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Physiochemical Analysis of River Sutlej, Sindh and the Arabian Sea to Evaluate the Water Quality

Saima Anjum[1], Afroz Hussain Syeda[1], Mussarat Jabeen[1*], Ansa Madeeha Zafar[1], Aqeela Shaheen[1] and Muhammad Arshad[2]

[1]*Department of Chemistry, Government Sadiq College Women University Bahawalpur, Pakistan.*
[2]*Regional Agriculture Research Institute, Bahawalpur, Pakistan.*
**Corresponding Author Email: dr.mussaratjabeen@gmail.com*
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Abstract

Globally, water pollution is caused primarily by growing populations, urbanization, and modern agricultural techniques. In this study, freshwater samples were collected from Sutlej river, Sindh river, and Arabian sea to assess water quality. A variety of physicochemical parameters were measured in these samples, including pH (7.5 to 8.4), color (variable), odor, turbidity (7 NTU to 18 NTU), taste (salty/bitter), total dissolved solids (182 mg/L to 34768 mg/L), total soluble solids (52 mg/L to 1244 mg/L), EC (109 µS/cm to 51488 µS/cm), total hardness/Ca^{+2}+Mg^{+2} (25 mg/L to 125 mg/L), total alkalinity or CO_3^{-2}, HCO_3^- (80 mg/L to 172 mg/L), exchangeable ions like Cl^- (27 mg/L to 19742 mg/L), F^- (0.3 mg/L to 1.29 mg/L), SO_4^{-2} (30 mg/L to 2974 mg/L), PO_4^{-3} (8 mg/L to 35 mg/L), NO_2^{-2} (18 mg/L to 43 mg/L), Mn^{+2} (0.0002 mg/L to 0.63 mg/L), Cu (0.0005 mg/L to 0.08 mg/L), Cd^{+2} (0.0005 mg/L to 0.88 mg/L), Cr^{+3} (0.003 mg/L to 0.32 mg/L), Zn^{+2} (0.001 mg/L to 2.72 mg/L), Fe^{+2} (0.01 mg/L to 0.9 mg/L), Ni^{+2} (0.002 mg/L to 0.23 mg/L), Na^+ (15 mg/L to 10157 mg/L), K^+ (4.4 mg/L to 379 mg/L), Ca^{+2} (20 mg/L to 380 mg/L), Mg^{+2} (5.4 mg/L to 1584 mg/L) tested by standard methods reported in Association of Official Analytical Chemists (AOAC) with little modifications. Most of the parameters studied in these water samples were beyond the National Environment Quality Standard of drinking water guidelines for seawater, but within acceptable limits for rivers. Consequently, these trends made seawater unfit for the survival of aquatic plants and marine life as well as for the people who use river water for domestic and agricultural purposes.

Keywords: Heavy metal content, Exchangeable ions, Total hardness, Physiochemical analysis, National Environment Quality Standard.

Introduction

Water is the most vigorous liquid for sustaining life on the earth. About 97% of water subsists in oceans that cannot be used for drinking [1-3]. With two-thirds of the earth's surface shielded by water and the human body comprising 60% water, it is clear that water is one of the prime elements responsible for life on Earth [4-6].

In the present world, fresh water is considered to be the limiting factor for the establishment of a new large number of urban areas, overpopulation, and climate change under-design system [7, 8]. Unfortunately, in developing countries like Pakistan, the quality of drinking water is adulterated. The water in these countries is proved to be hazardous for the use of humans [9]. Several cities in Asia and South Asia are facing water pollution of organic, inorganic, industrial, pesticides, chemical fertilizers and nutrient materials in the drinking water sources [3, 9-11].

Pakistan is considered an extremely sensitive area concerning global climate change more than any other region [12]. Almost 1200 m^3/capita of water is available which is declining rapidly. Whereas the industrial and domestic waste production in Pakistan is about acre-feet (MAF) per year [13]. Only a little percentage of about 3% of this waste is brought under treatment and the remaining is discharged directly into water bodies [14].

