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Research Article

Evaluation of Water Quality and Scarcity Issues for Sustainable Water Management Strategy in Twin Cities of Rawalpindi/ Islamabad, Pakistan

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Abstract

Today's water world is pebbledashed with two main trepidations of water security/ scarcity, which need in-depth elaboration. Developing countries are particularly facing the impacts of water contamination and scarcity but lack the required impetus and technical infrastructure, thus necessitating swift actions to evaluate the effects of water security/ scarcity on the environment and water resources. In this study, an effort has been made to assess the water security/ scarcity situation in the twin cities of Rawalpindi/ Islamabad, elucidating the water quality/ quantity parameters in the Rawal Lake reservoir in Pakistan by analysing the contamination. The samples were collected/ tested during spring/ monsoon seasons to analyse temporal/fluvial impacts on water discharge. The results were compared with Pakistan's and WHO's drinking water standards before and after the water treatment. Almost all the testing parameters of the raw water samples from the Rawal Lake reservoir feeding streams exceeded the standard limits or fell close to the upper threshold limits, suggesting that this water was unsuitable for drinking without extensive treatment and an efficient distribution system. The contamination, untreated sewage disposal, non-regulated water utilisation, drawdown and supply/ demand gaps are the grave factors causing the water security/ scarcity in the capital/ twin cities of Islamabad/ Rawalpindi. Pakistan has already entered the water scarcity threshold of 1014 m^3/ person/ annum in 2018, reduced from water availability of 5260 m^3/ person/ annum in 1950 and will likely reach a drought level by 2050 due to increased population and reduced water resources. The study proposes an organisational implementation model for catchment-level river management to ensure good quality of water, construction of 5-10 small dams, and the provision of water from Terbella Dam suggested as the long-term strategy to prevent water scarcity.

Keywords: Water quality, water scarcity, Rawal Lake, water testing contamination, supply/ demand gap, sustainable Water Management.

Introduction

Water is the source of human development (Nadir and Carrivick, 2019) and the initiating place for all the civilisations/ metropolitans which were established and thrived along the water streams (Gimenez, 2015). Today, water resources are used as a source of life, biodiversity, energy generation, irrigation, transportation/ shipping, and primary food sources in the life/ food cycle (Nadir and Ahmed, 2023). The increased use of water resources, wastages, transborder streams inflow/ outflow, regionalisation/ zoning of the earth in cities/ countries, global warming and climatic changes are the main factors causing the drought and availability of a sufficient/ suitable quantity of this precious commodity (Gimenez, 2015; Kumar, 2018; Nadir and Ahmed, 2023). The technological adventures and misuse, vast exploitation of natural resources by the developed countries after industrialisation and lack of understanding about the upkeep/ conservation of water resources by the developing countries have prompted the critical issues of water security and scarcity (Donoso *et al*., 2012). The developed countries in Europe, the USA and the UK have started endeavouring the steps to understand better/ tackle these security/ scarcity issues and have incorporated the regulations to keep things on the right track, though still, these efforts require enormous inputs, finances and time to fully implement rules to manage the water resources on the catchment scales (Botosu *et al*., 2012; Carranzo, 2012; Mateen and Garstang, 2008; McBride and Spears, 2001; Read and Fernandas, 2003; Sohail *et al*., 2012). However, developing countries still need to understand these issues. They are reluctant to implement proper water management strategies due to their insignificant infrastructures, financial impacts and lack of awareness/ disposition (Ayaz *et al*., 2012; Bhosale and

Salkar, 2015; Nadir and Ahmed, 2023). In this paper, the Rawal Lake reservoir in Pakistan (A South Asian developing country) has been considered as a case study by analysing the physical/ chemical/ biological factors of water quality parameters and supply/ demand gaps to elucidate the water security/ scarcity in the capital/ twin cities of Islamabad/ Rawalpindi. Rawal Lake is an artificial water reservoir of 8.8 km^2 constructed in the foothills of Margalla National Park on the outskirts of Islamabad (the capital of Pakistan) in the 1960s. Its primary objective is to store and supply water to the twin cities of Rawalpindi and Islamabad as drinking water. Water and Sanitation Authority (WASA) Rawalpindi and Capital Development Authority (CDA) Islamabad are the managing authorities (Daud *et al*., 2017; Docslib, 2023; WASA,2022; Qureshi, 2023). The main feeding water stream is Kurang River, along with 3 other big and 43 small streams from Murre Hills and the local areas, as shown in Figure 1 (Ali, 2014).

