Assessment of Physical-Chemical Parameters of Water along the Catchment Areas of Rawal Dam Islamabad, Pakistan

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Abstract: Clean drinking water is the basic needs of human-beings. Contamination in drinking water is the most prominent issue in the rural and urban areas of the developing countries. Rate of causalities is increasing because of water borne diseases which is due to rapid rise in urbanization which sequentially leads to elevation of water pollution level. World Health Organization (WHO) bears that almost three billion people are the effectives of unsafe water. Developing countries like Pakistan have a growing urbanization rate 31 to 34% whereas accessibility of safe drinking water has declined more than 40 percent. The present research was conducted to examine the water quality characteristics of Rawal Dam Reservoir, Islamabad, Pakistan. Water samples were randomly collected from streams and mid of the Dam. Standard methods were used to determine the physiological parameters. Chemical parameters were also assessed in the samples by using UV Visible Spectrophotometer and standard method. The results obtained were compared with Pak-EPA standard limit, the concentration of Physical and chemical parameters were above the permissible limits made by Pak-EPA in different streams as well as in Rawal dam.

Keywords: Physiochemical Evaluation, Water Quality, Drinking Water, Water Supply, Safe Drinking Water Rawal Dam, Pakistan

1. Introduction

Globally, water demand is increasing drastically in coming decades. It is reported that situation will deteriorate further by year of 2025 because population around the world will be facing low water supply. Water issues have been documented in several regions, particularly in Asian regions including India, Bangladesh, Vietnam, Cambodia, and China. Currently, water bodies are polluted by different types of contaminants and chemicals. Several forms of water pollution are identified such as organic pollution, the liberation of organic matter into water bodies, food and drink processing, untreated household manure, domestic animals wastes, textiles, tanneries etc. Most of solid waste garbage is directly dumped in rivers, drains, streams, and creeks. Water becomes polluted, foul smelling and severely degraded (Sanjrani, 2019; Mahesar 2015; Sanjrani, 2017; Chudhary 2012; PAK-EPA 2005). Safe and clean drinking water is one of the important needs of life and society. Hence, water quality assessment is a very important issue for water resource management.

In Pakistan, the contamination in water has seriously affected the people health. Quality of water in

not suitable for drinking because according to studies conducted in several regions, water quality is above the limit by WHO level standard. In addition, arsenic is present in water in Pakistan which brings several diseases (WHO 2011; Sanjrani, 2017; Sanjrani, 2018; Hansen, Sato, & Ruedy, 2012; Shiklomanov, 1998; Naeem 2012). The situation of arsenic in Sindh province and Punjab province is worse than other provinces of Pakistan. The literature and medical studies have confirmed 40 cases of arsenicosis and recent studies. Based on samples from 1,184 wells across the country, it is concluded that 36% and 16% of population is exposed to arsenic contaminated water over 10 ug/L and 50 ug/L respectively. Studies have proved that the process of boiling or filtration was not efficient to remove Arsenic contamination from groundwater (Sanjrani, 2017; Naeem, 2012; Brahman et al., 2013; WWF 2007). Around the country, studies have identified the water quality has crossed the limit above WHO level standard for the drinking water in several cities including Karachi (Hussain 2007); Tharparkar (Brahman et al., 2013); Peshawar (Zahoorullah, Akhtar, & Zai, 2003; Sarwar, 2004); and Lahore (Anwar 2004). Different types of waterborne diseases are reported. Improper water-supply is also a reason for water pollution in Pakistan. Heavy metals and other dangerous chemicals are caused that Pakistan is at high risk in the sense of water issues. In several cities, the ground water supply has been studied. Studies identified that several pathogens including many viral, bacterial, and protozoan agents in groundwater supply are the main causes for endemic diarrheal disease each year (Sanjrani et al., 2018; Sanjrani et al., 2017; Sci.net 2018; Soomro et al., 2011; Sahu, Rahu, & Behra, 1995; Chilton, 2000, Aziz, 2002, Kosek, 2003). The present research was conducted to examine the water quality characteristics of Rawal Dam Reservoir, Islamabad, Pakistan.

2. Study Area

Study area is Rawal Dam; it is located at 73°13 E 33°71 N in Islamabad city at the foothill of Margalla and Murree Hills. It was built across the Korang Nullah in 1960. Across the Korang River the climate of the region is mostly humid subtropical. It supplies water for domestic purposes to two cities, Islamabad and Rawalpindi. This 700-foot-long concrete dam has a storage capacity of 47,500 acre feet; it not only supplies drinking water to the twin cities but also irrigates a 500-acre area (Ali & Malik, 2010).

