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Physiochemical Analysis of Surface Water in Rohri Canal from Sukkur Barrage to Mehrabpur

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ABSTRACT

This research study aims to assess the impact of discharge of untreated wastewater from domestic and industrial sources on the water quality of Rohri Canal in the reaches of the canal from its off-take at Sukkur Barrage to Mehrabpur town. A total of eight surface water samples were collected from the canal. The water quality parameters that were analyzed in the water samples include temperature, COD, pH, BOD, turbidity, TDS, chlorides, hardness, E.coli and alkalinity. The average value of BOD (212 mg/L) and COD (423 mg/L) in the water samples was very high and exceeded the permissible limits for drinking water. pH values of all the groundwater samples were found within the permissible limits, whereas dissolved solids concentration (TDS) exceeded these limits only at two sampling stations (4 and 3). The average turbidity value was recorded as 545 NTU and exceeded the permissible limits for drinking water at all sampling points. Moreover, the chlorides, alkalinity and hardness values in the water samples were within the drinking water permissible limits. Low dissolved oxygen values and positive results for E.coli were observed at sampling points located near major settlements.

Keywords: Rohri Canal, Encroachment, Pollution, Physiochemical Analysis, Irrigation water..

1. INTRODUCTION

Water is the most essential chemical compound required for the existence of life. Water availability is required for fulfilling the various needs of humans including domestic consumption, agriculture, and industrial purposes. (Moe et. al, 2006). Despite the universally recognized importance of water for life, the water bodies which provide fresh water supplies like rivers, lakes and canals are continuously being polluted by humans through the discharge of agricultural, domestic and industrial wastewater (Qadri et. al, 2020). This phenomenon is more prevalent in the underdeveloped and developing countries in comparison with the developed countries due to the lack of government intervention and implementation of environmental regulations (Pimentel et. al, 1994). On a global level an estimated population of 1.3 billion people suffer from lack of access to safe drinking water (Chapman, 2021). Due to the contamination of water bodies and lack of water treatment facilities many people in the developing and underdeveloped countries consume contaminated water which is unsafe for drinking purposes (Afroz et. al, 2014).

In Pakistan, irrigation canals are predominantly used for irrigating agricultural land. However, in command areas of the canals where there is no water supply system or the groundwater is saline, this canal water is also used for domestic consumption (Inam et. al, 2007). Urban settlements and industrial units near the canal which have no suitable method of disposal of wastewater discharge their wastewater into the canals, causing the canal water to become severely polluted (Soomro et. al, 2014). This surface water contamination can cause water-borne diseases when used for drinking purposes. Irrigation with chemically contaminated canal water can also to accumulation of these pollutants in agricultural crops (Sohag et. al, 2014). Faecal contamination from the discharge of domestic wastewater into the canal system has been found to be associated with diarrheal diseases in the downstream areas of the major canals in Sindh province (Inam et. al, 2007).

Rohri canal off-takes from the Sukkur barrage and is the chief source of irrigation water in Khirpur, Naushero Feroz and Shaheed Benazirabad districts of Sindh province. At some places of its command area, water from this canal is also used to fulfil the water requirements for drinking purposes (Talpur et. al, 2021).

From literature review of previous studies, it has been observed that several researchers have studied the water quality in irrigation canals of Sindh province, but no previous research has been conducted on the water quality

of Rohri canal, which necessitated the conduct of this study. The objective of this study is to assess the water quality of Rohri canal from its off-take point up to its reaches at Mehrabpur town..

2. MATERIALS AND METHODS

The study area of this research study is the reaches of the Rohri canal from Sukkur barrage up to Mehrabpur town. A total of eight water samples will be collected for this study. Sampling locations are provided in figure 1 and table 1.

Table 1: Locations of Sample Collection Sites

Sampling Station #	GPS Coordinates	
	Latitude	Logitude
RHS-1	27°39'37"	68°51'05"
NBS-1	27°35'34"	68°49'25"
KRS-1	27°32'04"	68°43'31"
TMS-1	27°25'58"	68°39'02"
GBS-1	27°20'43"	68°32'12"
RPS-1	27°17'02"	68°30'41"
STS-1	27°12'15"	68°28'24"
MPS-1	27°07'07"	68°23'51"

