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Impact of Seawater Intrusion on Coastal Aquifers of Karachi, Pakistan

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Abstract: Groundwater is an important resource for domestic and agricultural use. In several countries coastal regions are facing groundwater salinization due to seawater intrusion. The coastal aquifers of Karachi are continuously at risk of salinization. The deeper aquifers in the study area are mainly hosted in Nari (Oligocene) and Gaj (Miocene) formations, while shallow aquifers are situated in Holocene and Pleistocene unconsolidated deposits. In order to evaluate the impact of seawater intrusion on groundwater quality of Karachi region, 25 groundwater samples were collected from different wells (ranging from 12 to 46 m) of Chanesar Gotth, Karachi, Sindh for determining their physical and chemical characteristics. The analytical results of physical (turbidity, pH, TDS, EC, hardness, odor, and chemical (sodium, potassium, magnesium, calcium, chloride, nitrates, bicarbonate, sulfate, zinc, nickle, cobalt, copper and iron) constituents showed that EC and TDS range between1828- 5190 µS/cm, and from 1550 to 4920 mg/L, respectively. The results indicate that groundwater EC and TDS are above the guidelines set by WHO and did not satisfy the requirement for various purposes like domestic and agricultural use. Data revealed that groundwater is dominated by sodium and chloride, and dominant water types in the area are NaCl>$NaHCO_3$>CaCl. Seemingly, low Na/Cl ratio suggests that groundwater is severely affected by seawater intrusion. High Na/Cl ratio in few water samples reflect impact of infiltration of polluted surface water. In addition Gibbs plot showed evolution of groundwater from seawater intrusion to evaporative process. Durov diagram revealed the mixing of fresh water with seawater. Furthermore, sodium absorption ratio (SAR) and Wilcox diagrams showed that water is highly saline and is unsuitable for irrigation purpose. The natural cause of seawater intrusion is sea-level rise, which has significantly impacted the groundwater salinization dynamics in the study area.

Keywords: Seawater intrusion, groundwater salinity, hydro-geochemistry, Karachi.

Introduction

Groundwater is considered a reliable source for domestic, irrigation and industrial purpose around the globe (Ji et al., 2025; Hossain et al., 2025; Islam et al., 2019; Naseem & Rafi 2024; Abbasi et al., 2022; Clarke et al., 1995). One fifth of the water used is obtained from the groundwater resources and in many areas ground water is the only fresh source available (Aladejana et al., 2021). In Asia, 1000 million population use groundwater for domestic, industrial and agricultural purposes (Patil et al., 2001; Peeler et al., 2006; Sarada and Bhushanavathi, 2015; Dahiya & Kaur, 1999). Pakistan is among few developing countries, where 50% population lack access to clean water (Ullah et al., 2014; Mehmood et al., 2013). In the last few decades, the dependence on groundwater has drastically increased. This is particularly true for Pakistan which is 5th most vulnerable country to climate change, and has been viewed as water stressed, and is likely to be water scarce in near future (Sehar et al., 2011).

Seawater intrusion in coastal aquifers is a serious threat to sustainability of safe groundwater resources (Aladejana, et al., 2021; Bahir, et al., 2020; Idowu et al., 2022). In coastal regions of Pakistan, aquifers are at the risk due to sea-level rise, climate change, over-abstraction, anthropogenic input and seawater intrusion. The rapid growth of population, industrialization, seawater intrusion, urbanization and unabated disposal of industrial and domestic waste has badly affected the groundwater quality in Karachi. Several studies done in Karachi revealed (Abbasi et al., 2022; Rafi et al., 2019) that groundwater quality in Karachi has been badly deteriorated due to natural and anthropogenic agents. Continuous movements of seawater alters the geochemistry of groundwater through the process of complex ion-exchange, and make the water unsuitable for human use (Ji et al., 2025, Bahir et al., 2020). This causes the irreversible impact on aquifer environment as well as coastal ecosystem. Geochemical tools are highly useful for the characterization of aquifers, and help to identify the extent of sea-water intrusion, and mixing of sea-water and freshwater. Previous studies were limited to groundwater quality assessment, and impact of seawater intrusion was not taken into consideration (Abbasi et al., 2022, Rafi et al., 2019). Considering the above aspects of groundwater pollution, present study was undertaken to investigate the source and extent of seawater intrusion, and level of pollutants in the coastal aquifers of Karachi, Sindh. An attempt has been made to assess the geochemical parameters to investigate the groundwater evolution pathways to assess the extent of seawater intrusion in the study area. The findings of this study will provide a baseline data for the assessment and management of seawater intrusion and groundwater salinization process.

Materials and Methods

Study Area

Chanesar Goth locality of Karachi, was selected to investigate the impact of seawater intrusion (Fig.1). It is one of the populated places in Karachi, and 0.6 million population of the region use municipality provided pipeline water for domestic purpose. The estimated terrain elevation above sea level of the area is ~ 15 meters. Chanesar Goth, lies at latitude and longitude of 24.8500° N and 67.0614°E, respectively, and surrounded by Malir River on western side and south-western side is occupied by Arabian Sea. Annual temperature of Karachi varies between ~6°C to ~42°C. The maximum temperature of 40°C or possibly above is recorded in May and June. Throughout the year, Karachi witnesses limited rain with average precipitation rate of 250 mm per year (Salma et al., 2012).