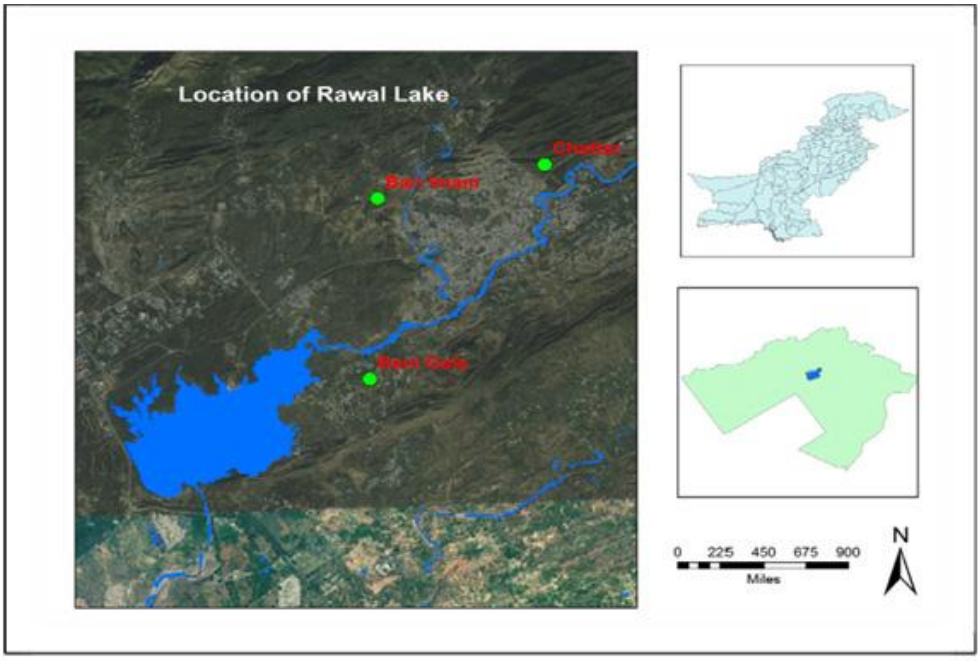

Figure 1: Map showing the entire Rawal Lake area (Modified from Yousaf 2016)

There is a lake namely Rawal Lake; it situates at the same location in Islamabad (at longitude 73°07 E, latitude 33°42 N, and altitude of 1,800 m), also it is at the distance of 10kms from the Rawalpindi city. Islamabad and Rawalpindi get drinking water from this lake, around 22 million gallons for each day. The normal temperature ranges from 15◦C in January to 37◦C (98.6◦F) in June. The surface territory of lake is around 8.8 km2. The most extreme profundity of repository is 31 m. The catchment territory of Rawal Dam can be partitioned into three zones to be specific Noorpur, Kurrang, and Shahdara. The aggregate catchment zone of the lake is 268 km2 (Ali & Malik, 2010). Salient features of Rawal Dam are shown in Table 1.

Table 1: Salient features of Rawal Dam

Descriptions	Details
Purpose of Dam	Irrigation and municipal water supply
Type of dam	Earth and rock fill
catchment area	106 sq. miles –miles
Gross capacity of reservoir	47,500-acre feet
Live storage capacity	43,000-acre feet
Irrigation outlet sluice length	665 ft.
Number of irrigation canals	2
Purpose of RBBC*	Drinking water supply to Rawalpindi
Capacity of RBBC	70 ft^3/s (2.0 m^3/s)
Purpose of LBBC**	Irrigation
Length of LBBC	40 ft^3/s (1.1 m^3/s)
RBBC* LBBC*	Right Bank Branch Canal Left Bank Branch Canal

3. Methodology

Sampling was performed in March. Total 11 samples were randomly collected from different locations of the study area. All the water samples were tested for physical and chemical by using standards methods employed by WHO and ASTM. Physiochemical analysis was done in the lab (Pakistan environmental protection agency). Data analysis was done and presented in graphical representation.

