

Determination of Water Quality Index of Simly Dam, Islamabad by Arithmetic Weighted Method

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Abstract: Water quality is of great importance due to its impact on human health and aquatic systems. Since Islamabad and Rawalpindi get their drinking water from Simly dam, this makes it an important drinking water source. In this study water quality parameters of Simly dam were determined and water quality index (WQI) using Arithmetic weighted method was calculated. Collection of water samples from different locations of dam and the filtration plant installed in the facility was done. Twelve physicochemical parameters of water quality including: p^H , Electrical Conductivity (EC), Total Dissolved Solids (TDS), alkalinity, hardness, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Chloride, Calcium, Nitrates, Potassium and Sodium (Na) were measured to estimate the sentiment and water quality of the Simly dam. WQI of both raw dam water and filtered dam water was determined using World Health Organization (WHO) standards for drinking water. The water quality index of raw dam water was found to be 62.79 while that of filtered dam water was 49.43. The WQI of the unfiltered raw dam water was found to be in class C that is poor category, while the filtered dam water was falling in Class B that refers to good category according to water quality index categories. Regular monitoring of water quality is recommended to ensure safe water supply to consumers.

Keywords: Water quality analysis, water quality index, Simly dam, physicochemical parameters, weighted arithmetic.

Introduction

The Simly dam is located 30km east of Islamabad on river Soan of Rawalpindi district. The purpose of reservoir is to provide drinking water to residents of Islamabad. It is situated between 33°43'08" N and 73°20'25"E. Simly dam is the largest reservoir with total depth of about 2,300 ft. The main sources of water Simly dam are Murree nala and rainwater (Qaiser et al., 2014). Water quality is of great importance due to its impact on human health and aquatic systems (Iqbal et al., 2019). Anthropogenic influences and activities lead to detrimental effects on water (Azizullah et al., 2011; Saeed and Hashmi, 2014; Iqbal et al., 2020; Khalil et al., 2020; Rahman et al., 2020). The release of domestic and industrial wastes contaminates the rivers and water reservoirs. Human development and growth exert a great amount of pressure on the water quality, its resources and access to them. Water quality includes the chemical, biological and physical characteristic of water (Imneisi and Aydin, 2016; Shirani et al., 2018; Subedi et al., 2019; Li et al., 2020).

Water quality index (WQI) is used for clear and brief representation of water quality for the public coverage, this resembles the UV or air quality index. The criteria of WQI have been used by various studies to assess the water quality and its use for various purposes. A study was conducted on lower Jhelum canal and its suitability for irrigation. The water quality was fit for irrigation with the quality matching to excellent (Iqbal et al., 2020). Another study on Godavari river at Nashik was carried out by using WQI. They inferred

that WQI criteria should be used by the municipal corporation for surface water quality assessment for human consumption (Nayak et al., 2020). Similarly, the evaluation of surface and ground water quality of Haripur basin was carried out and assessment based on water quality index (Nayak et al., 2016). The hazard quotient was found to be having no health risk (Jabeen et al., 2014).

In a study, water quality of fresh water springs was determined. Various physicochemical and heavy metals were found within WHO standards (Jamil et al., 2018). Another work using WQI determined in groundwater to find the impacts of pollution due to brick kilns in the area. It showed poor quality for drinking purpose (Khanoranga and Khalid, 2018). Previously water quality index was also determined for presence of nutrients, metals and other chemical parameters in water and sediments of Soan river and its tributaries. WQI data indicated the effect of human settlement and activities on water quality (Ghumman, 2011; Toor et al., 2013; Nazeer et al., 2014).

Mainly the WQI data are calculated by comparing the water quality data to certain standard value of drinking water of the required area. The WQI tests the surpassing of water quality, frequency and amplitude and then combines all these measurements into one common assessment value. Water quality parameters used in these indices differ by number and types (Tahera et al., 2016). Previous studies report hydrological modeling and land use change pattern of the Simly dam area (Butt et al., 2015). Other studies on Simly dam indicate the presence of various

pesticides in Simly dam (Iram et al., 2009). The bacteriological analysis of various water reservoirs including Simly dam has also been reported previously (Ahmed et al., 2004; Qaiser et al., 2014). The monitoring of water quality of this drinking water reservoir is important for the supply of safe drinking water and health of consumers.

