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; Khalid 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 Ihelum 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 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 (Tabera 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.

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 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), total dissolved solids (TDS), dissolved oxygen (DO), BOD Biological oxygen demand (BOD), Total hardness, Total alkalinity. Various ions including Calcium (Ca²⁺), 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 physiochemical 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).

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 had DO 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, the low value of BOD may be 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., 2011). 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 2 Mean values of physicochemical parameters of raw dam water samples.

| Sr# | Samples | pH | EC | TDS | Alkalinity | Hardness | BOD | DO | Ca+ | Na+ | K+ | NO3 | Cl- |
|-----|---------|----|----|-----|------------|----------|------|----|-----|-----|----|-----|-----|
| 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  | 4.6 | 130 | 55.98 | 3.5 | 2.9 | 86.0 |
| 7   | B2      | 7.75 | 253 | 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 | 35.62 | 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 | 183 | 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 | 39.72 | 4.1 | 2.6 | 60.1 |
| Mean Value (Vu) | 7.75 | 259.5 | 184.8 | 113.24 | 137.8 | 3.45 | 4.98 | 125.6 | 41.62 | 3.64 | 2.67 | 63.94 |

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).
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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References

Ahmed, R., Vigar-un-Nisa, Hussain, M., Tanwir, R., Qureshi, S. A. (2004). Monitoring of fluoride and iodide levels in drinking water using ion selective electrodes. The Nexus, 41(1-4), 51-58.

Ahmed, T., Kanwal, R., Tahir, S. S. Rauf, N. (2004). Bacteriological analysis of water collected from different dams of Rawalpindi/ Islamabad region in Pakistan. Pakistan Journal of Biological Sciences, 7(5), 662-666.

APHA (2005). Standard methods for the examination of water and wastewater. 21st edition, American Public Health Association. Washington DC. http://cp-analitika.hu/reagecon/reageconapha2.pdf

Azizullah, A., Khattak, M.N.K., Richter, P., Hader, D.P. (2011). Water pollution in Pakistan and its impact on public health: A review. Environment International, 37, 479-497.

Bashir, N., Saeed, R., Afzaal, M., Ahmad, A., Muhammad, N., Iqbal, J., Khan, A., Maqbool, Y., Hameed, S. (2020). Water quality assessment of lower Jhelum canal in Pakistan by using geographic information system (GIS). Ground water for Sustainable Development, 10, 100357.

Butt, A., Shabbir, R., Ahmad, S. S., Aziz, N. (2015). Land use change mapping and analysis using Remote Sensing and GIS: A case study of Simly watershed, Islamabad, Pakistan. The Egyptian Journal of Remote Sensing and Space Science, 18(2), 251-259.

Chandra, D. S., Asadi, S. S., Raju, M. V. S. (2017). Estimation of water quality index by weighted arithmetic water quality index method: A model study. International Journal of Civil Engineering and Technology, 8, 1215-1222.

Edwards, A., Withers, P. (2008). Transport and delivery of suspended solids, nitrogen and phosphorus from various sources to freshwaters in the UK. Journal of Hydrology, 350, 144–153.

Ghumman, A.R. (2011). Assessment of water quality of Rawal lake by long-time monitoring. Environmental Monitoring and Assessment, 180, 115–126.

Imneisi, I., Aydin, M. (2016). Water quality index (WQI) for main source of drinking water (Karaçomak dam) in Kastamonu City, Turkey. Journal of Environmental and Analytical Toxicology, 6, 5. DOI: 10.4172/2161-0525.1000407

Iqbal, J., Shah, N.S., Sayed, M., Imran, M. (2019). Synergistic effects of activated carbon and nanozerovalent copper on the performance of hydroxyapatite-alginate beads for the removal of As3þ from aqueous solution. Journal of Cleaner Production, 235, 875–886.

Iqbal, J., Shah, N.S., Sayed, M., Muhammad, N. (2020). Deep eutectic solvent mediated synthesis of ceria nanoparticles with the enhanced yield for photocatalytic degradation of flumequine under UV-C. Journal of Water Process Engineering, 33, 1010-12.

Iram S., Ahmad I., Ahad K., Muhammad, A., Anjum, S. (2009). Analysis of pesticides residues of Rawal and Simly lakes. Pakistan Journal of Botany, 41(4), 1981-1987.

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

| Sr No | Samples | pH | EC | TDS | Alkalinity | Hardness | BOD | DO | Ca²⁺ | Na⁺ | K⁺ | NO₃⁻ | Cl⁻ |
|-------|---------|----|----|-----|-----------|----------|-----|----|------|-----|----|------|-----|
|       |         | µS/cm | mg/l | 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 |
Jabeen, M.T., Shah, I. Ahmed S., Khan, M.Q. (2014). Physico-chemical parameters of surface and ground water and their environmental impact assessment in the Haripur Basin, Pakistan. Journal of Geochemical Exploration, 138, 1–7.