3.1 Sampling (Rawal Dam Water Collection)

Samples were collected in 1 liter of plastic bottles washed with detergents and rinsed with distilled water. Sample water was taken from surface of streams and Rawal Dam. Samples collection was done from different sides of the Catch mate area of Rawal Dam, such as societal, agriculture, Rawal Dam lake surface runoff and Centre of the dam etc. Sampling was done with proper way to ensure that no unwanted sediments enter the bottles. Cap of the bottles were sealed with tape. Bottles were dried and coded. Sample code and location are shown in Table 2.

Table 2: Rawal Dam samples code location

Sample Code	Location of Sample
Sample 01	Stream from Bidhva Village
Sample 02	Stream from Ghoraghali
Sample 03	At Chatar Park
Sample 04	Bharia Enclave
Sample 05	Shahpure
Sample 06	Bani Gala
Sample 07	Stream from Shahdra
Sample 08	Stream From QAU
Sample 09	Bare Imam
Sample 10	Diplomatic Enclave
Sample 11	Mid of Rawal Dam

3.2 Water Quality Parameters and Analysis Methods

All the water samples were tested for physical and chemical by using standards methods employed by WHO and ASTM. Physiochemical analysis was done in the lab (Pakistan environmental protection agency). Data analysis was done and presented in graphical representation. Different physiochemical parameters were analyzed with analytical methods which are shown in Table 3.

Table 3: Water Quality Parameters and analysis methods

Sr#	Parameter	Analytical technique used
01	TDS	TDS Meter
02	Color	Visual / color kit
03	Turbidity	Turbidity Meter
04	Electrical conductivity	Conductivity meter
05	pH	pH meter
06	Total Hardness	Complex metric titration
07	Alkalinity	Acid – Base titration
08	Temperature	Thermometer
09	Total Hardness	Complex metric titration
10	Alkalinity	Acid – Base titration
11	Chloride	Argent metric titration
12	Phosphate	UV Visible Spectrophotometer
13	Sulfate	UV Visible Spectrophotometer
14	Dissolved oxygen	Redox titration
15	Biochemical Oxygen Demand (B.O.D.)	Incubation followed by titration
16	Chemical oxygen demand (C.O.D	C.O.D. digester

4. Result and Discussion

All the physiochemical characteristics of different water sampled are shown in Figure 2. As pH is one of the important parameters to be checked. Conductivity and pH of water samples taken from Rawal Dam were found as 7.71 to 8.95 and 611 to 1522 µS/cm respectively. Pak-EPA standard for Conductivity and pH is 6.5 to 8.5 and 1000 µS/cm respectively, so it concludes the Conductivity and pH level in Rawal Dam and different stream water is satisfactory as shown in Figure 2. While the temperature of water samples fluctuated from 30.6 C° to 31.7 C°, it is shown in Figure 2. The average (mean) temperature of the study area was 31.15 C°. It shows the lower temperature in sample near Shahadra and maximum at bharia and shahpure sites.