Rawal Dam

Rawal Dam is an arched gravity dam made of stone masonry and earthfall with a crest level of 531 m. The site is home to beautiful birds, wild animals, and migratory birds and contains recreational parks, picnic spots and boating/ private clubs. Rawal Lake supplies 80000–100000 m^3 of water daily to Rawalpindi/ Islamabad treated/ filtered through the Rawal Lake water treatment plant. The conventional water treatment process and the latest process employed in Rawal Lake are illustrated in Figure 2 (Ali, 2014) and Figure 3 (Docslib, 2023). The reservoir spillways discharge overflow water back to Kurang River in case of excessive inflow/ heavy rainfall events (Haque *et al*., 2007). The treated water is stored in WASA and CDA storage tanks and then supplied to end users after doing necessary testing at the WASA water testing laboratory (Ayaz *et al*., 2012). Periodic water testing is done after taking samples from all the feeding streams and reservoir before feeding the water to the treatment plant. The incoming streams are the source of contamination and effluents due to anthropogenic activities like directly discharging raw waste/ sewerage from different farms, populated areas, agricultural land, and waste from picnic spots, recreational / boating clubs and small industrial units (Ali, 2014). Moreover, leakages in water supply lines result in drainage/ sewerage water infiltration, thus making tap water unfit for human consumption. Therefore, tap water in Rawalpindi/ Islamabad has been declared as unhealthy and unsuitable for drinking purpose.

Water Quality/ Security Issues and Factors Causing Water Contamination

All the impurities, sediments/ metals, faecal coliform and reduced dissolved oxygen show the substandard quality of water and uncontrolled behaviour of people living in the catchment area which throw garbage, mix sewerage and uncontrolled use of chemicals by farmers/ industries. This situation indicates poor implementation of drinking water regulations specified by the WHO/ UNESCO/ Pakistan government, bad catchment management, the absence of proper sewerage treatment plants prior to final discharge of wastewater into water streams, uncontrolled/ unhygienic disposal of solid waste and poor water resource management by related authorities. Surface water quality is essential as it affects human health and well-being of aquatic life. Anthropogenic influences and natural processes deteriorate surface water and blight its use for drinking, industrial, agricultural, recreational or other purposes. Different sources of pollution in the streams are shown in Figure 4 (Ali, 2014).

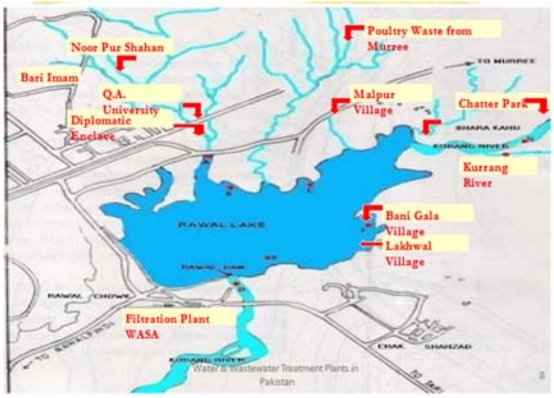

Fig. 1: Catchment area of Rawal Lake reservoir (Ali, 2014).

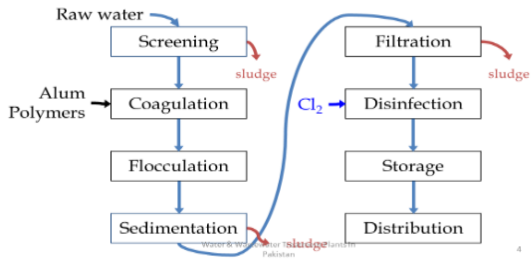

Fig. 2: Conventional water treatment process (Ali, 2014).