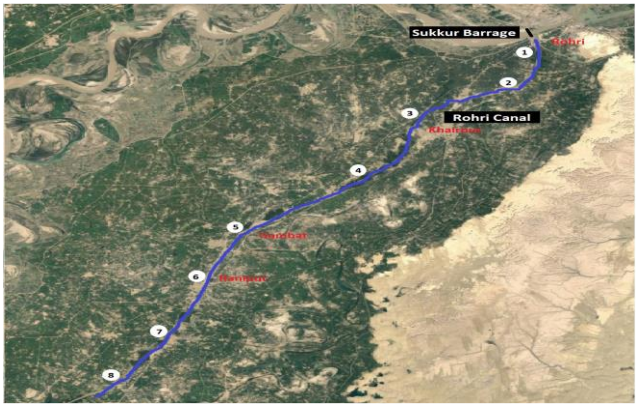

Figure 1: Map of Sample Collection Sites

Surface water samples were collected by following the standard procedure for the collection of water samples from the irrigation canals. Large objects such as twigs, leaves, rags and other materials floating in the water were removed from the water samples. Standardized plastic bottles were used for collection of the water samples. Before taking the sampling bottles to the field, they were thoroughly cleaned with the help of washing soda and tap water followed by rinsing with distilled water. During sample collection, care was taken to fill the sampling bottle till the top so as prevent the dissolution of air in the sample. After sample collection, details of the sampling location including sampling station GPS coordinates and date and time were marked on the sampling bottle and also noted down in the notebook for record. Water quality parameters like the water temperature were measured at site immediately after collection of sample with the help of a centigrade thermometer. Preservation of the water samples was carried out and they were transported to the laboratory from the sampling site for water quality analysis.

The experimental for this research study is divided into two parts. The first part consisted of on field measurement of temperature with the help of a centigrade thermometer immediately after collection of the water samples. This part also includes preservation of the water samples as per preservation requirement of the various water quality parameters to be analyzed in this study. The second part of the experimental work includes laboratory analysis of the various water quality parameters. These parameters included TSS, TDS, hardness, BOD, alkalinity, COD, dissolved oxygen, chlorides and turbidity. During the analysis of the various water quality parameters in the laboratory chemicals of analytical grade was used. The details of these water quality parameters and their methods of analysis used are further detailed in table 2.

Table 2: Physical / Chemical water Quality Parameters analyzed

Physical Parameter	Method of Analysis	Chemical Parameters	Method of Analysis
pH	Using digital pH meter.	Chlorides	Using titrimetric method
TSS	Using gravimetric method	Hardness	Using EDTA titration method
Turbidity	Using digital nephlo-turbidity meter	Nitrites	Using photometric method
TDS	Using gravimetric method	COD	Using dichromate method
EC	Using electrical conductivity meter		
Temperature	Using Centigrade thermometer		

3. RESULTS

Various chemical and physical water quality parameters were analyzed to assess the extent of water contamination in the canal water.

3.1 Physical Water Quality Parameters:

Various physical parameters of water quality were analyzed in the study including pH, turbidity, total suspended solids (TSS), temperature, total dissolved solids (TDS) and total suspended solids (TSS). The results of these physical water quality parameters were obtained as detailed in table 3.

Table 3: Results for Physical Water quality Parameters

*SS Nos.	*SS Codes	pH	Turbidity (NTU)	TDS (mg/L)	Temp (˚C)	TSS (mg/L)
1	RHS-1	7.0	760	310	33.1	943
2	NBS-1	6.8	412	256	33.8	678
3	KRS-1	6.9	821	2100	33.9	968
4	TMS-1	8.0	740	1800	31.6	1058
5	GBS-1	7.1	418	680	35.6	798
6	RPS-1	7.0	597	320	35.4	953
7	STS-1	7.0	237	550	36.3	816
8	MPS-1	7.3	377	910	33.7	618
Maximum		8.0	821	2100	36.3	1058
Mininum		6.8	237	256	31.6	618
Mean		7.14	545	865.75	33.4	854
**SEQs for Drinking Water (2015)		6.5-8.5	<5	<1000	***NGVS	***NGVS

*SS: Sampling Stations
**SEQs: Sindh Environmental Quality Standards
***NGVS: No Guideline Value Standard

3.1.1 Temperature

The temperature of the water samples ranged from 33.1˚ C to 36.3˚ C, with an average value of 34.2 ˚C. There is a fluctuation in the temperature values as depicted in figure 2. As the water sampling was carried out in April during afternoon timings the air temperature was high, as summer season was prevailing in the study area. The average temperature of the atmosphere at sampling site was 38 °C and the average temperature of the water samples taken from the Rohri Canal was recorded as 34.2 °C, indicating that the temperature difference between the surface water and the atmosphere at the sampling site was 4 °C.