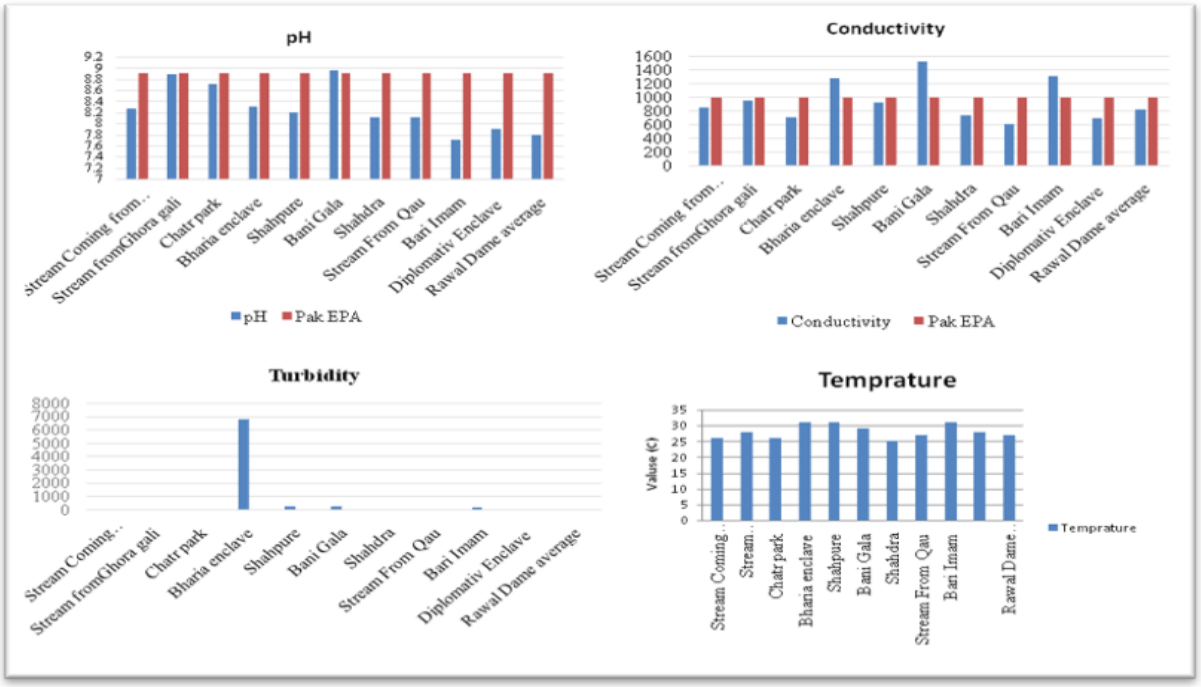

Figure 2: Water sample analysis for pH, conductivity, turbidity and temperature

Figure 2 illustrates the turbidity variations in surface water of different sites. The main cause of turbidity could be suspended matter, such as clay silt finely divided organic and inorganic matter, soluble colored organic compounds, planktons and another microscopic organism. The highest value of turbidity was observed in sample from zero to 6790 NTU) maximum turbidity was in sample Bharia enclave because this area was under construction of new colony by the Bharia town. According to WHO standards and Pakistan national drinking water quality standards, the turbidity of drinking water should be less than 5 ntu. The few water samples had turbidity values within the permissible limits of WHO and NSDWQ other sample had above the permissible value. Generally, Turbidity reduces the clarity of water and increases the muddiness and dirt in the water. Samples were tested for TSS level, results show the range was 74 to 2115 mg/l as Pak-EPA limit is 200 mg/L, respectively as shown in figure 3. Sample from Bani Gala was found to have maximum TSS level and sample from Shadhra sites was found to have minimum TSS level. For TDS, all the samples had below permissible limits of Pak-EPA and WHO which is < 1000 mg/L respectively as results shows that TDS ranged from 410 to 1241 shown in figure 3. Maximum levels of total solids were found near Rawal dam i.e. 3126 mg/l and minimum total solids were found in the tube water from Shahdara i.e. 622mg/L. TS are composed of carbonates, bio carbonates, chlorides, potash, magnesium etc. This can be caused by the turbidity. Due to contamination of domestic waste water, garbage, fertilizer in the natural surface water the TS was reported to be high.