Sewerage Mixing and Waste Disposal in Rawal Lake Reservoir's Water

During the visit to Kurang River and Rawal Lake, untreated sewage and rubbish were observed mixed/

thrown into the water streams. CDA plans to construct 4 sewerage treatment plants with an estimated cost of 30 million USD, but the requisite funds have yet to be allocated by the government. Unfortunately, the capital of Pakistan lacks a proper sewerage treatment system and untreated sewage is directly discharged to streams (Ahad, 2023; Pakistan Today, 2017; Saimar, 2016; Shahzad, 2014).

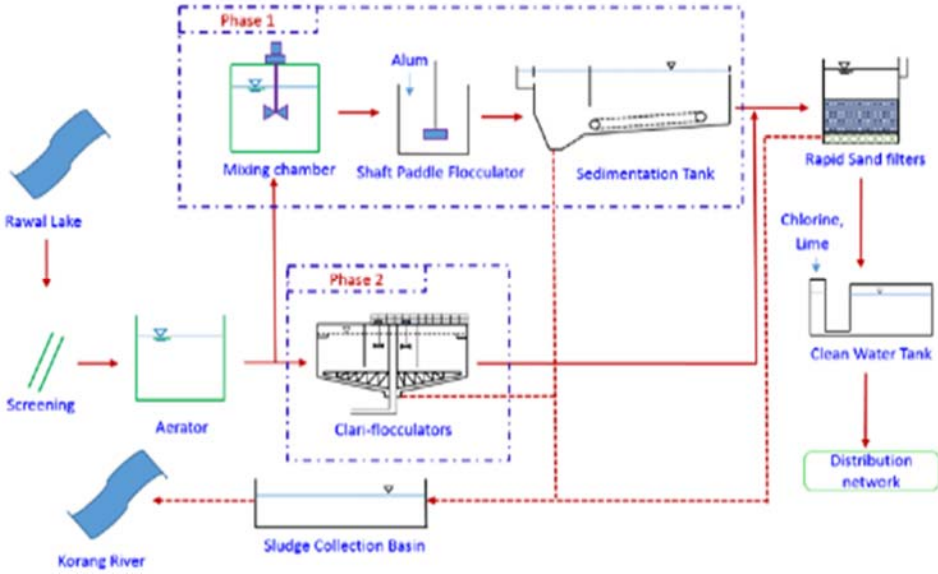

Fig. 3: Water Treatment Process used in Rawal Lake Treatment Plant (Docslib, 2023).

The catchment area is badly suffering from deforestation by the forest/wood-cutting resulting in excessive sediment transport to water streams/ Rawal Lake (Mahreen and Sana, 2014). Mushroom growth of car washing stations and open-air car washing near the water streams and Rawal Lake have been found during the site visits, discharging their waste directly into streams. Recreational parks, picnic spots, boating clubs, private clubs, and farmhouses throw rubbish into water streams, including petrochemical waste from boats. This area is suitable for poultry farming due to its supportive ambient temperatures. Similarly, industrial manufacturing units have been established in the capital city. All these farms and industrial manufacturing units discharge their untreated wastewater into streams. It is essential to prevent all kinds of untreated waste disposal into the water streams to maintain the quality of the Rawal Lake.

Mixing of Drainage water/ Sewerage into Damaged Water Supply Lines

The treated water from the WASA plant is supplied through pipelines to different residential sites, villages and the local population. These pipelines were laid in the last 30 to 100 years and have already been deteriorated in most places. Drainage and sewerage water from nearby sewerage lines enter these damaged channels/ pipes. Thus, this contaminated water is unfit for human consumption and requires further treatment by localised water filtration/ treatment plants. These plants need to be adequately maintained with improved departmental efficiency to treat/ clean water fully as incapable filtering arrangements, and the dirty environment around these filter plants makes them somewhat vulnerable. However, these small plants cannot remove faecal coliform and other heavy metal pollutants that remain in the water and cause different gastric/ liver diseases in humans. The monitoring report of these drinking water filtration plants by the Pakistan Council of Research in Water Resources revealed that WASA had established 53 water treatment plants for further water treatment locally to provide safe drinking water. Still, only 13 plants provide clean water that is safe to drink, whereas the remaining 40 plants were found to provide unsafe/ polluted water. 10 out of 40 unsafe water plants were chemically contaminated, 30 were micro-biologically contaminated, and 8 experienced both contaminations (Jamal, 2020; PCRWR, 2013; PEPA, 2004). The maintenance/ repair/ replacement of existing pipelines is essential to prevent the ingress of surface drainage/ sewage/ chemicals in the water supply line for better security/ quality of drinking water.