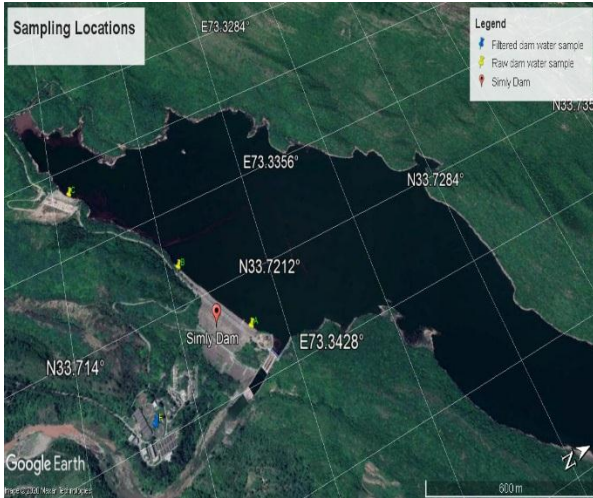


Fig. 1 Satellite image of Simly dam sampling locations.

Keeping in view the significance of WQI concept and its applications in environmental studies and data analysis, the present study was designed to calculate the WQI for Simly dam based on evaluation of physicochemical parameters of water quality.

Materials and Methods

Sampling was done during September to November 2019 and collection of samples was twice. The water samples were collected in 500ml plastic carried out bottles according to standard protocols. Samples were collected at two different locations in Simly dam i.e. directly from Simly dam (before filtration) and from filtration plant (after filtration) of Simly dam (Fig. 1).

For raw dam water, the samples were collected from three different locations across the dam coded as A, B and C with five sublocations each. For the filtered water, five water samples were collected from filtration plant directly and coded as F1-F5. The WQI of the both raw and filtered water was determined for physicochemical parameters namely; pH, electrical conductivity (EC), TDS total dissolved solids (TDS), dissolved oxygen (DO), BOD Biological oxygen demand (BOD), Total hardness, Total alkalinity. Various ions including Calcium (Ca⁺), Sodium (Na⁺), Potassium (K⁺), Total chloride (Cl⁻) and Nitrate (NO₃⁻) were also determine. All the tests of physicochemical parameters were carried out according to standard protocols (APHA, 2005).

WQI used in this study is the weighted arithmetic method. The Index was calculated from physicochemical parameters with respect to WHO and

Pakistan Standards and Quality Control Authority (PSQCA) standards (Table 1). In present study, WQI was calculated by methods proposed by Horton and modified by Tiwari and Mishra (1985) and Kuttmani et al. (2017).

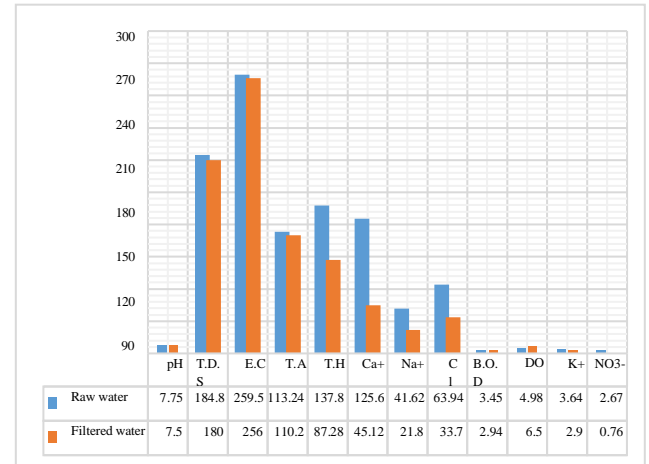


Fig. 2 Comparison of physicochemical parameters of raw and filtered water samples

Table 1: WQI rating levels and status.