Pakistan's 70% population relies on groundwater resources for their household uses [15, 16]. On average, 50% of the big city centers of Pakistan have clean water supply connections [17]. In Pakistan, an estimated percentage of about 30% of all diseases and 40% of all deaths are mainly caused by poor status water quality [17-23]. Therefore, various studies were carried out to examine and determine the quality of drinking water. For instance, the Pakistan Council of Research in Water Resources (PCRWR), in all provinces of Pakistan, studied the reservoir's water quality and clinch that majority of the water is uncertain for drinking purposes. In major industrial cities of Punjab and Khyber Pakhtun Khaw (KPK) province, high arsenic and iron concentrations are present due to chemical waste discharge in the drinking water [24-26]. In Sindh, a high turbidity level is observed in the water resource [27, 28].

According to a study, 50 million people in Pakistan are at risk of arsenic poisoning from contaminated water with a level of over 200 µg/L, which was much higher than the Government's limit and WHO's recommendation of 50 µg/L and 10 µg/L respectively [29, 30]. Similarly, the limit for heavy metals and anions was also crossed in Pakistan mentioned by WHO [22, 31].

According to the research report published in Science Advances by WHO and National Standards for Drinking Water Quality Pakistan about 1200 samples were collected from across Pakistan that contain a deadly amount of heavy metals which may not only lead to skin disorders, lung cancer and cardiovascular diseases but also cause harmful effects on crops [12, 32]. Keeping in view the above facts, the present study was conducted to explore the analysis of water described by water quality in terms of physio-chemical parameters. The research may be helpful for the analysis and purification of water in Pakistan.

Materials and Methods

Monitoring Site

A total of nine samples were collected from different localities of River Sutlej, Sindh and the Arabian sea.

S. No.	Name of the locality	Geographical location
1	*Head Salman*-S-1 (Khairpur)	Latitude: 29.582578(DMS: 29°34'57.28"N), Longitude: 72.242301(DMS is 72°14'32.28"E)
2	*Head Islam*-S-2 (Bahawalpur)	Latitude: 29°49n'23.06", Longitude: 72°33E'2.24"
3	*Lal Sohana* Tehsil-S-3 (Bahawalpur)	Altitude:29°19′N, Latitude: 71°55′E
4	*Ahmed Pur Sharqi*-S-4 (Bahawalpur)	Latitude: 29°8'28.16"N or 29.141155, Longitude: 71°15'27.8"E or 71.257723
5	*Kotri Barrage*-S-5 (Sindh)	Latitude: 24, 1667 (2410'0.120"N)
6	*Kamari Deep Sea-S-6 (Karachi)*	Latitude; 32.5482 or latitude DMS: 32°32' 54N
7	*Kamari Coast*-S-7 (Karachi)	Longitude: 69.7396 or longitude DMS: 69° 44' 23E
8	*Menorah Deep Sea*-S-8 (Karachi)	Coordinates:24°47′38.6″N 66°58′39.1″E
9	*Menorah Coast*-S-9 (Karachi)	Coordinates:24°47′38.6″N 66°58′39.1″E

The water samples were collected in cleaned glass bottles and brought to the Analytical Chemistry laboratory of the Department of Chemistry, Govt. Sadiq College Women University Bahawalpur; in an icebox jar to avoid unusual changes in water quality. Before the sampling, all the bottles are washed and rinsed thoroughly with distilled water. All the experiments were performed in triplicate and AOAC methods with little modification were adopted [33].

Reagents & Chemicals

The chemicals used in this research were of Analytical grade and highly purified purchased from Sigma Aldrich (USA).

Instrumentation

The pH meter WTW 82362 was used for pH measurement, thermometer BE1500 for temperature measurement, EC1056 electrical conductivity meter for the determination of conductivity and flame photometry for estimating alkali metals were used. AA500-Atomic Absorption Spectrophotometer was used for determination of metals like copper, nickel, zinc etc. Turbidity of samples was measured using Turbidity meter Hach 2100 N.

Taste of Water

The taste of water was examined after rinsing the mouth with a portion of the sample for some seconds on the tongue.

Determination of Total Dissolved Solids (TDS)

To determine total dissolved solids 30 mL water sample was evaporated in the oven and placed in a designator for a few hours. After cooling, the TDS in the water sample was calculated by:

$$TDS\left(\frac{mg}{l}\right) = \frac{(B-A)}{C} \times \frac{1000mg}{g} \times \frac{1000ml}{l} \qquad (1)$$

A= Weight of clean dried china dish (grams)
B= Weight of china dish and residue (grams)
C= Volume of sample (30 mL)

Determination of Alkalinity

Alkalinity in water samples was calculated by acid-base titration as reported by Thomas and Lynch [34].