Impact of Rawal Lake Water Treatment Plant

The life of sand filters is reduced, and they need to be flushed/ replaced frequently, causing a substantial financial burden. Rawal Lake could initially store up to 45 to 58 million m^3, and the water quality used to be very good. However, due to the continuous deposition of silt and other sewerage into the Lake, its colour has turned brownish and storage capacity has decreased (Shahzad, 2014). The rapid filtration plant installed in 1962 is now overburdened because of the Lake's uncontrollable levels of organic pollution (Saimar, 2016). Recreational activities in Rawal Lake are further deteriorating the quality of raw water. The lake water is further contaminated with organic runoff carrying pollutants arising from both domestic and commercial activity and fertilisers, which cause increased dosages of coagulants and disinfectants, resulting in higher treatment costs (Jamal, 2020). Water security is a community/ social responsibility, so all the residents/ farmers/ industries should be aware of the proper treatment/ disposal of trash/ waste into the feeding streams to reduce the treatment burden of untreated/ polluted water in the WASA treatment plant.

WASA Water Monitoring Laboratory

WASA water testing laboratory was established to evaluate water samples taken from the Rawal Lake, which contributes 50 significant/ small water streams, around 300 WASA tube wells, and 50-plus water filtration plants in Rawalpindi. It has outdated equipment and untrained staff; therefore, water test reports from WASA are not considered reliable. Consequently, people prefer getting reports from PCSWR or PSQCA laboratories. WASA should consider equipping the laboratory with the latest equipment/ techniques and train the staff to work with integrity without taking political/ departmental pressure while testing water samples.

Fig. 4: Contamination sources in the water streams feeding the Rawal Lake (Ali, 2014).

Water Scarcity/ Quantity Issues and Demand/ Supply Gap

WASA Rawalpindi and CDA Islamabad supply 194 million gallons of water per day (MGD) to the Rawalpindi Islamabad population of around 3.5 million. It includes the supply of 102.5 MGD from 300 tube wells and 91.5 MGD from 3 reservoirs, but still, there is a deficit of 153 MGD, as shown in Figure 5 (Ayaz et al., 2016; MES, 2022). The deficit is made up of private boring and the supply of water tankers from other sources. The excessive boring for tube wells resulted in drawdown and reduced water table from 200-300 feet in 1998 to 450-550 feet in 2018, as shown in Figure 6 (Mehreen and Sana, 2014). Therefore, proper monitoring/ management of tube wells boring to a specific limit should be implemented to avoid an accelerated pace of drawdown. Moreover, cleaning/ maintenance/ dredging of reservoirs/ feeding channels to regulate their intended capacity/ discharge for a long-term life should be ensured. Military Engineering Services Pakistan (2022) studied overall water scarcity/ quantity issues in the twin cities of Rawalpindi/ Islamabad. It observed that in 1951, it had excess water with 5260 m^3/ person/ annum, which has reduced to 1014 m^3/ person/ annum in 2018 (water scarcity level) and is projected to reach a dangerous drought level of 575 m^3/ person/ annum in 2050 as shown in Figure 7a (MES, 2022). Rawalpindi and Islamabad will likely face a shortfall of 661 MGD projected in 2050 as per a depletion rate of 2% and an increase in population if the situation remains the same, as shown in Figure 7b (MES, 2022).