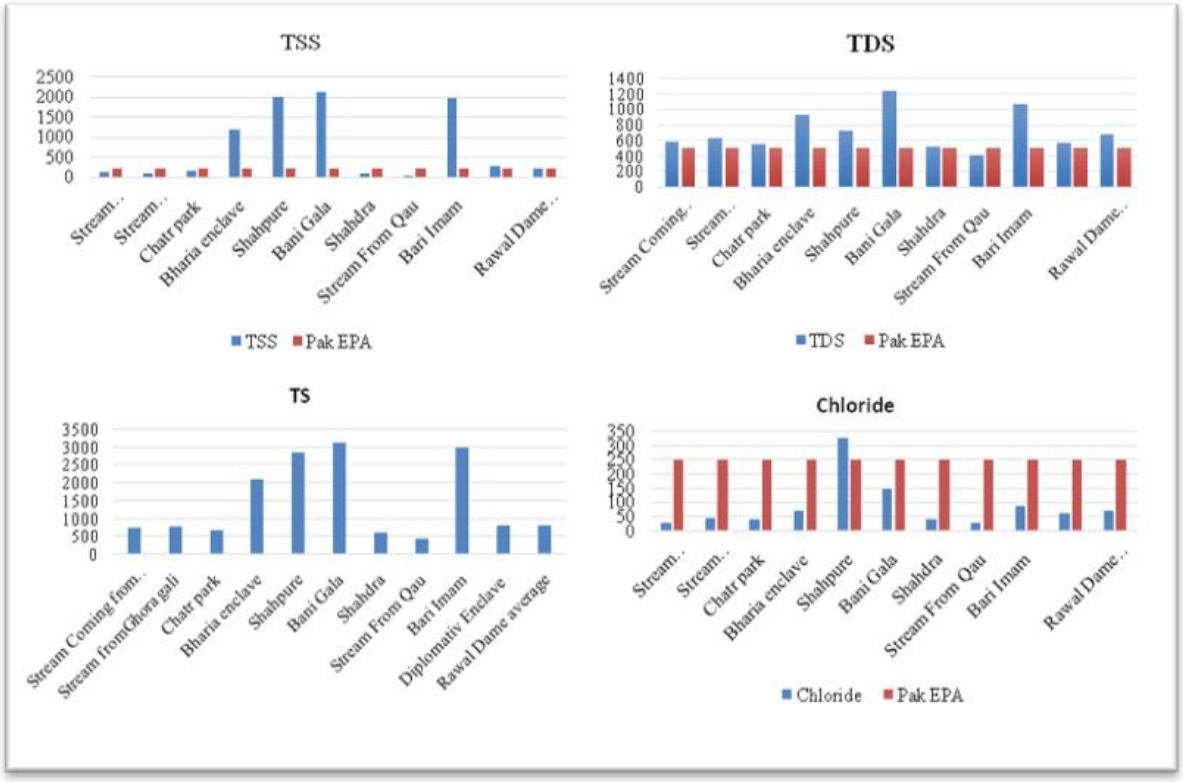

Figure 3: Water sample analysis for TSS, TDS, TS and chloride

Laboratory testing of Rawal Dam and their streams water samples for chloride were analyzed and their results were ranged from 27.993 to 146 Pak-EPA standard limits for chloride range is < 250 mg/l respectively as shown in Figure 4. Pak-EPA standard limit for drinking water is 250 mg/L. Comparing the values with standard limit of Pak-EPA the results showed within the permissible limits. It concludes that the sample results of Chloride level in area of Rawal dam showed satisfactory level except Bani Gala where is very high. There are no known impacts of chloride; however, table salt is linked to kidney and heart diseases. Sodium Chloride may impact a salty taste at 250 mg/l; however, Calcium or Magnesium Chloride is usually detected by taste until levels of 1000 mg/l are reached. Public drinking water standards require chloride level not to exceed 250 mg/l.

Decomposition of dead plants and animals increases the levels of alkalinity. The alkalinity of water is caused mainly due to OH, CO3, HCO3 ions. In this study, alkalinity was the maximum 173 mg/L from the samples of Ghora gali and maximum 331 mg/L in surface water near bani gala. While hardness was also checked, hardness is caused by the evaporation and the mixing of calcium and magnesium. The streams from Banni gala had the maximum hardness i.e. 1517 mg/l, whereas, three streams from chattar park had hardness in the water i.e 405 mg/ shown in Figure 4.