In the study and surrounding areas, aquifers are shallow and are hosted in Holocene and Pleistocene sediments, while deeper aquifers lie in Nari Formation of Oligocene and Gaj Formation of Miocene age, and provide significant quantity of groundwater (Table 1). Nari Formation is mainly exposed in Manghopir area, while in subsurface it is found between 350-400 m depths (Kazmi and Jan, 1997). In Karachi-2 well, its thickness is measured around 1798 m. Nari Formation is divided into Tobo, Hub, Pir Mangho and Orangi members. The formation consists dominantly of sandstones and shales with subordinate limestone and conglomerate (Blandford, 1876). The limestone and the conglomerate are found mainly in the basal strata of the Nari succession. The upper part of the Nari Formation is mostly brown, fine to coarse-grained sandstone inter bedded with shale. The lower part consists of inter bedded grey to brown fossiliferous sandy limestone, calcareous sandstone and shale. The Gaj Formation (early Miocene) is composed of gypsiferous shales with subordinate sandstone and limestone. Its lower contact with Nari Formation is transitional and conformable (Iqbal and Shah, 1980). Gaj/Nari contact is exposed in the north of Karachi. Gaj is divided into four members namely Mundro, Mole and Gulistan-e-Johar members. The fractured limestone of Gaj Formation is a significant source of groundwater in the region. Gaj Formation aquifer in Karachi typically lies at a depth of 50 m (164 feet). The thickness of Gaj Formation in Karachi is between 65-650 m. The aquifers are primarily composed of fractured limestone and subordinate shale, and act as aquitard. Shallow aquifers in the study area lie in Recent and sub Recent deposits, which are mainly comprised of rock fragments and conglomerates. They are unconsolidated and embedded in sand and silt matrix from the older river terraces and from the rocks of Tertiary period. The geomorphology of Karachi region is varied in nature and origin, and landscape features show structural and lithological control. Most of the landform is irregular in shape and covered mostly by aeolian sandy/silty material. The sub-aerial erosion and the process of differential erosion played a dominant role in shaping the landforms on the soft, friable alternatively placed folded beds of hard and soft nature.

Malir and Liayri are the main rivers in the study area. Malir River, passes through the entire eastern area of the city, while Lyari River, flows through the densely populated northern side of Karachi. The area is drained by Lyari and Malir rivers having independent catchment areas (Fig. 2). The drainage in the study area is a combination of dendritic and parallel patterns, and mostly streams are bifurcated into second order (Fig. 2). The tributaries have dendritic drainage pattern in hilly area and parallel drainage pattern in plain area. The piedmont and sub-piedmont area extending up to coastline exhibits a typical parallel drainage pattern. All rivers in the western half of this region drain directly into the Arabian Sea. The Lyari River flows towards southwest and drains into the sea. Malir River and its distributaries have been recharged on the coastal areas.

Sampling and Analysis

Twenty five groundwater samples were collected from Chanesar Goth Karachi, which included 22 samples from bore wells, while three were collected from hand pump wells (Table 2 a, b). These groundwater samples were collected at various depths ranging from 12 to 46m. Water from these sources is mostly used for domestic purpose. All twenty five samples were taken in polystyrene bottles of 500 ml capacity. The color, odor and taste were examined using sensory method at the time of sampling. Longitude and latitude of each sampling location were marked on the map using Global Positioning System (GPS). Additionally, depths for all wells were asked and noted by interviewing owners of the wells. Electrical Conductivity and TDS were measured using Eutech CON 11, conductivity meter, which was calibrated using 0.01 M standard solution of potassium chloride. Samples were stirred and reading was allowed to be stabilized before determining electrical conductivity. Temperature, pH and turbidity were examined at the time of samples collection.

All water samples were transported same day for analyses at Geoscience lab, Department of Geology, University of Karachi for their physico-chemical analyses and trace elemental constituents. All samples were examined for groundwater quality parameters including hardness, bicarbonate, nitrate, calcium, sodium, potassium, magnesium, zinc, copper, nickel, cobalt and iron. For the determination of hardness, 10 ml sample was taken into the beaker and 1ml of buffer solution was added, while 2 drops of Eriochrome BlackT were used as an indicator. Titration was done with EDTA. Hardness was calculated using following formula.

Hardness = Volume of EDTA*Normality of EDA (0.01)*100*1000/volume of sample.

For the determination of sodium and potassium, flame photometer was used. The instrument was calibrated using standard solution (Scharlau®) ranging between 20 and 100 ppm. Concentrations of Ca and Mg were determined using (EDTA) titration method (APHA 2005). Nitrate and sulfate concentrations were determined using spectrophotometer (Model U-1100, Hitachi). Calibration was done using standard solutions ranging between 2 and 10 ppm. Before running standard solution, a blank sample of distilled water was also used to calibrate the instrument. In order to analyze the concentration of HCO_3 in water, titration was done against standard sulphuric acid, while methyl orange was used as an indicator. Furthermore, Iron, Mn, Ni, Zn, Cu, Cr and Co concentrations were determined on Atomic Absorption Spectrophotometer. Before analyses standard solutions were prepared for the calibration. Chloride titration (silver nitrate) standard method was used for the analysis of chloride, while potassium chromate was used as an indicator.