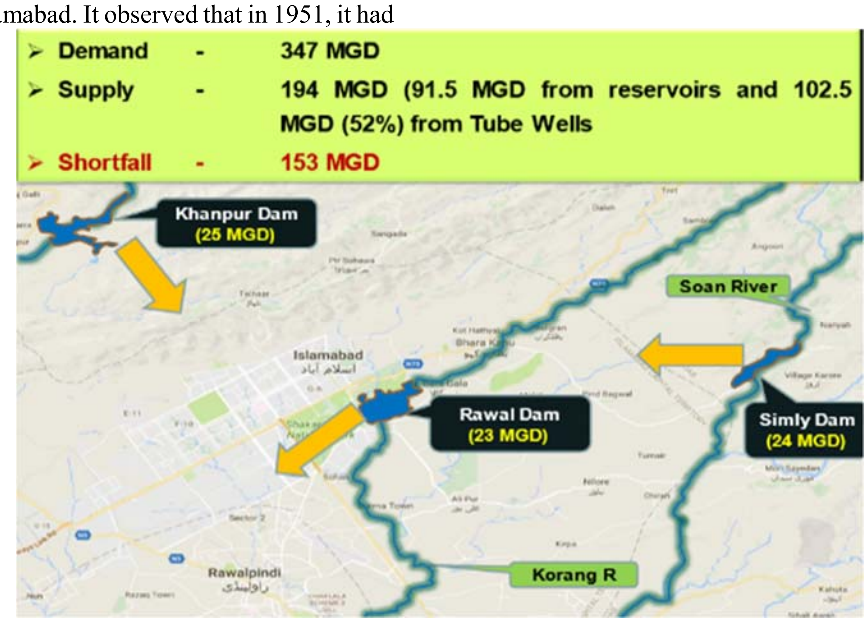

Fig. 5: Water supply demand/ shortfall gap to Rawalpindi/ Islamabad (Ayaz et al., 2016; MES, 2022).

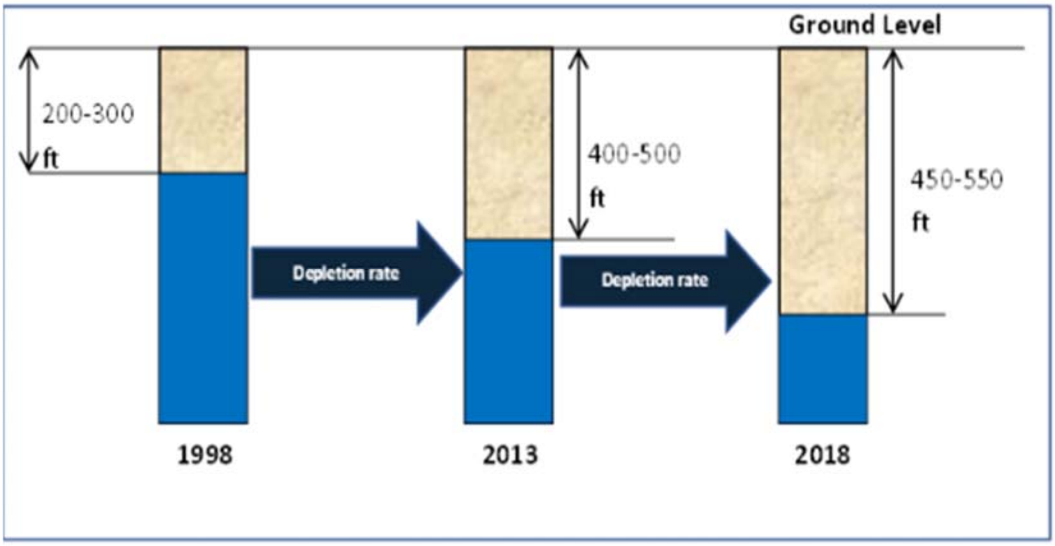

Fig. 6: Groundwater levels and drawdown situation in Rawalpindi/ Islamabad 1998-2018 (Mehreen and Sana, 2014; MES, 2022).