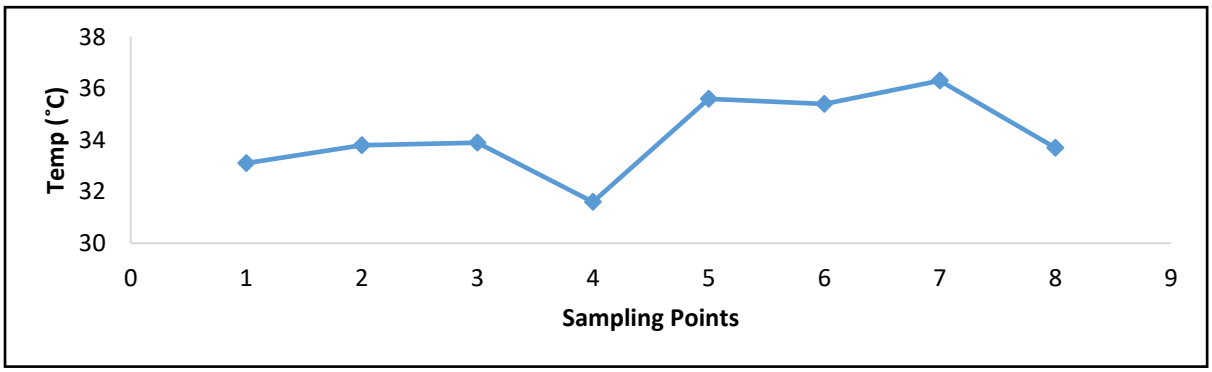

Figure 2: Temperature of Water Samples

3.1.2 pH

pH values of the water samples ranged from 6.8 to 8.0, with an average value of 7.12. There is a slight fluctuation in the pH values as depicted in figure 3. All the analyzed water samples had their pH values well within the NEQs permissible limits of this parameters for drinking water and irrigation water standards of Pakistan. Mastoi et al., 2017 in his study on the water quality of Phuleli Canal had reported the average pH of 7.52 in the surface watersamples collected from Phuleli Canal, and these values are comparable with the results of the present study.

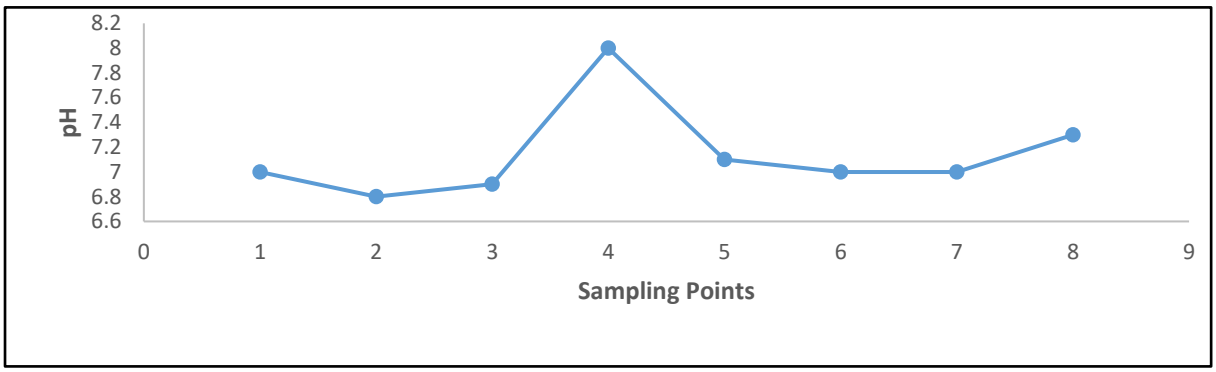

Figure 3: pH of Water Samples

3.1.3 Total Dissolved Solids

The TDS values of the water samples ranged from 256 to 2100 mg/L, with an average value of 867 mg/L. There is wide a fluctuation in the TDS values of the water samples as depicted in figure 4. Maximum TDS values were recorded at sampling station KPS-1 (Khairpur) and minimum values were recorded at sampling station BMS-1 (Begmanji station). The addition of salts from the sewerage line inlets located alongthe canal at Khairpur can be attributed as the reason for the elevated concentration of dissolved solids at sampling station KPS-1. Dilution of the water further downstream resulted in lower TDS values in sampling stations 5-8.