Bicarbonate determination

In 5 mL of water sample, 2 drops of mixed indicator (bromocresol green + methyl red) were added. The solution was titrated against 0.02 N HCl until the color changed from bluish-green to pink. The concentration of bicarbonate was calculated by the equation below:

$$\text{Bicarbonate concentration} = \frac{\text{Vol. of acid consumed} \times \text{N of acid} \times 5 \times 100}{\text{Vol. of sample used}} \qquad (2)$$

Carbonate determination

5 mL of water sample was pipette out in a conical flask. The color of the solution turned light pink after the addition of 1-2 drops of phenolphthalein indicator. The solution was titrated against a standardized 1 N HCl to give a colorless endpoint. Using the analytical calculations equation 2, carbonate concentration in the water sample was calculated.

Determination of Hardness

The hardness of water was calculated by complexometric titration as reported [35-36]. 5 mL of each of the water samples and 5 mL of deionized water were pipette out in a washed conical flask with 1-2 mL ammonia/ammonium chloride buffer solution and 2 drops of murexide indicator for Ca^{2+} and EBT for Mg^{2+} were added. The solution was titrated against a standardized EDTA solution until the endpoint was reached. The final reading of the burette was noted and using the analytical calculation, calcium hardness was calculated in terms of mg/L of $CaCO_3$ and $MgCO_3$.

Determination of Chlorides

Chlorides in water samples were detected by the argentometric method. In a 30 mL water sample, 2-3 drops of $K_2Cr_2O_7$ solution was added and titrated against a standard solution of $AgNO_3$ (0.0141 N) to a pinkish-yellow endpoint.

Determination of Fluorides

Fluoride was determined by the ion-selective electrode method [37]. The stock solution was prepared from NaF (1000 mg/L). From this stock solution, a series of fluoride standards ranging from 0.020 mg/L to 1.0 mg/L were prepared.

Determination of Sodium and Potassium

The concentrations of sodium and potassium in water samples were calculated on flame photometer 410. Standard stock solutions of 1000 mg/L of Na and K were prepared by dissolving 2.352 g of NaCl and 1.805 g of KCl in 1 L deionized water. Then standard working solutions of concentrations 2.5 mg/L to 10 mg/L were prepared from this stock solution. After calibration, the concentrations were recorded in mg/L of sodium and potassium from 587-766.5 nm [38].

Determination of Sulfate Ions

For standard, in 5 mL of deionized water, 1 mL of sulfate buffer solution was added, followed by the addition of one pinch of Barium chloride crystal. The same procedure was done for water samples. The solutions were stirred enthusiastically for about 1 min and the absorbance was measured after 5 min of reaction time at a wavelength of about 420 nm. The concentration of sulfate ion was calculated by the following equation,

$$\text{Sulfate ion concentration} = \frac{\text{Concentration of Standard}}{\text{Absorbance of standard}} \text{ x absorbance of sample} \quad (3)$$

Determination of Nitrates

Nitrate in water was calculated by the method reported by Singh and coworkers [39]. Before analysis water was neutralized with a 5.0 N sodium hydroxide standard solution. In 5 mL of deionized water, 0.2 mL of 1 N HCl was added which was used as standard. In 5 mL of water sample, 0.2 mL of 1 N HCl was added and the absorbance was measured at 220 nm. Nitrate ion concentration was calculated by equation 3.

Determination of Heavy Metals

All the heavy metals (Zn^{2+}, Cd^{2+}, Cr^{3+}, Fe^{3+}, Cu^{2+}, Ni^{2+} and Mn^{2+}) were measured in the water samples with the help of AA500-Atomic Absorption Spectrophotometer with Reduced Air-Acetylene flame. After calibration, the concentration was measured in mg. In order to make standard solutions for zinc, copper and cadmium, 1 g of each metal was dissolved in HCl, then diluted up to 1 L with deionized water, whereas deionized water (1 L) was used to dissolve 3.735 g potassium dichromate, 3.235 g mohr salt for iron, 1.375 g nickel oxide, and 4.517 g manganese sulphate. We measured zinc's absorbance at 213.9 nm, cadmium's at 228.8 nm, chromium's at 357.9 nm, iron's at 248.3 nm, copper's at 324.8 nm, nickel's at 232 nm, and manganese's at 279.5 nm.