Results and Discussion

All the samples were odorless except D19, it has oily smell as well as all water samples were colorless, except D19 and D8 which show yellowish color. About 70% of the samples were slightly saline to highly saline in taste (Table 2a). Turbidity was examined at the time of sampling. Low turbidity was observed in all 23 samples except in D8 and D19. These two samples show yellowish color thus, indicating high turbidity that is due to colloidal and extremely fine particulate material. Maximum value of pH was 7.83 for D18 and minimum was 6.88 (D5). Electrical conductivity ranges from 1828 µS/cm to 5190 µS/cm with mean value of 2899 µS/cm, while TDS values range from 1550 mg/L to 4920 mg/L with average value of 2602 mg/L. High values of TDS show the impact of recent seawater intrusion as well as anthropogenic input. Hardness shows minimum and maximum values of 650 mg/L and 4500 mg/L, respectively, while average value of hardness is1616 mg/L. Water is classified as soft, if its hardness is less than 75 mg/l, while >300 mg/l is classified as very hard water. On the basis of the classification (Yadav et al., 2012), all water samples are classified as very hard water (Table 2a). Domestic use of hard water can create the scaling and lime deposits on plumbing system as well as skin irritations. Determination of Ca shows that the minimum value of Ca is 60 mg/L at sample location D10, while maximum value is 560 mg/L at sample location D19. The average concentration was found 222 mg/L (Table 2b). Around 50% of the samples have concentration greater than the established limits (75mg/L) and (200mg/L) of Pakistan Council of Research in Water Resources PCRWR and WHO (2011), respectively. Potassium content in the water samples ranging from 11 mg/L to 120 mg/L was recorded at sample locations K2 and K4, respectively, and its mean value is 50.7 mg/L which is found above the prescribed limit 12 mg/L and 10 mg/L standard by PCRWR and WHO. Magnesium content in the investigated groundwater samples ranges from 15 mg/L to 58 mg/L at sample locations D9 and D19, respectively with an average value of 35.5 mg/L. Magnesium concentration found higher than the prescribed limit (150mg/L) of PCRWR and (50mg/L) of WHO. High values of Mg indicate that the study area is polluted with sewage and waste material (Yadav et al., 2012; Shyamala et al., 2008).

Sodium concentration in the study area ranging from 174 mg/L to 962 mg/L was recorded at sample locations D4 and D2, respectively and its mean value is 465 mg/L (Table 2b). The average concentration of Cl was 504 mg/L. Chloride concentration in 16 groundwater samples is greater than the standard limits (250 mg/L) prescribed by PCRWR. Sulfate shows the minimum and maximum values of 65 mg/L and 1220 mg/L recorded at sample location D10 and D8, respectively, and its mean value is 430 mg/L. Only 6 samples out of 25 have higher concentrations of sulfate as compared to standard limits of PCRWR (250mg/L) and WHO (500 mg/L). Bicarbonate content has shown minimum value of 350 mg/L (D18) and maximum 1500mg/L(D1)) with an average value of 787 mg/L, which is higher than the permissible value (250 mg/L) of WHO.