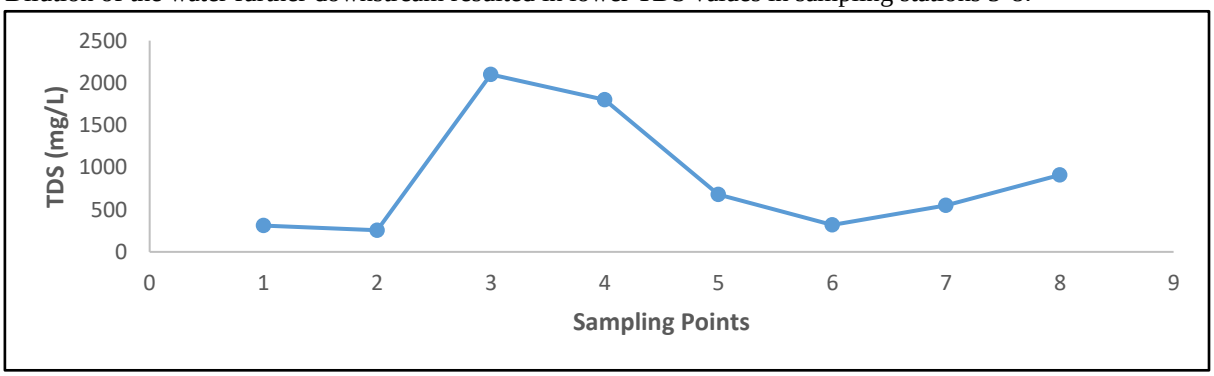

Figure 4: TDS of Water Samples

3.1.4 Total Suspended Solids

The TSS values of the water samples ranged from 618 to 1058 mg/L, with an average value of 854 mg/L. There is a fluctuation in the TSS values of the water samples as depicted in figure 5. Maximum TSS values were recorded at sampling station TMS-1 (Tando Masti) and minimum values were recorded at sampling station MPS-1 (Mehrabpur). All the analyzed water samples had their TSS values exceeding the NEQs permissible limits of this parameters for drinking water. Cheema et al., 2017 in his study on the water quality of Phuleli Canal had reported the average TSS of 575 mg/L in the surface water samples collected from Phuleli Canal, and these values are much lower then the results of this research study.

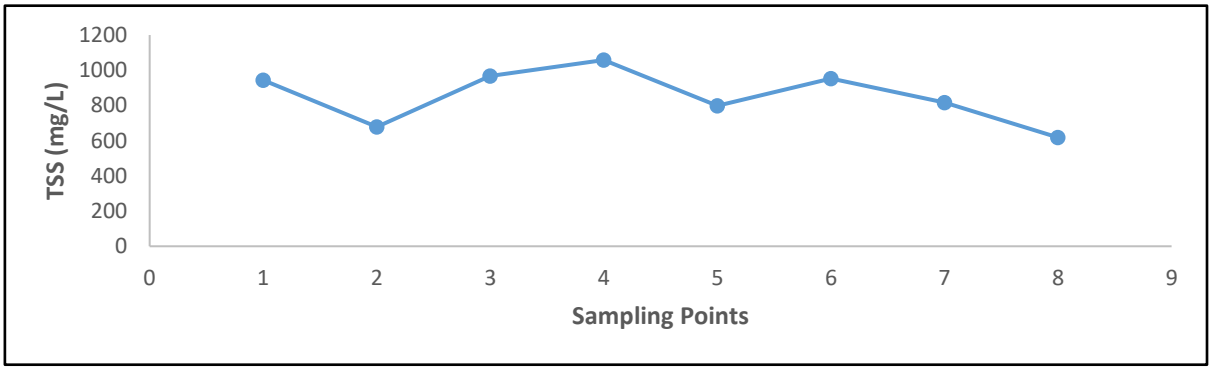

Figure 5: TSS of Water Samples

3.1.5 Turbidity

Turbidity measurements of the water samples had an average value of 545 NTU. Maximum recorded values of turbidity in the water samples was 821 NTU, while the minimum value was 237 NTU. There is a fluctuation in the turbidity values of the water samples as depicted in figure 6. Maximum turbidity values were recorded at sampling station KPS-1 (Khairpur) and minimum values were recorded at sampling station STS-1 (Setharja). All the analyzed water samples had their turbidity values exceeding the WHO permissible limits of this parameters for drinking water. Cheema et al., 2017 in his study on the water quality of Phuleli Canal had reported the turbidity values ranging from 121 to 214 NTU in the surface water samples collected from Phuleli Canal, and these values are much lower then the results of the present study.