Jamil, A., Khan, T., Majeed, F., Zahid, D., Zaibullah. (2018). Drinking water quality characterization and heavy metal analysis in springs of Dewan Gorah, District Paliandi, Azad Jammu and Kashmir, Pakistan. International Journal of Economic and Environmental Geology, 9, 33-39.

Khalil, A., Jamil, A., Khan, T. (2020). Assessment of heavy metal contamination and human health risk with oxidative stress in fish (Cyprinus carpio) from Shahpur Dam, Fateh Jang, Pakistan. Arabian Journal of Geosciences, 13, 928. https://doi.org/10.1007/s12517-020-05933-3.

Khanoranga, Khalid, S. (2018). An assessment of groundwater quality for irrigation and drinking purposes around brick kilns in three districts of Balochistan province, Pakistan, through water quality index and multivariate statistical approaches. Journal of Chemical Exploration, 197, 14-26. https://doi.org/10.1016/j.jcexpl.2018.11.007.

Kuttimani, R., Raviraj, A., Pandian, B. J., and Gouranga K. G. (2017). Determination of water quality index in coastal area (Nagapattinam) of Tamil Nadu, India. Chemical Science Review and Letters, 6, 2208-2221.

Li, L., Iqbal, J., Zhu, Y., Wang, F., Zhang, F., Chen, W., Wu, T., Du, Y. (2020). Chitosan/ Al2O3-HA nanocomposite beads for efficient removal of estradiol and chrysoidin from aqueous solution. International Journal of Biological Macromolecules, 145, 686–693.

Nayak, J. G., Patil, L. G., Patki, V. K. (2020). Development of water quality index for Godavari river (India) based on fuzzy inference system. Groundwater for Sustainable Development, 10, 100350.

Nayak, J.G., Patil, L.G. (2016). Assessment of water quality of Godavari river at Nashik, Maharashtra, India. International Journal of Civil Engineering and Technology, 7, 83-92.

Nazeer, S., Hashmi, M. S., Malik, R. N. (2014). Heavy metals distribution, risk assessment and water quality characterization by water quality index of the Soan river, Pakistan. Ecological Indicators, 43, 262–270.

PCRWR (2007). Water quality status of Pakistan. Fifth Monitoring Report. Publication No. 133-2007.

Quiser, S., Hashmi, I., Nasir, H. (2014). Chlorination at treatment plant and drinking water quality: A case study of different sectors of Islamabad, Pakistan. Arabian Journal of Science & Engineering, 39:5665–5675. DOI 10.1007/s13369-014-1097-4

Rahman, M.M., Howladar, M.F., Hosain, M.A., Mazemder, A.T.M., Numanbakht, M.A. (2020). Impact assessment of anthropogenic activities on water environment of Tillai river and its surroundings, Barapukuria thermal power plant, Dinajpur, Bangladesh. Groundwater Sustainable Development, 10, 100310.

Reza, R., Singh, G. (2010). Heavy metal contamination and its indexing approach for river water. International Journal of Environmental Science and Technology, 7, 785–792.

Saeed, A., Hashmi, I. (2014). Evaluation of anthrogeogenic effects on water quality and bacterial diversity in Rawal lake. Environmental Monitoring and Assessment, 186, 2785–2793.

Shirani, Z., Santhosh, C., Iqbal, J., Bhatnagar, A. (2018). Waste Moringa oleifera seed pods as green sorbent for efficient removal of toxic aquatic pollutants. Journal of Environmental Management, 227, 95–106.

Subedi, N., Lahde, A., Abu-Danso, E., Iqbal, J., Bhatnagar, A. (2019). A comparative study of magnetic Chitosan and graphene oxide modified magnetic chitosan nano composites for efficient removal of Cr (VI) from water. International Journal of Biological Macromolecules, 137, 948–959.

Tahera, A., Jihura, F. T., Akter, F., Chowdhury, T. R., Mistry, S. K., Dey, D., Barua, M. K., Islam, M. A., Rahma, M. (2016). Water quality index for measuring drinking water quality in rural Bangladesh: A cross-sectional study. Journal of Health, Population and Nutrition, 9, 35–50.

Tiwari, T.N., Mishra, M. (1985). A preliminary assignment of water quality index of major Indian rivers. Indian Journal of Environment Protection, 5, 276-279.

Toor, G.S., Han, L., Stanley, C.D. (2013). Temporal variability in water quality parameters a case study of drinking water reservoir in Florida, USA. Environmental Monitoring and Assessment, 1,16 pages.

World Health Organization (2010). WHO guidelines for drinking-water quality, 1. Recommendations, 2. health criteria and other supporting information, World Health Organization, Geneva.