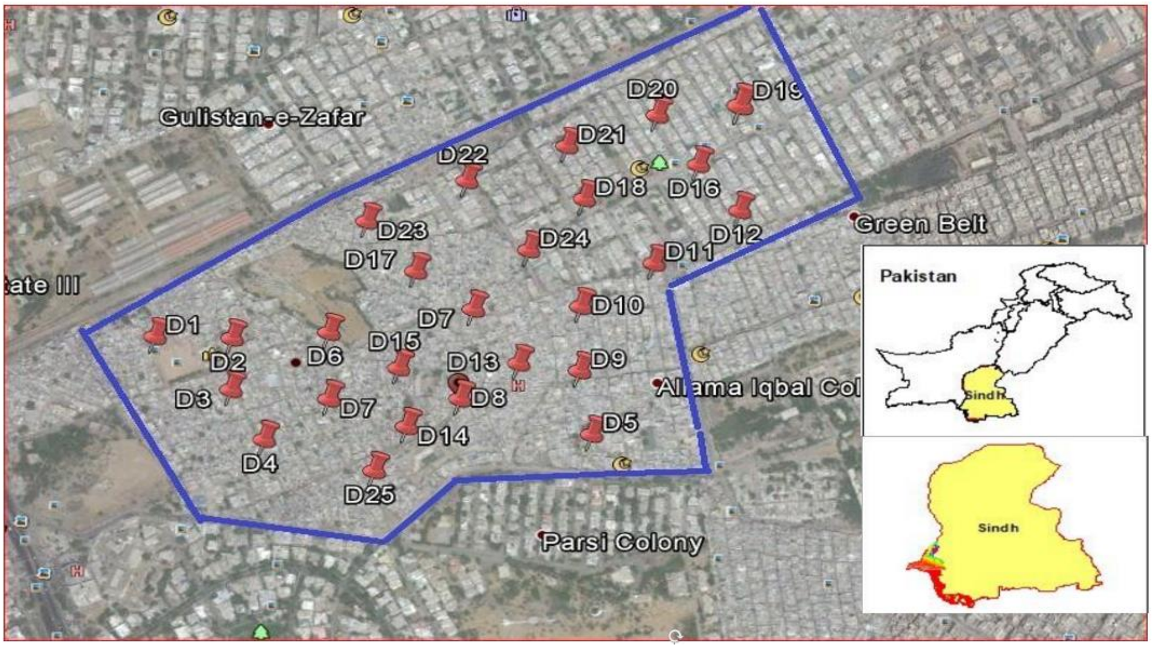

Fig. 1 Location map of the study area showing the water sampling sites.

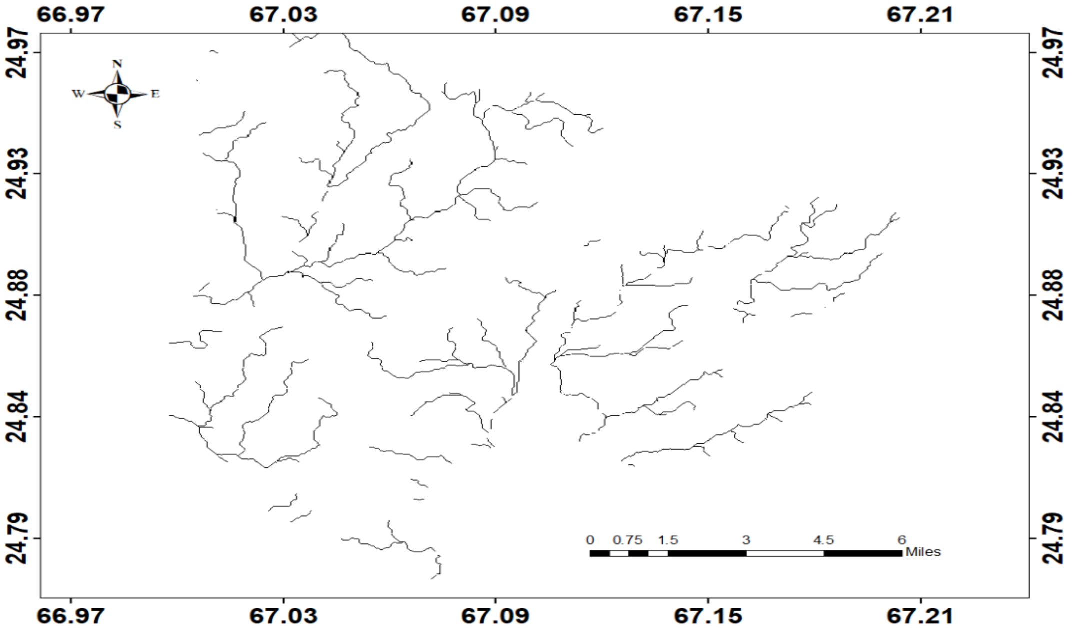

Fig. 2 Drainage map of the study area.

Table 1. Stratigraphy of Karachi (modified after Kazmi and Jan, 1997).

Geological Age		**Formation**	**Lithology**
Quaternary	Recent to sub-Recent	Quaternary deposits	Stream bed, terrace deposits and mangrove swamp deposits comprising rock fragments, conglomerates and aeolian sand deposits
Tertiary	Pliocene	Manchar	soft, friable, coarse grained sandstones, shales and clays with subordinated conglomerates
	Miocene	Gaj	Soft, loose, friable sandstone with limestone and minor conglomerate.
	Oligocene	Nari	Mainly consists of sandstone, mudstone and fossiliferous limestone.

Table 2a. Physical characteristics of groundwater in Chanesar Goth Karachi, Sindh.