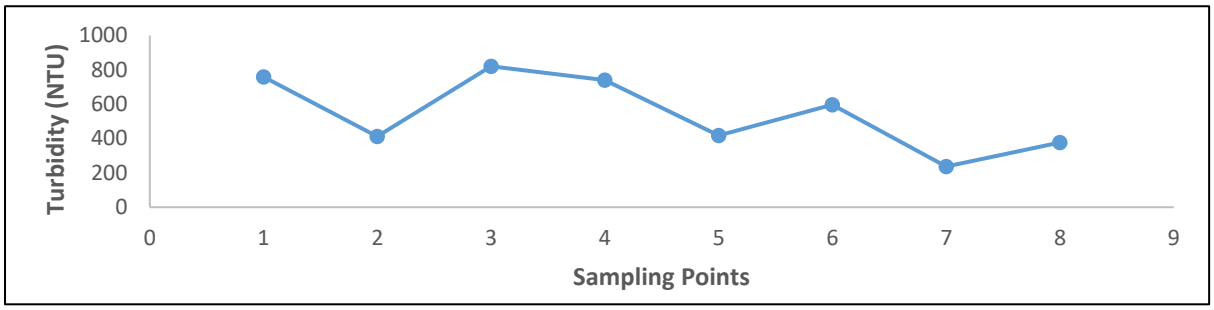

Figure 6: Turbidity of Water Samples

3.2 Chemical Water Quality Parameters

The chemical water quality parameters examined during the study were chlorides, alkalinity, COD, hardness, BOD and DO. The results of the chemical water quality parameters for the water samples taken from Rohri canal are provided in table 5. Various chemical parameters of water quality were analyzed in this study including chlorides, alkalinity, hardness, dissolved oxygen, chemical oxygen demand (COD) and BOD (Table 5).

Table 5: Results for Chemical Water quality Parameters

*SS Nos.	*SS Codes	Chlorides (mg/L)	Hardnes (mg/L)	COD (mg/L)	BOD (mg/L)	DO (mg/L)	Alkalinity (mg/L)
1	RHS-1	103	172	579	289.5	4.9	130
2	NBS-1	36	146	352	176	4.2	121
3	KRS-1	85	156	378	189	8.3	230
4	TMS-1	76	176	400	200	4.2	120
5	GBS-1	98	300	503	251.5	3.8	120
6	RPS-1	93	264	392	196	3.9	150
7	STS-1	43	236	366	183	4.6	230
8	MPS-1	47	272	417	208.5	4.3	140
Maximum		103	300	579	289.5	8.3	230
Minimum		36	146	378	176	3.8	120
Mean		34	768.9	72.63	423	155.125	215.25
**SEQs for Drinking Water (2015)		250	500	***NGVS	***NGVS	***NGVS	***NGVS

*SS: Sampling stations
**SEQs: Sindh Environmental Quality Standards
***NGVS: No Guideline Value Standard

3.2.1 Chlorides

The chlorine concentration in the water samples ranged from 36 to 103 mg/L, with an average value of 72.6 mg/L. There is a fluctuation in the Cl- concentration values of the water samples as depicted in figure 7. Maximum chloride concentration was recorded at sampling station RRS-1 (Rohri) and minimum values were recorded at sampling station BMS-1 (Begmanji station). All the analyzed water samples had their chloride concentratio well within the WHO permissible limits of this parameters for drinking water.