Results and Discussion

Different Geographical Localities of River Sutlej and Sindh

Physical properties of water

pH is the measure of free hydronium and hydroxide ions. Water is neutral with a pH of 7.0, greater than 7 pH indicates alkaline water whereas less than 7 pH indicates acidic water. Both alkaline and acidic water are harmful to drinking and cause digestion problems, itching, dryness, muscle spasms, weakness, tooth erosion etc. The results showed (Table 1) that the pH is almost neutral but variable at different points of river Sutlej and Sindh. The highest pH was recorded at the point of Head Salman (7.8). Followed by Head Salman the pH of Head Islam revealed the highest value (7.6). While the lowest pH was observed at Ahmadpur East point (7.2).

Naturally, water is tasteless, odorless and colorless. Due to the presence of total dissolved solids, taste is variable i.e., salty, brittle, sour and sweet. In all the tested samples, the taste of the water was mainly salty throughout the river at different localities. While the color appeared due to visible sand particles, dissolved organic and inorganic materials and the presence of metals.

The temperature of the water was variable and noted at the time of sample collection. The mean temperature was highest at the point of Lal Sohanra and Kotri Barrage (31-31.1 °C) which may be due to the industrial waste and high temperature of the environment.

Water clarity is measured by turbidity, which is caused by invisible particles. The highest turbidity calculated in the Nephelometric turbidity unit (NTU) of water was recorded at the point of Koteri Barrage (8.8) while the lowest was (7.4) at Lal Sohanra. The turbidity of all the samples was more than NEQ standards (5.0 NTU) which indicates high amounts of organic particles or plant-like materials. Due to the lack of ions in pure water, it is a poor conductor of electricity, but as it is contaminated with impurities, it becomes a better conductor. In accordance with NEQ standards, the electrical conductivity of River Sutlej and Sindh should not exceed 150 µS/cm, but all samples except S5 (Koteri Barrage) (109.4 µS/cm) exceeded that value ranging from 205 µS/cm to 256 µS/cm.

Table 1. **Physical properties of water in different geographical localities of River Sutlej and Sindh.**

Physical properties of water	NEQ standards *(Sutlej)*	NEQ standards *(Sindh)*	S1	S2	S3	S4	S5
pH	6-9	7.3-8.5	7.8	7.6	7.5	7.2	7.5-8.4
Taste	Not Satisfactory	Not Satisfactory	Salty	Salty	Salty	Salty	Salty
Color	15HU Pt/Co	15HU Pt/Co	Grayish + VSP	Grayish + VSP	Grayish + VSP	Light bluish+ VSP	Slightly Yellowish+ VSP
Odor	Not Satisfactory	Not Satisfactory	Soil like	Soil like	Soil like	Soil like	Soil like
Temp (°C)	<30	21-29	25-27	25-28	31.1-32.1	27-30	31-32
Turbidity (NTU)	5.0	5.0	7.5	7.6	7.4	7.0	8.8
EC (µS/cm)	150	150	255	254	250	256	109.4
CO_3^- & CO_3^- (mg/L)	>200	>200	88.2	80	86	81	80
TDS (mg/L)	3500	500-1000	294	338	210	182	705
TSS (mg/L)	200	500	142	252	52	83	166

TSS= Total soluble salts; TDS= Total dissolved solids

The total dissolved solids are the dissolved particles like metals, salts, organic, inorganic materials and minerals dissolved in water while total suspended solids are the solids that remain undissolved like algae, sand, soil, sediment and slit. This TDS was highest at 705 mg/L at Koteri Barrage while the total suspended substances (TSS) (mg/L) was highest at the Head Islam point (252 mg/L) of river Satle as compared to the all geographical localities of river Sutlej and Sindh. Both TDS and TSS are within the range of NEQ standards which is due to the presence of a small amount of minerals.