Sample ID	Well type	Depth meter	Colour	Turbidity	Odour	Taste	Temp °C	pH	TDS mg/l	EC µS/cm	Hardness mg/l
D1	Hand Pump	12	Colourless	Clear	Odourless	Saline	24	7.58	2850	2501	900
D2	Hand Pump	29	Colourless	Clear	Odourless	Saline	22	6.9	3024	2996	1300
D3	Electric well	40	Colourless	Clear	Odourless	saline	23	7.45	2890	2860	1300
D4	Electric well	46	Colourless	Clear	Odourless	Saline	22	7.4	2340	2566	1100
D5	Electric well	40	Colourless	Clear	Odourless	Fresh	26	7.83	2254	2405	1000
D6	Electric well	46	Colourless	Clear	Odourless	Saline	23	7.56	2071	2490	2600
D7	Electric well	14	Colourless	Clear	Odourless	Saline	22	7.29	3040	3402	1400
D8	Electric well	40	Yellowish	Turbid	Odourless	Saline	21	7.28	1970	2254	1100
D9	Electric well	43	Colourless	Clear	Odourless	Fresh	19	7.47	1860	1862	650
D10	Electric well	38	Colourless	Clear	Odourless	Saline	24	7.67	2010	2130	1650
D11	Electric well	18	Colourless	Clear	Odourless	Saline	25	7.05	2343	2941	900
D12	Electric well	21	Colourless	Clear	Odourless	Saline	22	7.61	2042	2804	1300
D13	Electric well	15	Colourless	Clear	Odourless	Saline	25	7.69	1550	1828	1300
D14	Electric well	24	Colourless	Clear	Odourless	Saline	23	7.57	1962	2325	1000
D15	Electric well	37	Colourless	Clear	Odourless	Saline	22	6.97	2200	2610	2200
D16	Electric well	27	Colourless	Clear	Odourless	Saline	25	7.03	2062	2490	1800
D17	Electric well	20	Colourless	Clear	Odourless	Saline	18	6.98	2250	2628	1500
D18	Electric wel	40	Colourless	Clear	Odourless	Saline	21	6.88	2790	2740	1600
D19	Hand Pump	50	Yellowish	Turbid	Oily	Saline	24	7.38	2716	3548	4500
D20	Boring Well	34	Colorless	Clear	Odorless	Saline	27	7.21	3996	4233	2000
D21	Boring Well	23	Colorless	Clear	Odorless	Saline	19	7.29	4920	5190	2500
D22	Boring Well	37	Colorless	Clear	Odorless	Fresh	23	7.02	3082	3642	800
D23	Boring Well	30	Colorless	Clear	Odorless	Saline	21	7.45	2254	2941	1800
D24	Boring Well	24	Colorless	Clear	Odorless	Saline	24	6.99	2510	2863	1100
D25	Boring Well	15	Colorless	Clear	Odorless	Saline	25	7.1	2800	3030	1200

Table 2b. Chemical and trace metal analysis of water samples (n= 25) collected from the study area.

Sample ID	**Ca** (Mg/L)	**Mg** (Mg/L)	**Na** (Mg/L)	**K** (Mg/L)	**HCO_3** (Mg/L)	**SO_4** (Mg/L)	**Cl** (Mg/L)	**NO_3** (Mg/L)	**Hydrofacies**	**SAR**	**Fe** (Mg/L)	**Mn** (Mg/L)	**Ni** (µg/L)	**Cr** (µg/L)	**Zn** (µg/L)	**Na/Cl**
D1	152	50	450	35	1200	410	120	48	$NaHCO_3$	8.09	BDL	BDL	BDL	BDL	0.043	3.8
D2	122	30	650	33	1500	456	172	40	$NaHCO_3$	13.7	BDL	BDL	BDL	BDL	0.042	3.8
D3	152	30	571	28	1200	301	390	10	$NaHCO_3$	11.1	BDL	BDL	BDL	BDL	0.172	1.5
D4	120	26	570	22	650	410	425	13	NaCl	12.3	BDL	BDL	BDL	BDL	0.14	1.3
D5	112	23	489	40	801	455	315	15	$NaHCO_3$	11	BDL	BDL	BDL	BDL	0.22	1.6
D6	119	31	417	40	650	320	448	48	NaCl	8.76	BDL	BDL	BDL	BDL	0.085	0.9
D7	280	31	550	35	800	690	596	50	NaCl	8.32	BDL	BDL	BDL	BDL	0.043	0.9
D8	220	26	278	32	700	390	318	3	$NaHCO_3$	4.72	BDL	BDL	BDL	BDL	0.055	0.9
D9	140	15	296	42	670	146	300	8.66	$NaHCO_3$	6.35	BDL	BDL	BDL	BDL	0.03	1.0
D10	141	39	300	13	772	65	375	9	$NaHCO_3$	5.77	BDL	BDL	BDL	BDL	1.15	0.8
D11	160	21	550	11	722	402	470	5.46	NaCl	10.9	BDL	BDL	BDL	BDL	0.2	1.2
D12	260	30	308	20	550	301	554	16.7	NaCl	4.82	BDL	BDL	BDL	BDL	0.396	0.6
D13	168	30	216	32	450	323	177	48	$NaHCO_3$	4.03	BDL	BDL	BDL	BDL	0.049	1.2
D14	150	23	390	40	590	334	380	50.1	NaCl	7.83	BDL	BDL	BDL	BDL	0.033	1.0
D15	320	51	174	25	700	448	390	49	CaCl	2.38	0.498	BDL	BDL	BDL	0.065	0.4
D16	300	42	192	120	550	429	378	49	CaCl	2.75	BDL	BDL	BDL	BDL	0.047	0.5
D17	310	35	266	76	650	350	480	49	CaCl	3.82	BDL	BDL	BDL	BDL	0.024	0.6
D18	280	37	322	85	1220	504	290	50.2	$NaHCO_3$	4.8	BDL	BDL	BDL	BDL	0.024	1.1
D19	560	50	194	88	450	350	972	50.2	CaCl	2.11	BDL	0.173	BDL	BDL	0.043	0.2
D20	240	47	924	89	1250	480	890	50.84	NaCl	14.3	BDL	BDL	BDL	BDL	0.029	1.0
D21	392	58	962	91	1150	1220	990	46.46	NaCl	12	0.146	BDL	BDL	BDL	0.038	1.0
D22	260	35	650	45	650	550	836	51	NaCl	10	BDL	BDL	BDL	BDL	0.029	0.8
D23	200	42	487	46	350	470	650	7.5	NaCl	8.17	BDL	BDL	BDL	BDL	0.058	0.7
D24	160	56	384	118	650	320	667	50.3	NaCl	6.66	BDL	BDL	BDL	BDL	0.04	0.6
D25	60	28	822	32	550	208	920	44	NaCl	22	BDL	BDL	BDL	BDL	0.028	0.9