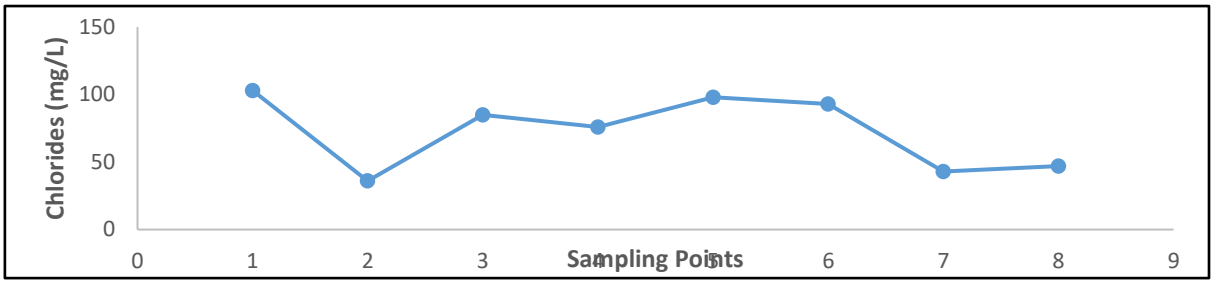

Figure 7: Concentration of chlorides in water samples

3.2.2 Hardness

Hardness measurements of the water samples gave an average value of 215 mg/L. Maximum recorded values of hardness in the water samples was 300 mg/L, while the minimum value obtained was 146 mg/L (Figure 8). Maximum hardness values were recorded at sampling station GBS-1 (Gambat) and minimum values were recorded at sampling station BMS-1 (Begmanji station). All the analyzed water samples had their hardness values well within the NEQs permissible limits of this parameters for drinking water. Mastoi et al., 2017 in his study on the water quality of Phuleli Canal had reported the average hardness value of 156.32 in the surface water samples collected from Phuleli Canal, and these values are lower than the results of the present study.

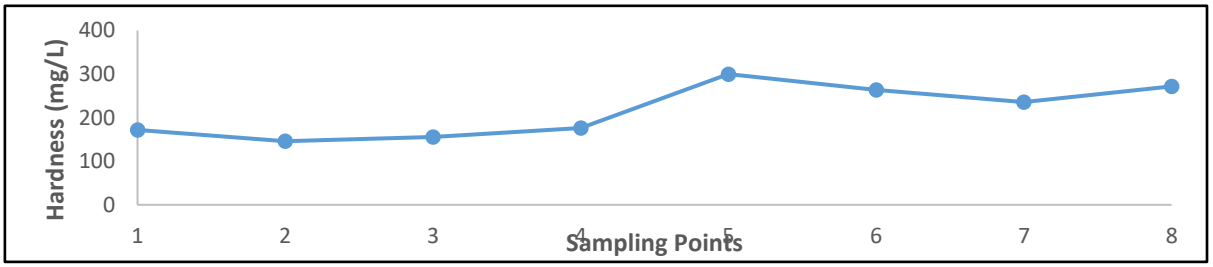

Figure 8: Hardness of water Samples

3.2.3 Chemical Oxygen Demand (COD)

COD values of the water samples ranged from 352 to 579 mg/L, with an average value of 423 mg/L.There is a fluctuation in the COD values of the water samples as depicted in figure 9. Maximum COD values were recorded at sampling station RRS-1 (Rohri) and minimum values were recorded at sampling station BMS-1 (Begmanji station). The inflow of untreated domestic wastewater from the sewerage line inlets located along the canal at Rohri can be attributed as the reason for the elevated COD values at sampling station # 1.

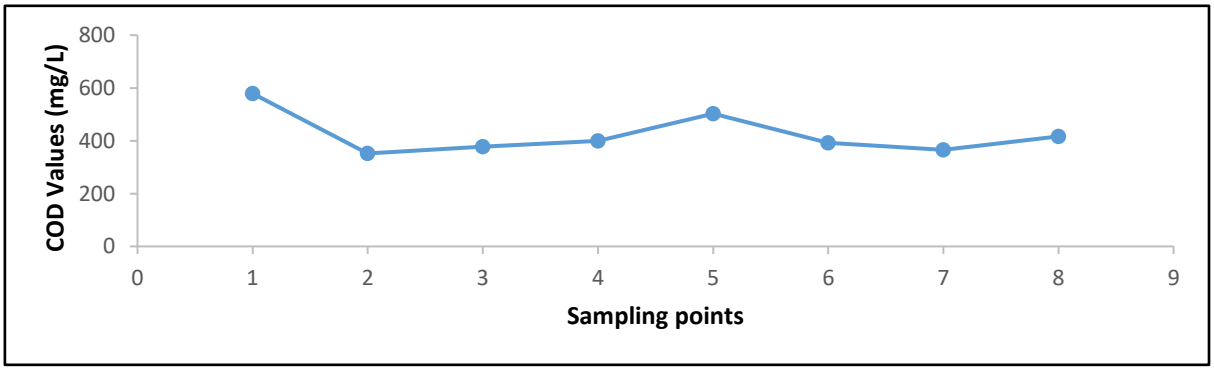

Figure 9: COD of Water Samples

3.2.4 Biochemical Oxygen Demand

Range of BOD in the water samples was obtained as 176-289.5 mg/L, with an average value of 212 mg/L. There is a fluctuation in the BOD values of the water samples as depicted in figure 10. Maximum BOD values were recorded at sampling station RRS-1 (Rohri) and minimum values were recorded at sampling station BMS-1 (Begmanji station). The inflow of untreated domestic wastewater from the sewerage line inlets located along the canal at Rohri can be attributed as the reason for the elevated BOD values at sampling station # 1.