Exchangeable ions

Usually, chloride ions do not cause any harmful effects but excess concentration effect the taste of water while low concentration causes vomiting, sweating, diarrhea and high fevers. Similarly, a high concentration of sulphate ions causes a bitter taste, dryness and diarrhea while a low concentration is supposed to be best for use. The concentration of both ions was low as compared to NEQ standards of 1000 mg/L for chloride ions and 600 mg/L for sulphate ions. The lowest exchangeable ions of the chloride (Cl) and sulfates (SO_4) were found at the point of *Ahmadpur East* (27 mg/L & 30 mg/L) and highest at *Head Salman* point (57 mg/L & 80 mg/L).

The highest fluoride ions were found at *Koteri Barrage* (0.981 mg/L) and lowest at *Head Islam* point (0.325 mg/L). All the tested samples were supposed to be unsafe and cause dental erosion due to the very low concentration of fluoride ions suggested by the NEQ standard (10 mg/L).

According to NEQ standards, for phosphate ions and nitrates ions, the standard limit must not exceed 10-14 mg/L for phosphates and 50 mg/L for nitrates. All the samples of River Sutlej contain these two ions lower than the reported range (8-8.7 mg/L phosphates and 18.33-1941 mg/L) but in River Sindh concentration of phosphate ions was very high (34.2 mg/L), while the concentration of nitrate ions was near to limit (43.01 mg/L). High concentrations of nitrates cause weakness, excess heart rate, blue or grey colored skin while low concentrations of phosphate cause muscle weakness, heart failure, respiratory failure, hypophosphatemia and comas. The results were summarized in Table 2, Fig. 1a.

Table 2. **Exchangeable ions in River Sutlej and Sindh Water at different Geographical localities.**

Ex. Ions (mg/L)	NEQ stand-ards Sutlej	NEQ stand-ards Sindh	S1	S2	S3	S4	S5
Cl^-	1000	250	57	53	45	27	36.35
F^-	10	10	0.768	0.325	0.452	0.721	0.981
SO_4^-	600	600	80	34	33	30	36.5
PO_4^-	10-14	10-14	8.4	8	8.2	8.7	34.2
NO_3^-	50	50	18.35	18.49	18.33	19.41	43.01

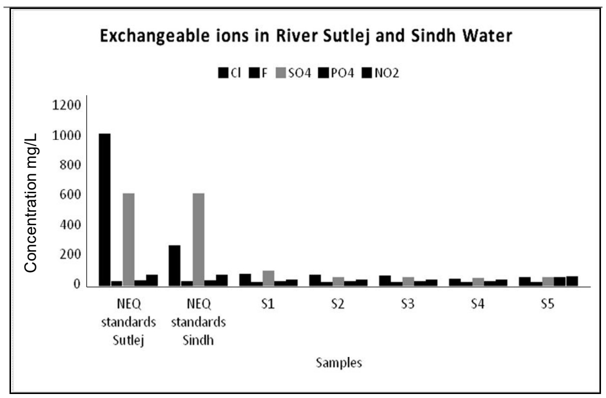

Figure. 1a. **Exchangeable ions in River Sutlej and Sindh Water at different Geographical localities**

Heavy metal contents

Water contaminated with heavy metals cause a lot of serious problems [15, 40] like cardiovascular disorder, high risk of cancer, diabetes, neuronal damage and renal injuries. The concentration of heavy metals like manganese (0.042-0.63 mg/L), copper (0.02-0.083 mg/L), chromium (0.0033-0.32 mg/L), zinc (0.001-0.22 mg/L), iron (0.076-0.918 mg/L) and nickel (0.0023-0.23 mg/L) was low as compared to NEQ standards while the concentration of cadmium was low in case of River Sutlej (0.003-0.009 mg/L) but very high in River Sindh (0.88 mg/L) rather than 0.1 mg/L (Table 3, Fig. 1b).

Table 3. **Heavy metal contents in River Sutlej and Sindh Water at different Geographical localities.**

Heavy Metal (mg/L)	NEQ standards Sutlej	NEQ standards Sindh	S1	S2	S3	S4	S5
Mn	1.5	1.5	0.094	0.046	0.044	0.042	0.63
Cu	1	1	0.083	0.024	0.023	0.027	0.02
Cd	0.1	0.1	0.009	0.0031	0.0034	0.003	0.88
Cr	1	1	0.01	0.0042	0.0041	0.0033	0.32
Z	5	5	0.02	0.001	0.0013	0.001	0.22
Fe	8	8	0.918	0.083	0.085	0.076	0.46
Ni	1	1	0.004	0.0036	0.003	0.0023	0.23