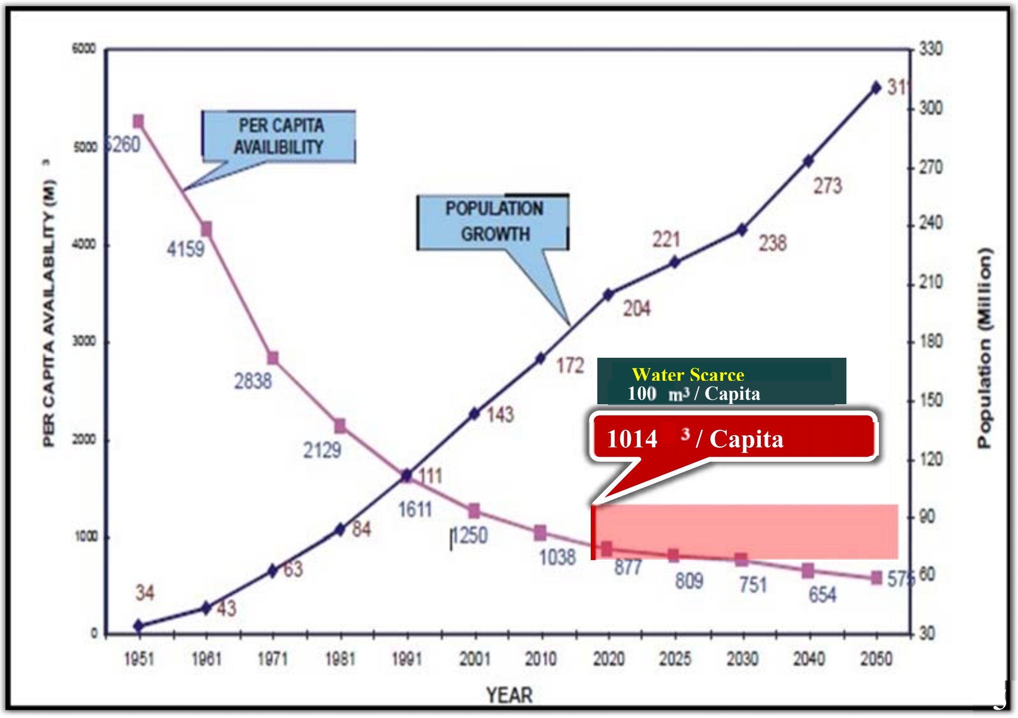

Fig. 7: Per capita annual demand and water scarcity statistics – Pakistan (MES, 2022).

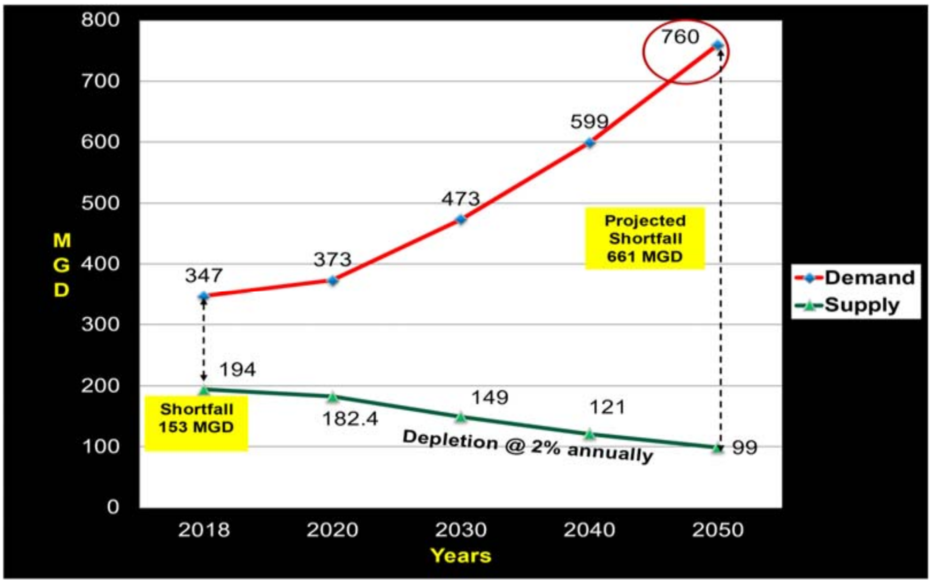

Fig. 8: Future water scarcity/ projected demand - Rawalpindi/Islamabad (MES, 2022).