WQI Value	Rating of Water Quality	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very Poor	D
Above 100	Unsuitable for Drinking	E

Results and Discussion

The average value of all water quality parameters showed better quality in samples collected from filtration plant. Electrical Conductivity is a useful tool to assess the purity of water (Chandra et al., 2017). Standard limit for EC is 300µS/cm according to US EPA. EC average value in the raw dam water was 259.5 µS/cm, while the EC in filtered water samples was found to be 256 µS/cm. Previous reports on Simly dam water quality showed the TDS value of 192 mg/l and pH value of 8.2 (PCRWR, 2007). The permissible limit of TDS for drinking water is 1000 mg/l (WHO, 2010). Both locations have TDS values well within the permissible limit. The pH, alkalinity and hardness values were also within limit.

The standard value of DO levels is greater than 4 mg/l. The samples of raw dam water consisted of DO with an average of 4.98 mg/l. While the filtered dam water showed DO concentration of an average of 6.5 mg/l. Unpolluted, natural waters should have a BOD of 5 mg/l or less (WHO, 2010). The samples of raw dam water had BOD in the range of 2.1 to 4.5 mg/l with average value of 3.45 mg/l. While the filtered dam water showed BOD values ranging from 2.8 to 3 mg/l, with an average value of 2.94 mg/l.

Soan river provides water to Simly dam. The Soan River is an important stream of the Pothohar or North Punjab region of Pakistan. It drains much of the water of Pothohar. It starts near the small village of Bun in the foothills of Patriata and Murree (Qaiser et al., 2014). The low value of BOD may be due to dilution factor after rainy season in the area. However,

according to WQI rating. The filtered water reduced mineral contents far below the permissible limit, which makes the filtered water suitable for drinking purpose. Thus, that the filtration plant installed at Simly dam is working efficiently as indicated by the reduced amounts of the salts content after filtration.

Table 2 Mean values of physicochemical parameters of raw dam water samples.

Sr#	Samples	p ^H	EC	TDS	Alkalinity	Hardness	BOD	DO	Ca+	Na+	K+	NO ₃ ⁻	Cl ⁻
		-	μS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	A1	7.79	264	187	101.2	134	3.28	5.6	127	35.95	3.2	2.5	55.2
2	A2	7.71	259	184	94	126	4.0	5.2	117	36.91	3.5	2.8	56.6
3	A3	7.73	254	181	115	136	3.5	4.9	125	57.6	3.1	2.6	88.5
4	A4	7.79	261	186	123.2	136	3.3	5.1	128	34.56	3.3	2.2	53.1
5	A5	7.77	260	185	98	152	4.5	4.8	134	52.98	3.2	2.4	81.4
6	B1	7.82	263	187	120	146	2.1	4.46	130	55.98	3.5	2.9	86.0
7	B2	7.73	255	182	98	138	2.2	4.5	124	35.25	4.1	3.0	54.1
8	B3	7.81	262	186	111.2	132	3.3	4.8	124	38.24	3.4	2.8	58.7
9	B4	7.83	259	184	124	144	3.1	4.4	122	39.12	4.2	3.1	60.1
10	B5	7.75	254	181	128	144	2.9	4.7	126	36.86	3.9	2.5	56.6
11	C1	7.65	263	187	116	134	3.9	5.6	122	33.62	3.5	2.9	51.6
12	C2	7.68	261	186	118	139	4.1	5.5	128	37.5	3.8	2.6	57.7
13	C3	7.72	257	185	114	134	3.8	5.1	127	46.8	3.9	2.3	71.8
14	C4	7.70	260	185	118	138	4.0	4.9	124	43.74	4.0	2.8	67.2
15	C5	7.79	261	186	120	134	3.7	5.2	127	39.2	4.1	2.6	60.1
Mean Value (Vn)		7.75	259.5	184.8	113.24	137.8	3.45	4.98	125.6	41.62	3.64	2.67	63.94

variation in the values may be expected at different locations and during sampling period. The samples of raw dam water and filtration plant had average nitrates values of 2.67 and 0.76 mg/l within WHO guideline (10mg/l).

Chloride is an indicator of salinity in water. The samples of raw dam water showed average chloride concentration of 63.94 mg/l. While the filtered dam water showed less concentration of chloride. The permissible limit for chlorides in drinking water is 200 mg/l (WHO, 2010). The calcium concentrations in samples of raw dam water ranges between 117 to 134 mg/l. While the filtered dam water showed calcium concentration with average value of 45.12 mg/l. Potassium is the most important mineral occurring naturally. The study locations showed values of sodium content within permissible limits. The previously reported values of Flouride and Iodide ions in Simly dam water are 0.34 and 0.212 mg/l respectively (Ahmed et al., 2004).