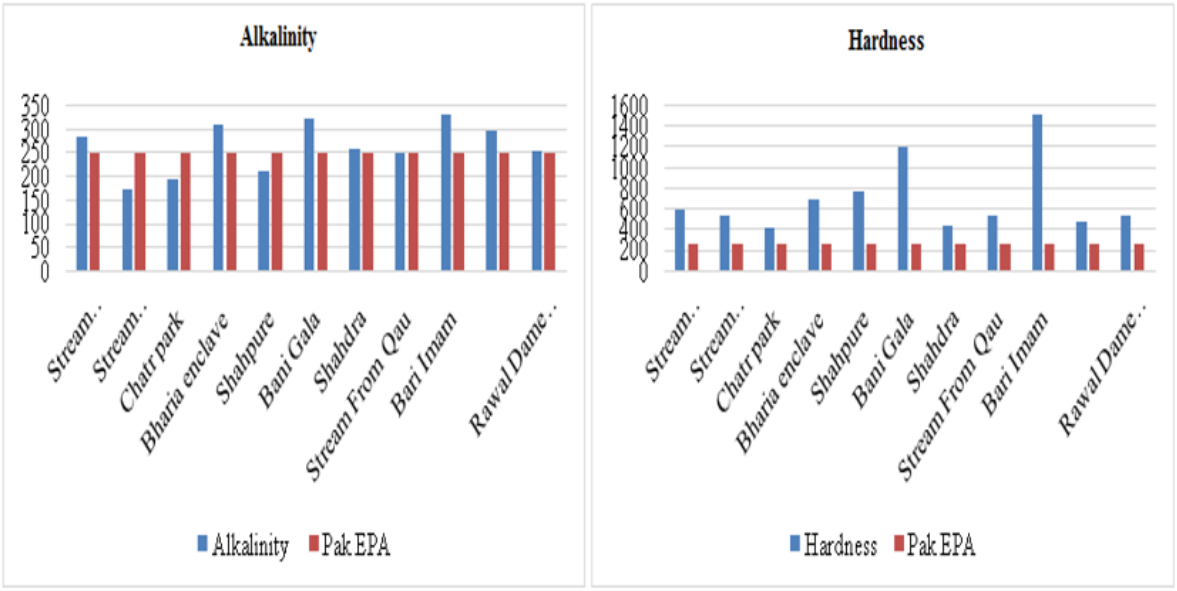

Figure 3: Water sample analysis for alkalinity and hardness

The presence of sulfur-compounds in water can have a distinctive taste. Although there has been no health impact derivations from the sulfates, there is the direction of notifying the authorities, if the sulfates increase the 500 mg/L limit (WHO, 2011). The sulfate in different sites is varied between 14mg/l to 96 mg/l in Figure 5 shows higher value of sulphate in sample 05 (Shahpure) and lower value in a sample 07 (Shahdra) with the mean value of 2.495 mg/l . The sulfate level is within the acceptable range according to the WHO standard. Figure 5 shows the content of sulfate present at different sampling sites in different streams as well in Rawal Dam. While Phosphate level is found higher in sample 09 Bani Gala i.e. 79 mg/L where as it is found minimum in surface water along village shadra in Rawal Dam Streams i.e.11 mg/L. No major increase was found in the Rawal Dam and the tap water in the areas around.

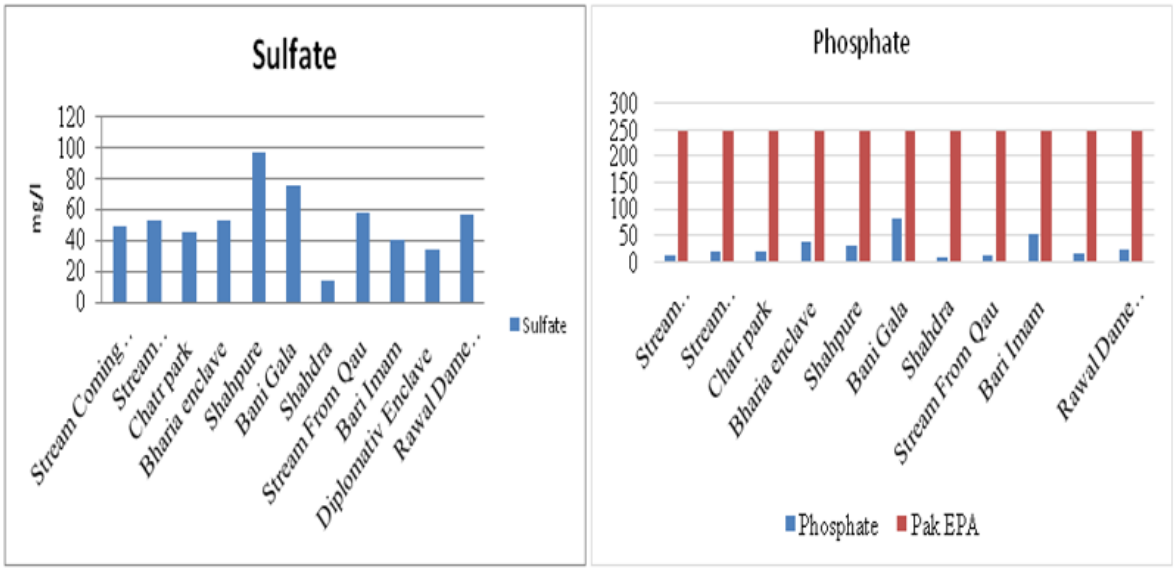

Figure 4: Water sample analysis for sulphate and phosphate

Dissolved oxygen (DO) is important parameter to be analyzed in water. Higher oxygen levels determine the health of the water quality. The dissolved oxygen concentration drops substantiality as water temperature goes up. Heavy organic pollution loads cause a sharp decrease of DO as bacteria use it up rapidly in decomposing the organic material. The values of dissolved oxygen are presented in Figure 6, the highest values of dissolved oxygen for Rawal Dam streams was 5.29.1mg/l whereas the highest values of dissolved in streams water was observed in sample 07(Shahdra) ranging 5,29 mg/l and minimum value was observed in three sample 05 (Shahpure) sample 06 (Bani Gala) and sample 09 (Bari Imam) ranging 0.17 mg/l.