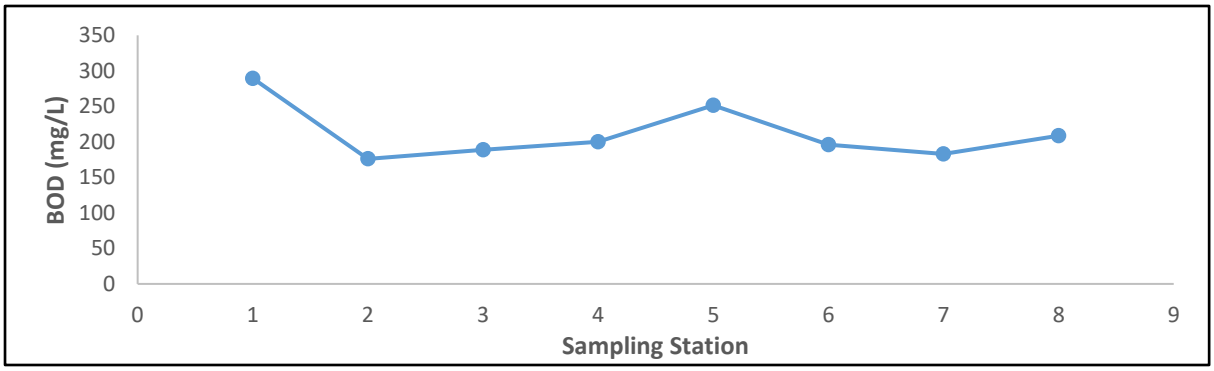

Figure 10: BOD of Water Samples

3.2.5 Alkalinity

Alkalinity values of the water samples ranged from 120 to 230 mg/L, with an average value of 155 mg/L. There is a fluctuation in the alkalinity values of the water samples (Figure 12). Maximum alkalinity values were recorded at sampling station KPS-1 (Khairpur) and minimum values were recorded at sampling station GPS-1 (Gambat). All the analyzed water samples had their alkalinity values well within the NEQs permissible limits of this parameters for drinking water (600 mg/L).

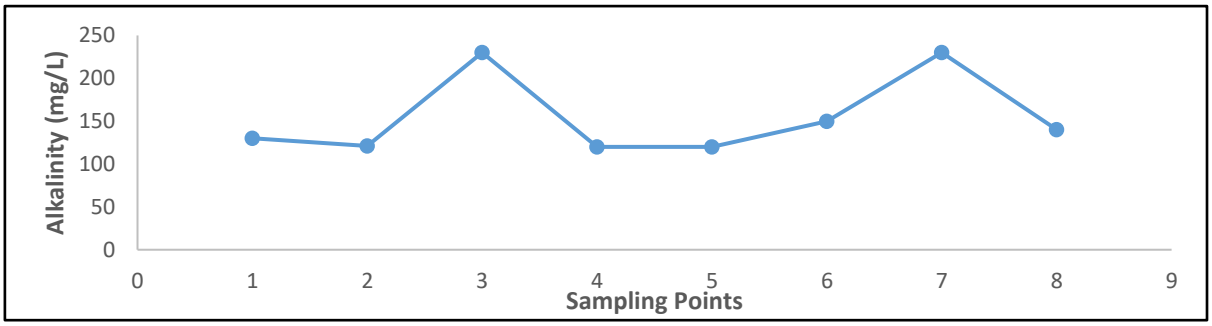

Figure 11: alkanity of water samples at different locations

3.2.6 Dissolved Oxygen

DO values of the water samples ranged from 3.8 to 8.3 mg/L, with an average value of 4.78 mg/L. There is a fluctuation in the DO values of the water samples (Figure 12). Maximum DO values was recorded at sampling station KPS-1 (Khairpur) and minimum values were recorded at sampling station GBS-1 (Gambat). Mastoi et al., 2017 in his study on the water quality of Phuleli Canal had reported the average DO value of 5.85 in the surface water samples collected from Phuleli Canal, and these values are slightly higher than the results of the present study.