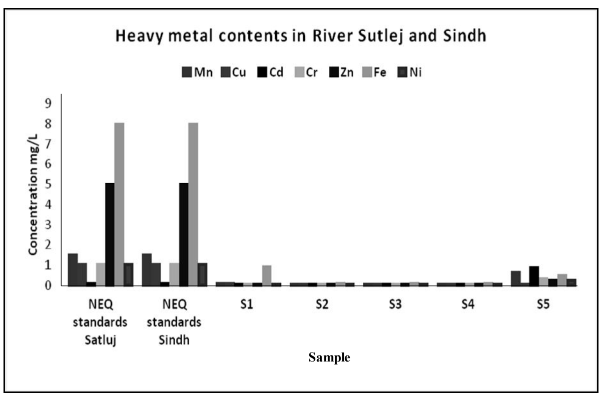

Figure 1b. **Heavy Metal Contents in River Sutlej and Sindh Water at different Geographical localities**

TSC/THC contents

Most people did not experience any serious adverse effects from either hard or soft water. By measuring sodium, potassium, calcium, and magnesium concentrations, hardness or softness of water can be determined. The highest total softness components (TSC) and total hardness components (THC) (mg/L) contents were observed at the geographical locality of Kotri Barrage in River Sindh (44.2, 44.4, 80, 17.8 and 124.4 mg/L) while the lowest TSC/THC contents were recorded in the water of the Lal Sohanra (16, 5.409 and 25.409 mg/L) except sodium and potassium which was higher in Lal Sohanra (20 mg/L or 4.9 mg/L) than Ahmadpur East (24 mg/L or 4.4 mg/L). This major change in the Koteri Barrage water is due to the water disposal from the many Textile and Sugar mills near the river Sindh at Shah Bandar point (Table 4, Fig.1c).

Table 4. **TSC/THC Contents in River Sutlej and Sindh Water at different Geographical localities.**

THC/TSC (mg/L)	NEQ Standards Sutlej	NEQ Standards Sindh	S1	S2	S3	S4	S5
Na	200	200	36	17	16	15	44.2
Ca	50	100	26	22	20	24	44.4
Mg	50	100	5.5	5.67	5.409	5.499	80
K	50	100	5.8	4.7	4.9	4.4	17.8
Ca + Mg	150	200	31.5	27.67	25.409	29.499	124.4

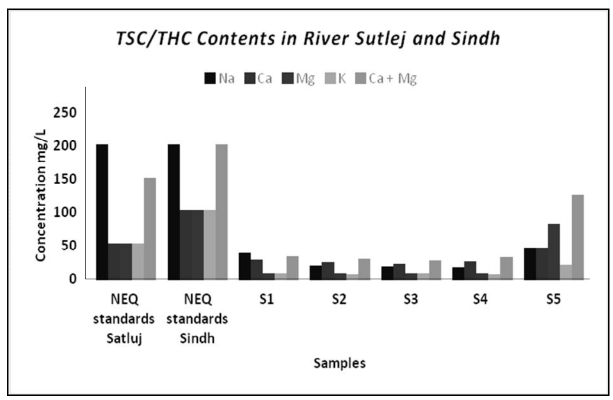

Figure 1c. **TSC/THC Contents in River Sutlej and Sindh Water at different Geographical localities**

Different Geographical Localities of Arabian Sea Water at Menorah and Kamari

Physical properties of coastal and deep sea water of mehnorah and kamari

The pH range was highest in the Costal and deep Seawater of Kamari (7.7) while lowest at the points of Costal and deep Seawater of Mehnorah (7.5).