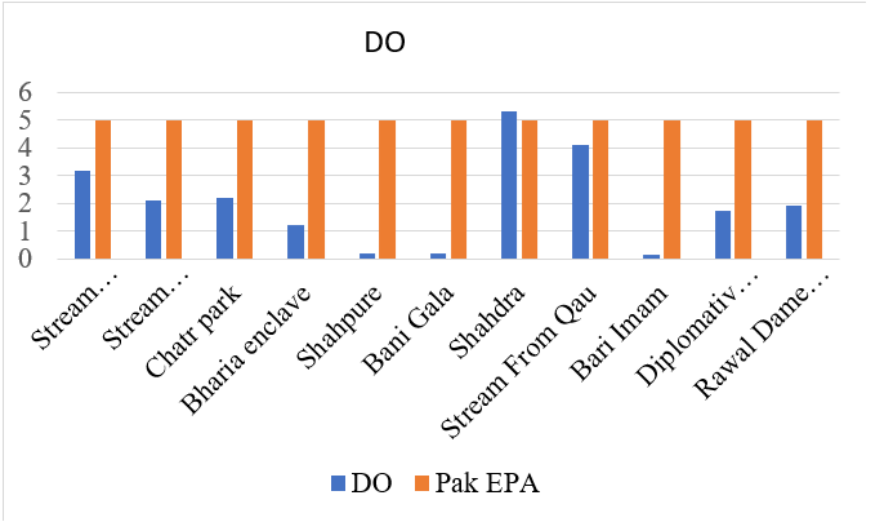

Figure 5: Water sample analysis for DO

Biodegradable waste present in the water acts as a nutrient for the growth of the plants and algae in the water. The BOD test shows the amount of oxygen consumed by the microorganisms to decompose that organic matter. Figure 7 shows the BOD present at different sampling sites in

different streams as well in Rawal Dam. BOD results in different sites is varied between 39mg/l to 196 mg/l, Figure 7 shows higher value of BOD in sample 09 (Shahpure) and lower value in a sample 07 (Bidhva) with the mean value of 196 mg/l . In addition, overall, the COD of the samples during investigation was high. Average COD of the wells was from 33.8 mg/L, and improved to 12.3 mg/L in dry season. Though the max value of 40.9 mg/L was recorded for water sample from well B1 during rainy season, this value is still below 50mg/L of the standard. Figure 7 shows that the COD values of Bani Gala and Bari Imam are much higher than the standard while other sampled locations are under the standard value.