Methodology

Site visits to Kurang River, Burry Imam, Bani Gala, Rawal Lake, and the water treatment plant were conducted to collect samples by grabsampling. Samples were collected from feeding streams in sterilised 1500 ml bottles. pH, temperature, dissolved oxygen (DO), and electric conductivity (EC) were measured in the field using electronic probes. The samples were tested for assessment of other chemical parameters in the laboratory within the next 24 hours as per the procedures outlined in the standards given by Pakistan Environmental Protection Agency (PEPA, 2004), Pakistan Council of Research in Water Resources (PCRWR, 2013), Pakistan Standards Quality Control Authority (PSQCA, 2004), and

American Public Health Association (APHA, 1985) in line with the methods/ procedures adopted by other organisations/ researchers (Ahad *et al.*, 2005; Kodarkar, 1992; Mitra and Gupta, 1999; Patel and Poll, 2003; Prajapati, 2004; Zhang *et al.*, 2006; Mahreen and Sana, 2014) to make the water drinkable as per World Health Organization (WHO) standards (WHO, 2023). All the samples were collected in the first week of April 2022 and July 2022 to compare the regular water inflow during spring and excessive surface runoff during monsoon season. Data regarding the demand/ supply of water from Rawal dam, Khan Pur dam and Simply dam, supply of water from the tube wells extraction/ pumping of water to Rawalpindi city/ cantonment areas and depletion of groundwater/ lowering of water table statistics were obtained from WASA Rawalpindi (WASA, 2022) and Military Engineering Services Rawalpindi (MES, 2022) for analysing water scarcity issues. The area is located in the foothill of Margalla in the suburbs of the capital city of Islamabad (Figure 1) (Ali, 2014). The main feeding water stream is Kurang River from the East, with 46 small streams coming from Nur Pur Shahan, Burray Imam, Quaid-e-Azam (QA) University/ diplomatic enclave in the West/North West, Murre Hills in the North, Chatat Park and Mulpur in North East, Bani Gala and Lakwal in the East. The Lake's excess water is spilt out to the south in the Kurang River again. In this study, raw water samples were collected from Korrang River, Burry Imam, and Rawal Lake Reservoir, and treated water samples were collected from the Rawal Lake water treatment plant (RLWTP) to compare the water quality before/ after the treatment, as shown in the catchment area map in Figure 1 (Ali, 2014).

Results and Discussion

The results of the samples taken during the spring season (April) were compared with the results of samples taken during the Monsoon season (July) for elucidation of temporal/ seasonal impacts on water quality, especially to see the effect of heavy rainfalls in the Monsoon month of July. Pakistan/ WHO standards have been used to compare water monitoring results. All the results of physio-chemical, micro-biological, and metal contamination testing, compiled/ compared with WHO/ Pakistan Standards, are shown in Table 1.

Water Quality - Comparison of Physical Contamination Parameters

Most of the water quality parameters for Rawal Lake and its contributory water streams were observed nearing the upper limits or exceeding the permissible parameters set out by WHO and Pakistan water quality standards, exhibiting deteriorated water standards (Table 1). However, treated water samples collected from the Rawal Lake water treatment plant (RLWTP) generally demonstrated satisfactory/within-the-range results exhibiting efficient water treatment at the treatment plant before the water supply. The pH in all tests is within the permissible limit of 6.5 to 8.5 except for Korang and Burry Imam, with 6.4 showing a more acidic nature due to contamination. Electrical conductivity was found within range. However, Rawal Lake reservoir water demonstrated the test results towards the upper threshold/ limits, establishing the presence of more salts and pollutants supplied by the streams culminating into the reservoir from the catchment areas (Table 1).