Nitrate concentration in groundwater samples ranging from 3 mg/L to 51 mg/L was recorded at sample locations D8 and D20, respectively, and average concentration of nitrate was 34 mg/L. Six samples out of 25 have nitrate concentrations more than WHO (50mg/L) standard (Table 2b). Rest of samples showed the low concentration of nitrate as established by WHO. The Fe content was detected only in one sample as 0.498 mg/l, which is more than WHO recommended level of 0.3mg/l. In all remaining samples, the Fe was reported below detection limit. Similarly, Mn concentration found in only one sample is 0.173 mg/l (Table 2b). The allowable concentration of Mn for drinking-water purpose is 0.5 mg/l. Concentrations below 0.1mg/l are usually acceptable (WHO, 2011).

Zinc concentration ranged from 0.024 to 1.15 µg/l. The concentrations are within the standard limit for Pakistan. The proposed limit for zinc in drinking-water is 5000 µg/l (Pakistan Environmental Protection Agency, 2008) while the standard value by WHO is 3000 µg/l (WHO, 2011). All samples have shown concentration of Ni, Cr, and Co below detection limit (Table 2b). In order to investigate the impact of seawater intrusion in the aquifers of the study area, SAR, Na/Cl ratio, Wilcox, Piper, Durov and Gibbs diagrams were used. The Sodium Absorption Ratio provides a comprehensive insight about Na toxicity. The value of SAR ranges from 2.11 to 22, which suggested significant extent of seawater intrusion in the area, and thus indicates that the groundwater is hazardous for the crops (Table 2b). Wilcox diagram showed that nearly all of the samples fall in poor and bad quality water categories (Fig. 3). The Durov and Piper diagrams were used to interpret the dominant hydrofacies and evolutionary extent of seawater and fresh water mixing. Piper diagram indicates that the dominant hydrofacies in the area are $NaHCO_3$ >NaCl>CaCl, showing that active seawater intrusion has drastically impacted the fresh water in the aquifers of the study area (Table 2b, Fig.4).

Similarly, Durov diagram shows that around 84% water samples have TDS> 2000 mg/L and Na ion is a dominant constituent, which is mainly originated from seawater (Fig. 5). The Durov diagram indicates evolutionary trend of fresh and seawater mixing and with passage of time, freshwater has been replaced with seawater. In addition, Gibbs diagram was also used to confirm the dominant hydro geochemical process in the area. Gibbs diagram is used to classify the predominant hydrogeochemical mechanisms including seawater, rock-water interaction and precipitation/evaporation (Fig. 6).

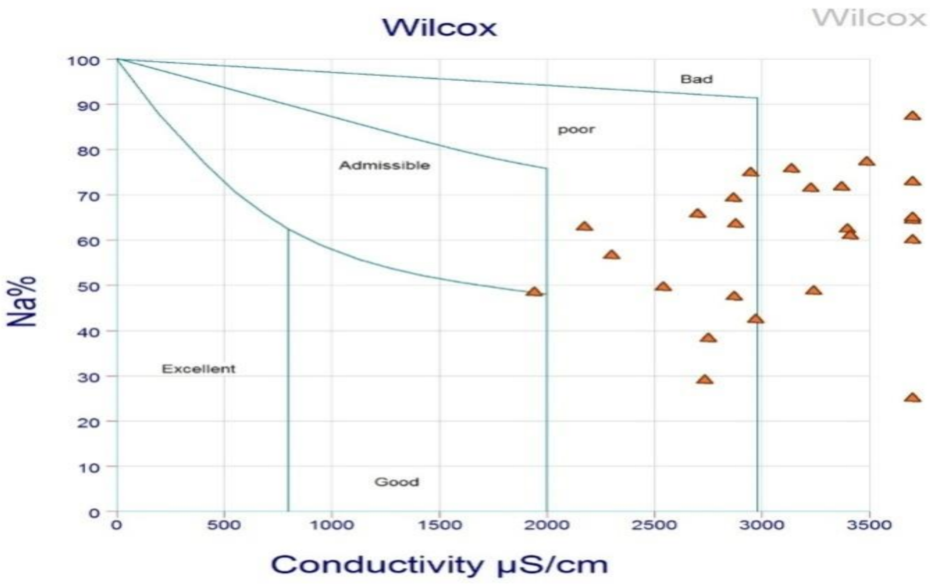

Fig. 3 Wilcoxdiagram showing the classification of groundwater for irrigation use.