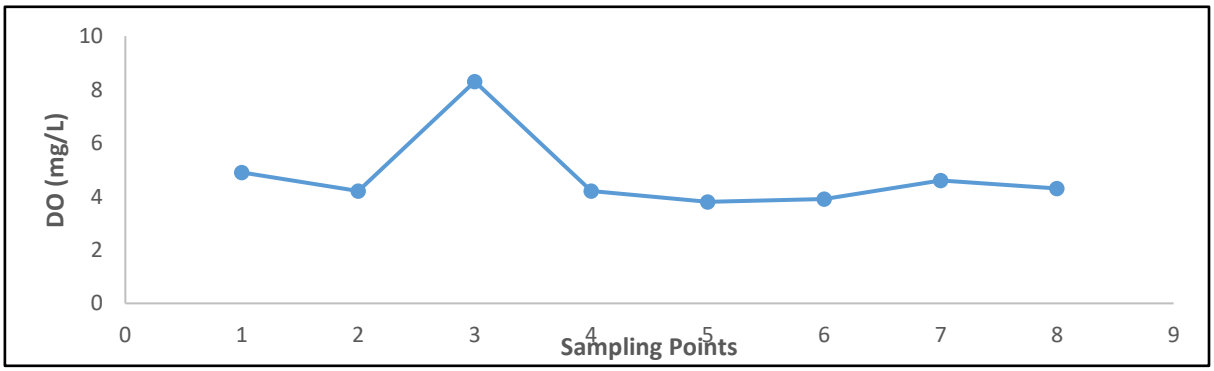

Figure 12: Dissolved Oxygen of Water Samples

3.3 Microbiological Water Quality Parameters

E. Coli test was conducted to check the presence/absence of fecal coliforms in the water samples. The positive result for E.Coli test show the presence of fecal coliform in water, which makes it unfit for human consumption according to both national and international standards for drinking water. The results of this microbiological analysis is provided table 6.

Table 6: Results for Microbiological Water quality Parameters

*SS Nos.	*SS Codes	E. Coli (+ve / -ve)
1	RHS-1	+ve
2	NBS-1	+ve
3	KRS-1	+ve
4	TMS-1	+ve
5	GBS-1	+ve
6	RPS-1	+ve
7	STS-1	+ve
8	MPS-1	+ve

4. CONCLUSION

This research study was conducted to assess the impact of the discharge of untreated sewage and industrial wastewater on the water quality of Rohri Canal in the reaches of the canal from its off-take at Sukkur Barrage to Mehrabpur town. The findings of this study indicate that the inflow of untreated industrial effluent and domestic wastewater into the canal has profound negative impact on the physical, chemical and microbiological characteristics of the surface water in Rohri Canal. The average TDS in the water sample was 866 mg/L, while the TDS values exceeded the permissible limits for drinking water only at two sampling stations, namely sampling station 4 and 3. The average pH of the water sample was 7.12, while the pH values lied well within the permissible limits for drinking water and irrigation water. While the turbidity values in the water samples was having range of 237-821 NTU, far exceeding the WHO permissible limits for drinking water.

The average value of BOD (212 mg/L) and COD (423 mg/L) in the water samples was very high and exceeded the permissible limits of these two water quality parameters for irrigation water and drinking water. Significantly higher BODs were recorded at sampling points from the canals near major settlements which can be attributed to the discharge of sewage water into the canal. While the alkalinity values in the water samples, having range of 120-230 mg/L, lied well below the WHO permissible limits for drinking water (600 m/L). While the values of hardness (range 146-300 mg/L) and chlorides (36 to 103 mg/L) lied well within the national and international drinking water standards.

The dissolved oxygen values in the sample had an average value of 4.78 mg/L. Significantly low DO levels at sampling stations 6, 1, 5 and 4 can be attributed to the high BOD values at these sampling stations, as the high organic loadings in water contributes to decreased DO levels in the water body. Positive E.coli results were recorded at sampling station GBS-1, RHS-1, GBS-1 and KRS-1. These sampling stations were found to located near major settlements along the canal where the discharge of untreated sewage may be the cause for fecal contamination in the canal water.

From the results of this study, it can be safely said that the physicochemical properties of the water in Rohri Canal have been adversely affected by human activities of indiscriminate wastewater disposal from domestic and industrial sources into the canal which can pose significant adverse effects on humans in the long run if left unmanaged.

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