Table 5. **Physical properties of costal and deep sea of Mehnorah and Kamari.**

Physical properties	NEQ standards	S6	S7	S8	S9
pH	8.1	7.7	7.7	7.5	7.5
Taste	Not satisfactory	Bitter	Bitter	Bitter	Bitter
Color	Variable	Blur + VSP	Blur + VSP	Blur + VSP	Blur + VSP
Odor of water	Strange odor	Odor less	Odor less	Odor less	Odor less
Temp (°C)	21	27.5-29	27.5-29	25.5-27.5	25.5-27.5
Turbidity (NTU)	1000	18	18	14	16
EC (µS/cm)	Vary with salinity	51488	51467	51,467	51465
CO_3^- & HCO_3^- (mg/L)	152	164	137	171	162
TDS (mg/L)	35,000	34840	34768	34,768	34772
TSS (mg/L)	9,800	1,244	1,214	1,234	1,238

The water was blurred at all points with visible suspended particles of sand and organic matter. The water of Arabian sea was odorless but bitter in taste due to high concentrations of TDS (34768 mg/L to 34840 mg/L) and TSS (1214 mg/L to 1238 mg/L). The turbidity of the water was less than NEQ standard (1000 NTU), lowest at deep Sea Mehnorah (14-16 NTU) and highest at deep sea Kamari (18 NTU). The carbonates and bicarbonates (CO_3^- & HCO_3^-) were highest at the Coastal and Deep Sea Mehnorah points' water as compared to all other localities of Arabian Sea water like Kamari. While the TDS and TSS were highest at the point of deep seawater of Kamari. At DSM and CSK points electrical conductivity was higher than at CSM and DSK. The data is given in Table 5.

Exchangeable ions

The concentration of sulphate ions (2948 mg/L to 2974 mg/L) and phosphate ions (0.364 the mg/L to 0.382 mg/L) were higher than NEQ standard 2740 mg/L (sulphate) and 0.088 mg/L (phosphate). Nitrate ions (0.47 mg/L to 0.64 mg/L) and fluoride ions (1.25 mg/L to 1.29were within the range given by NEQ standard 0.7 mg/L for nitrates and 1.4 mg/L for fluoride ion. Chloride ion's concentration was high at Kamari points (19742 mg/L) but low at Mehnorah points (10432 mg/L to 10438 mg/L). The results are summarized in Table 6, Fig. 2a.

Table 6. **Exchangeable ions (mg/L) in Different localities of Sea water of Mehnorah and Kamari.**

Ions (mg/L)	NEQ standards	S8	S9	S6	S7
Cl^-	19,700	10432	10438	19742	19742
F^-	1.4	1.29	1.29	1.29	1.25
SO_4^{2-}	2,740	2968	2974	2969	2948
PO_4^{3-}	0.088	0.364	0.366	0.382	0.374
NO_3^-	0.7	0.51	0.47	0.64	0.56

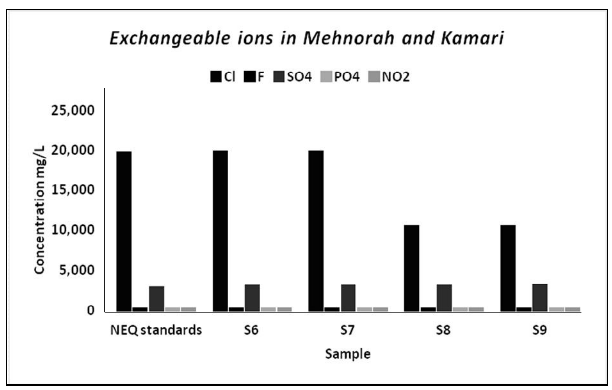

Figure 2a. **Exchangeable ions in Different localities of Sea water of Mehnorah and Kamari**

Heavy metals

Among all the tested samples concentration of cadmium (0.000538 mg/L to

0.000551 mg/L), chromium (0.00351 mg/L to 0.00371 mg/L) and zinc (2.65 mg/L to 2.72 mg/L) were higher than reported NEQ standard 0.00011 mg/L cadmium, 0.0002 mg/L chromium and 0.005 mg/L zinc while other metals like manganese (0.00021 mg/L to 0.00029 mg/L), copper (0.00053 mg/L to 0.00067 mg/L), iron (0.014 mg/L to 0.018 mg/L) and nickel (0.0036 mg/L to 0.0047 mg/L) were lower than reported values. (Table 7, Fig. 2b).