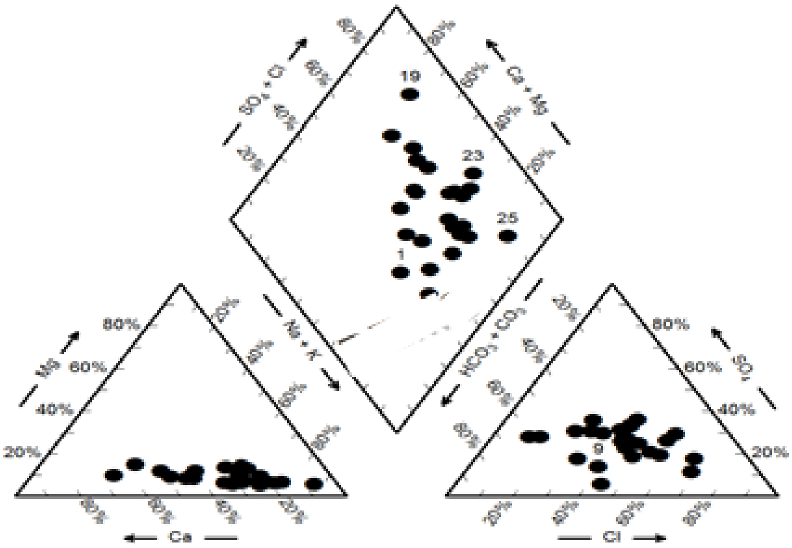

Fig. 4 Piper diagram showing the major hydrofacies in the study area.

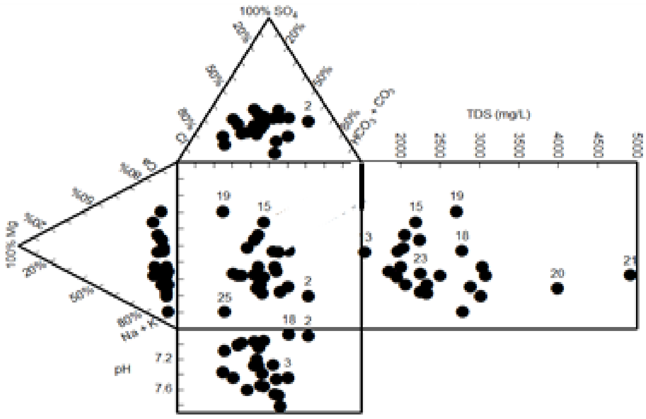

Fig. 5 Durov diagram showing the mixing of fresh water and seawater in the study area.

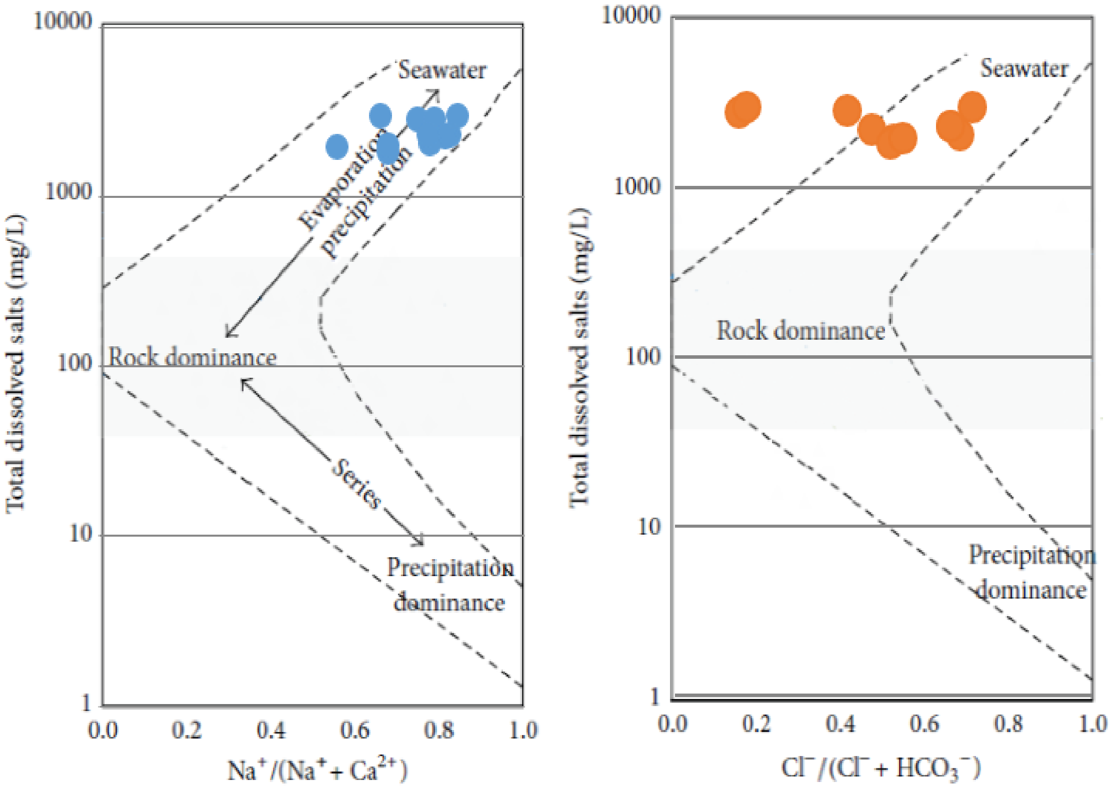

Fig. 6 Gibb's diagram showing the major hydrogeochemical process in the study area.

