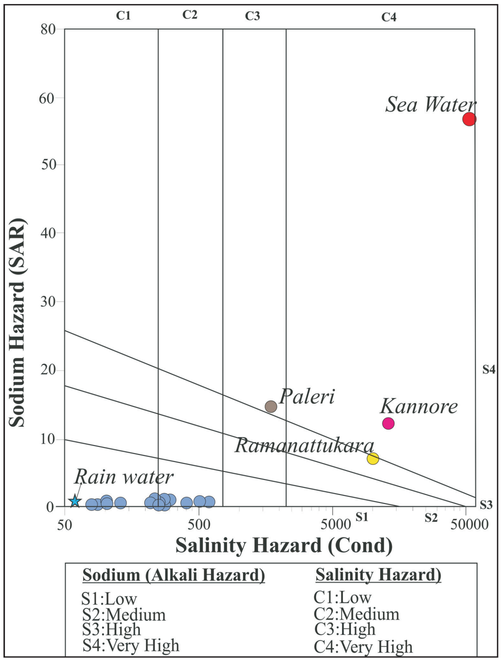

Fig.7. Wilcox diagram depicting salinity and sodium hazard assessment of groundwater

of the sodium hazard and salinity hazard. Based on the plot (Fig. 7), 21 out of 24 bore well samples analysed fall in the fields of C1S1 and C2S1 category and are fit for irrigation purposes. The other 3 samples from bore wells at Ramanattukara, Kannore and Paleri fall in C4S3, C4S4 and C3S4 fields, respectively and indicates their poor source to be used for the irrigation purposes. Relatively high salinity hazard and sodium hazard is noticed at these three sampling stations. The salinity may be attributed to the intrusion of saline water through fractures into the nearby brackish surface water bodies.

Conceptual Model on Prevailing Hydrogeological Scenario

Considering all the hydrogeochemical analysis and interpretation, the prevailing hydrogeological conceptual model is prepared (Fig.8) and inferred that the high TDS of the two bore well samples may be attributed to the inflow of saline water to the deep fractured aquifer systems through lineaments extending to river systems discharging into the sea, where tidal effects are copious.

Conclusions

The study has attempted to illustrate the incidence of saline water intrusion in the deeper fractured aquifer system in Kozhikode district of Kerala. Out of 24 samples analysed, 22 had TDS limits in the prescribed drinking water standards of BIS. About 88% of the samples fall in the field of Ca^{2+}- HCO_3^- type facies in Hill Piper diagram. In bore wells with fresh water, the ionic abundance can be expressed as Ca^{2+}>Mg^{+}>Na^{2+} for cations and for the anions as HCO_3>$^-$ Cl^-, SO_4^{2-}. Only two samples at Ramanattukara and Kannore are found to have relatively very high TDS values above 6000 mg/l and falls in the field of Na^+- Ca^+- Cl^- type water. The Field EC measurements of phreatic water samples in these two localities revealed that the values are pretty below 500µS/cm, indicating the absence of any sea water interaction there in the shallow aquifer system. Both these wells with high TDS tap fractured formations at similar depths at around 100 m below ground level. The bivariate plot between molar ratio of Cl^-/HCO_3^- to Cl^- (mg/l) in groundwater clearly indicates the possibility of sea water intrusion in fractured aquifer system. Moreover, both these wells are situated near to river courses, where salinity associated with tidal influx already exists. Molar ratios of Cl^-/HCO_3^- in these two wells are relatively high above 2.8 indicating possible saline water intrusion in the area. Besides, bivariate plot between EC and Chloride is also pointing in the same direction. In order to understand the extent of sea water mixing the molar Na/Cl ratio values of the water samples from the borewells in the study area is plotted against the chloride concentration. It has been noticed that the ratio for most of the water samples is high and that these plot in the field of freshening. However, the two bore wells at Ramanattukara and Kannore with high chloride concentration and low Na/Cl molar ratio are found to fall near the field of intrusion which may be suggestive of the fracture connectivity with saline surface water bodies. Also, to understand the irrigation suitability of the ground water samples Wilcox diagram has been plotted and found that 88% of the samples

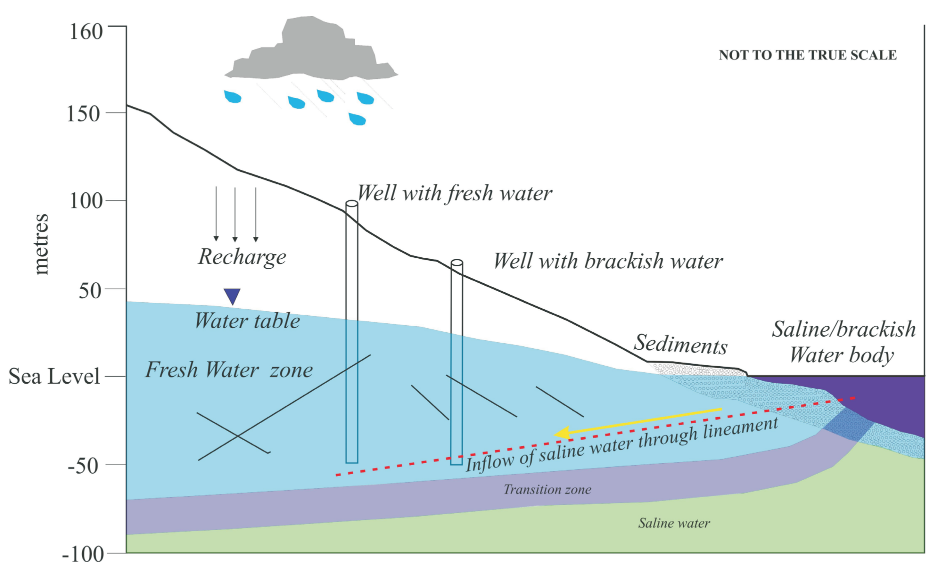

Fig.8. Conceptual diagram illustrating hydrogeological set up

are undoubtfully good for irrigational use whereas for 3 samples at Ramanattukara, Kannore and at Paleri (12% of total samples analysed) the irrigation suitability is not good. The hydrogeochemical analysis indicates that the elevated Total Dissolved Solids (TDS) in the two bore well samples is likely due to the intrusion of saline water into the deep fractured aquifer systems. This intrusion occurs via lineaments that connect to river systems flowing into the sea, where tidal effects are significant. A conceptual diagram has been created to illustrate the current hydrogeological conditions based on these findings.

Authors' Contributions

AK: Conceptualization, Investigation and Writing Original Draft. **JVS**: Data Curation, Visualization, Reviewing and Editing. **VVK**: Formal Analysis, Reviewing and Software. **ASTS**: Visualization and Supervision

Conflict of Interest

The authors do not have any conflict of interest in terms of financial or personal relationship with a third party whose interests could be positively or negatively influenced by the article's content.

Acknowledgements

The authors are thankful to the Chairman, CGWB and Registrar, CUSAT, Kochi, Kerala for providing support and continuous encouragement to carry out this research work and for granting permission for publication of this paper. They thank all the scientific officers of Central Ground Water Board, Kerala Region, Trivandrum, who were involved in the work and are also thankful to Dr. Pankaj P. Bakshe and Dr. Aneesh Kumar N. for analysis of the groundwater samples and for the fruitful discussions during the preparation of the paper.

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