The results of the WQI showed that the raw water from Simly dam has a WQI of 62.79 that falls in the “poor” category in the class C of the WQI rating. While the filtered water has a WQI of 49.43 that falls in the “good” category in the class B of WQI ratings (Fig. 3)

The statistical analysis of Simly dam water was done to determine the water quality. The calculations of physicochemical parameters of dam water showed the poor water quality of dam water because of the presence of high quantity of minerals in water. The water is still drinkable as all parameters are within permissible limits but not suitable for drinking purpose

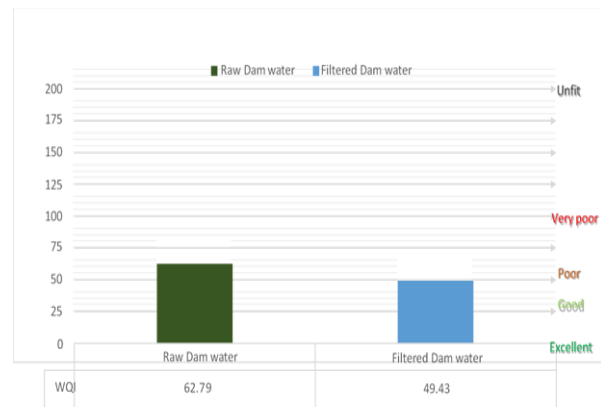


Fig. 3 WQI rating of study area (Dam raw water samples and filtered water samples)

The physicochemical analysis results of the dam water and filtered water of dam samples were compared with the WHO, PSQCA, US EPA, NSDWQ (2010) drinking water specification. The results of present study are in accordance with previous reports as the WQI of the water reservoirs gets lowered due to pollution sources and anthropogenic activities from surrounding areas (Saeed and Hashmi, 2014; Khalil et al., 2020) as in case of Rawal lake reported previously in different studies (Ghumman,2011; Toor et al., 2013). It was reported that quality of water was comparatively better in pre-monsoon season in Rawal lake and other water reservoirs (Edwards and Withers, 2008). The water quality in canal of lower Jehlum was found in excellent quality category (Bashir et al., 2020). Another study reported that WQI was low in areas polluted due to sewage and found relatively better in downstream areas (Reza and Singh, 2010).

Table 3 Mean values of physicochemical parameters of filtered water sample.

Sr No	Samples	pH	EC	TDS	Alkalinity	Hardness	BOD	DO	Ca+	Na+	K+	NO ₃ ⁻	Cl ⁻
			µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	F1	7.61	258	180	112.2	80	3.0	6.5	54.6	23.0	2.9	0.76	35.4
2	F2	7.3	255	178	108	88	2.9	6.6	41.2	23.6	3.0	0.70	36.4
3	F3	7.55	257	182	108.5	96	3.0	6.5	42.6	207	2.9	0.80	31.8
4	F4	7.6	258	180	112	83.2	3.0	6.6	48.0	19.1	2.8	0.81	29.3
5	F5	7.4	253	180	111	89.2	2.8	6.6	39.2	23.0	2.9	0.75	35.4
Mean Value (Vn)		7.5	256	180	110.2	87.28	2.94	6.5	45.12	21.8	2.9	0.76	33.7

Overall, the water quality of Simly dam shows its suitability for agricultural purpose and the filtration plant is efficient enough to reduce the levels of various parameters of water quality to put it under good category. In this way WQI helps to assign a status of water quality for water reservoirs and other sources.

Conclusion

The study indicates the water quality of Simly dam raw and filtered water and the WQI scores for both water sources. The analysis of filtered water showed that the water quality comes in class B grading which refers to good water quality indicating the filtered water from Simly dam is suitable for drinking purpose. However, the Water Quality Index of raw dam water was found to be in poor category of the WQI ratings and falls in class C. It signifies the need for protection and proper management of water reservoirs in country.

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