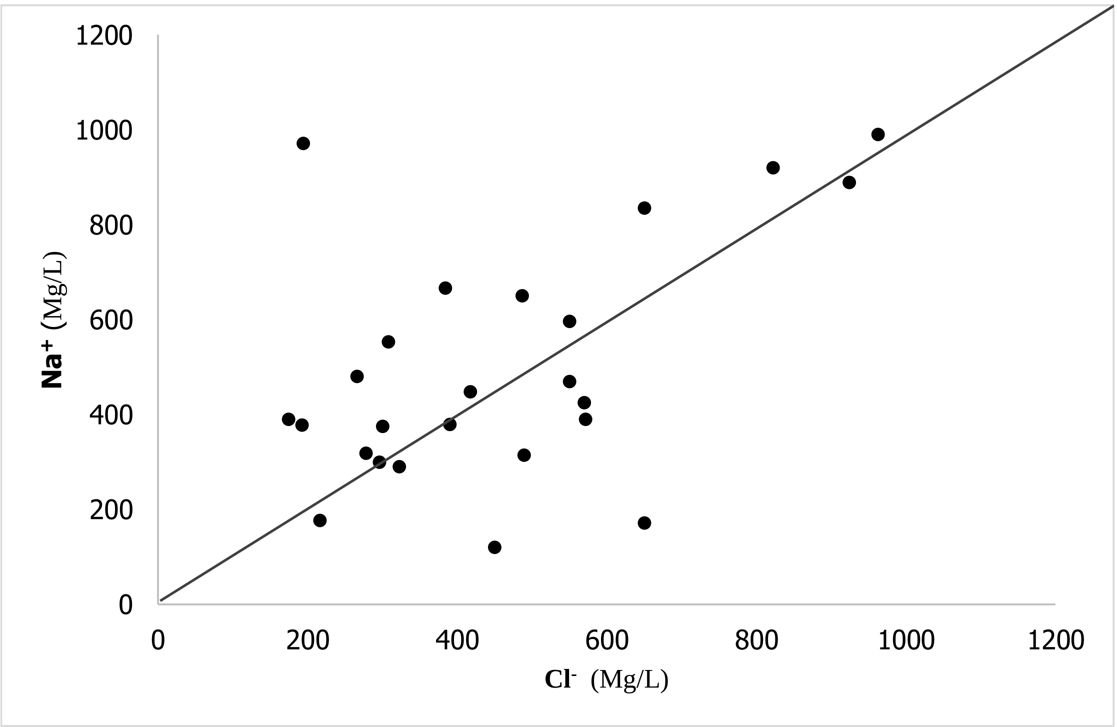

Fig. 7 Relationship between Na and Cl the study area.

The samples mainly fall in the seawater and evaporation/precipitation field, which confirms that wells of study area are severely impacted by seawater intrusion and later evaporation under semi-arid climatic conditions with minimal freshwater recharge from surface. It also shows multiple episodes of seawater intrusion, where evaporation and precipitation have also played a significant role to raise the TDS of the groundwater. Moreover, Cl behaves conservatively in the solution and can be used to interpret the origin of groundwater salinization. Therefore, Na/Cl ratio was used to decipher the source of salinity. The Na/Cl ratio in around half of the samples is <1, and most of the samples plots below the Na/Cl dissolution line, show that seawater intrusion is a dominant source of aquifer salinization (Fig.7). However, Na/Cl >1 indicates the influence of anthropogenic pollution as well. Sewage lines in the study area are broken and leaked at various places, resulting in eruptions of sewage water from gutters which accumulate at low lying areas. As the streets are not paved and cemented properly, the sewage water absorbed by the soil, infiltrates into the ground, and reaches the groundwater table, and contributes to groundwater salinization. In addition neighboring Malir River is a main source of anthropogenic input, where untreated sewage water as well as industrial effluent are directly dumped, which eventually percolate into the aquifers and aggravate the water quality further.

Conclusion

- Analyses of the groundwater samples which were drawn from different wells (ranges 12-46 m) of Chansesar Goth Karachi, Sindh revealed that 15 samples (n=25) showed higher concentration of TDS, EC, and hardness as compared with the standard limits prescribed by WHO and PCRWR.
- Electrical conductivity ranges 1828 µS/cm to 5190 indicates that the coastal aquifers in the area are severely impacted by sea water intrusion as well as anthropogenic input.
- The groundwater of the study area is dominated by NaCl>NaHCO3>CaCl, which shows that the fresh water in the aquifers have been replaced by active seawater intrusion.
- High Na/Cl ratio shows that river bed infiltration from neighboring Malir River is an active mechanism, which led to increase the salinity of the study area groundwater.
- Combined impact of seawater intrusion and polluted surface water recharge has significantly affected the groundwater.
- Monitoring of groundwater is recommended to evaluate and forecast the future seawater intrusion in the study area.

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