Table 7. **Heavy Metal Contents in Different localities of Sea water of Mehnorah and Kamari.**

Heavy Metals contents (mg/L)	NEQ standards	S6	S7	S8	S9
Mn	0.0004	0.00029	0.00023	0.00025	0.00021
Cu	0.0009	0.00067	0.00059	0.00054	0.00053
Cd	0.00011	0.000551	0.000538	0.000548	0.000546
Cr	0.0002	0.00371	0.00361	0.00351	0.00359
Zn	0.005	2.72	2.65	2.65	2.65
Fe	<0.02	0.018	0.016	0.016	0.014
Ni	0.0066	0.0047	0.0036	0.0036	0.0038

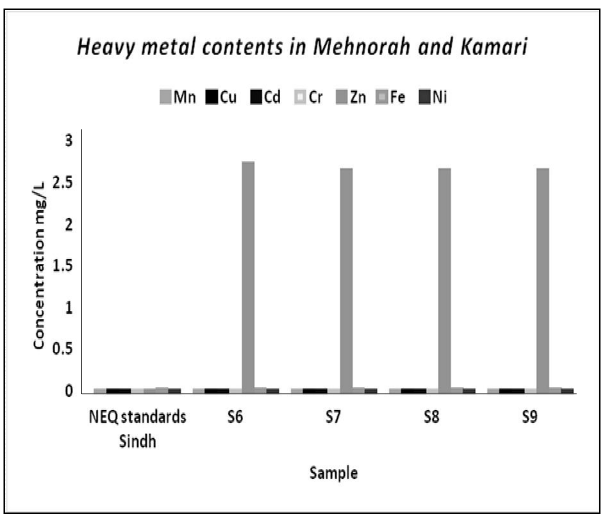

Figure 2b. **Heavy metal contents in different localities of Sea water of Mehnorah and Kamari**

TSC/THC in different localities of sea water of menorah and kamari

Sodium contents were highest in the water of *deep sea Mehnorah* (10,157). The calcium (Ca), magnesium (Mg) and potassium (K) contents were significantly higher but within the range of NEQ standards. Results were plotted in Table 8, Fig. 2c.

Table 8. **TSC/THC in Different localities of Sea water of Mehnorah and Kamari.**

Metals Contents (mg/L)	NEQ standards	S6	S7	S8	S9
Na^+	10,900	9,647	9,640	10,157	10,155
Ca^{2+}	410	387	374	380	375
Mg^{2+}	1,310	1,584	1,561	1,544	1,542
K^+	390	379	375	375	373
Ca^{2+} + Mg^{2+}	2,100	1,924	1,935	1,924	1,917

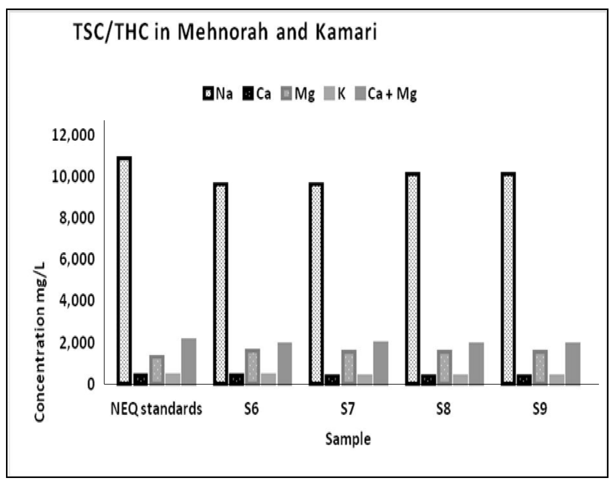

Figure 2c. **Softness / Hardness contents in different localities of sea water of Mehnorah and Kamari**

Conclusion

A comparison of water samples collected from the various geographical locations of the River Sutlej and Sindh, as well as the Arabian Sea, showed increasing or decreasing trends in terms of physical characteristics, exchangeable ions, heavy metals, and hardness/softness. Due to these trends, the water from the rivers is unfit for human consumption, either for use for household purposes or irrigation for long-term crop production. However, marine life, including animals and plants, is negatively impacted by these trends.

In comparison to NEQ standards, River Sutlej and River Sindh water have low pH, chloride ions, fluoride ions, sulphates, nitrates, phosphates, and heavy metal concentrations, while soil particles or soluble ions cause high turbidity and electric conductivity. However, when looking at sea water, all the trends except for the concentrations of metal ions like cadmium, chromium and zinc are within the range of reported values of the NEQ standard. As a result of all the tests, S-7 showed the highest values among all the samples tested.

Conflict of Interest

There is no conflict of interest related to this article.

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