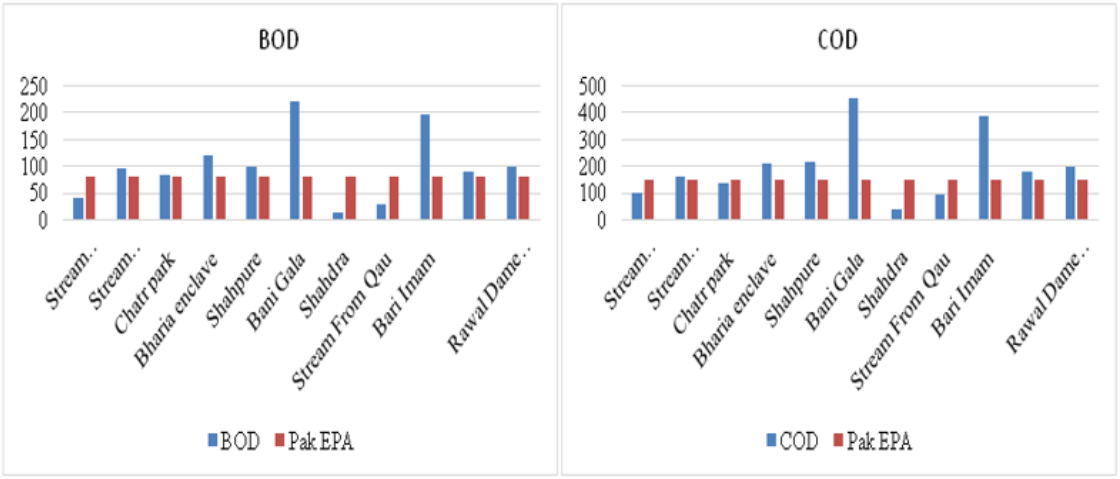

Figure 6: Water sample analysis for BOD and COD

5. Conclusion and Recommendations

The current study was directed to examine the physicochemical characteristics along the catchmate area of Rawal Dam Reservoir, Islamabad, Pakistan. Samples were collected from main streams, runoff, society and mid of the Dam. Physicochemical parameters were assessed by using standard methods. The results obtained showed that pH level was maximum along Bani Gala from Pak-EPA given a permissible limit. Conductivity was mostly high than the permissible limit. It showed the maximum level. Total Suspended Solids were maximum in Bani Gala stream it does not have a permissible limit. Total Dissolved Solids were maximum 1241 in near Bani Gala stream but some samples were in the permissible limit. Chloride was maximum in Pre- and minimum in Post monsoon, there was no sample above the permissible limit. Hardness level was maximum in different streams locations but mostly samples were above from the permissible limit. Sulfate and phosphate were also assessed in the same sample by using UV/ absorption spectrophotometer. Concentration of sulfate and phosphate level was maximum inmostly location of streams and Rawal dam, all the samples were above the permissible limit. DO was in ranged between 0.17 to 5.2. All the samples were below permissible limit. COD was, all the samples were not in the permissible limit. The values of different parameters of Rawal Dam water indicated their levels are above permissible limit, mostly samples have shown above than permissible limit. It is concluded that drinking water of the study area postures a serious threat to the living peoplesand to the people who drink it. Recommendations are given below:

1. Waste water effluents and chemicals should be treated before releasing into the Rawal Dam water

2. Environmental protection agency should inspect all the paraments of water before supplying to the public and ensure the health of aquatic organism by monitoring the effluents.
3. Mitigation programs should be monitored on a regular basis before releasing of chemical in Rawal Dam water.
4. There should be sign board display to aware the public about the clean environment of Rawal Dam, do not dump the garbage in the water.
5. Ensuring the availability of harmless drinking water to all residents of Pakistan should be the part of the manifestos of all political parties.
6. NGOs should take some steps and bring awareness to the people.

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Supplementary Data:

	TDS	pH	TSS	TS	Color	Turbidity	conductive	Temp:	Odor
Stream from Bidhva Village	583	8.26	129	752	11.35	--------	648	26	No Odor
Stream from Ghoraghili	621	8.88	96	798	2.98	--------	955	28	No Odor
At Chatar Park	556	8.72	128	681	6.05	--------	712	31	No Odor
Bharia Enclave	928	8.35	1174	2122	228.5	6790	1288	31	No Odor
Shahpure	715	8.26	1976	2856	594	198.5	926	29	smell
Bani Gala	1241	8.95	2115	3126	37	233.5	1522	25	smell
Stream from Shahdra	510	8.16	74	622	00	-------	728	27	No Odor
Stream from QAU	410	8.1	26	448	00	16.2	611	19	No Odor
Bare Imam	1068	7.71	1956	2998	23.28	128.9	1315	31	Smell
Diplomatic Enclave	559	7.95	282	816	10.34	12.8	698	28	Smell
Rawal Dam	688	7.89	199	826	9.21	8.2	821	27	Smell

	Alkalinit	Hardness	Chloride	Phosphate	Sulphate	COD	DO	BOD
Stream from Bidhva Village	286.4	586.4	27.99	11	48.88	96	3.18	39
Stream from Ghoraghili	173	542.4	43.25	18.65	52.44	158	2.08	96
At Chatar Park	193	405.2	37.39	17.64	44.5	138	2.18	84
Bharia Enclave	312	698	70.85	35.58	52.1	210	1.20	121
Shahpure	213.2	764	329.5	31.5	96.7	215	0.185	98
Bani Gala	325	1198	146	79.8	75.5	456	0.19	221
Stream from Shahdra	260	426	39.6	9.11	14	38.5	5.29	11.5
Stream from QAU	249	534.4	27.34	11.24	58.7	91.5	4.11	28.1
Bare Imam	332	1517	87.10	53.85	39.85	391	0.17	196
Diplomatic Enclave	300	480	60	15	34.7	179	1.72	88.5
Rawal Dam	255	543	71	20.5	65.1	198	1.92	97.9