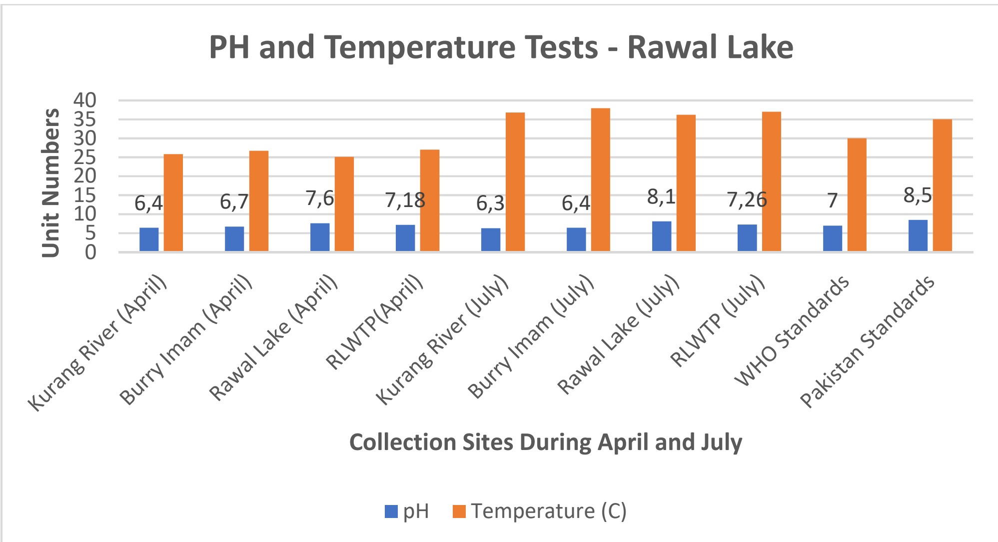

Fig. 9: PH and temperature test results - Rawal Lake

Table 1: Results of water samples - Rawal Lakes Sites

Parameters Tests	Units	Testing in Spring Season				Testing in Monsoon Season				WHO Standards	Pakistan Standards
		Kurang River	Burry Imam	Rawal Lake	RLWTP*	Kurang River	Burry Imam	Rawal Lake	RLWTP*		
pH		6.4	6.7	7.6	7.18	6.3	6.4	8.1	7.26	7	6.5-8.5
Temperature	C	25.8	26.7	25.1	27	36.8	37.9	36.2	37	30	35
EC	(µs)	387	326	287	248	512	456	357	254	200-600	200
Dissolved Solids (mg/l)	(mg/l)	380	295	498	254	485	402	756	289	1000	1000
Suspended Solids (mg/l)	(mg/l)	856	942	1080	321	1220	1389	1430	346	1000	1000
Alkalinity (mg/l)	(mg/l)	191	213	243	152	432	484	509	201	200	200
Chloride	(mg/l)	17.3	14.3	21	11	20.2	19.8	23.4	13	25	25
Sulphate (mg/l)	(mg/l)	67	73	89	15	78	81	89	15.8	25	25
Calcium Carbonate (mg/l)	mgCaCO3/l	51	45	51	42	48	43	47	42	40	40
Dissolved oxygen (DO) (mg/l)	mgO2/l	4.7	4.9	5.1	6	4.1	3.9	3.5	5.1	6	6
Nitrite (mg/l)	(mg/l)	12.8	14.7	17.8	2.5	11.1	10.2	14.3	2.2	2.5	2.5
Nitrate (mg/l)	(mg/l)	14.3	13.6	13.7	11.2	17.6	15.1	14.2	11.5	11.5	11.5
Fecal Coliform	CFU/100ml	131	128	133	0	155	145	160	0	0	0
Metals											
Cadmium (mg/l)	(mg/l)	0.46	0.51	0.48	0.23	0.52	0.56	0.51	0.22	0.003	0.001
Nickel (mg/l)	(mg/l)	0.339	0.41	0.338	0.25	0.431	0.512	0.437	0.27	2	0.1
Lead (mg/l)	(mg/l)	0.52	0.56	0.568	0.34	0.613	0.634	0.52	0.41	0.01	0.05
Zinc (mg/l)	(mg/l)	0.067	0.07	0.066	0.023	0.056	0.059	0.081	0.045	3	0.035
Copper (mg/l)	(mg/l)	0.05	0.08	0.048	0.04	0.058	0.069	0.053	0.038	2	0.01

RLWTP Rawal Lake Water Treatment Plant (Results of water samples after treatment)*

Dissolved and suspended solids exceeded the upper. Test values of water samples collected in July 2022 exceeded the water standards/ limits due to heavy rains/ surface runoff and washing off of clay, soil, garbage and pollutants from water streams into the reservoir, which caused more turbidity and impacted watercolour. The suspended solids reduce dissolved oxygen levels, which is very dangerous for aqua life, especially in Monsoon months. Dissolved oxygen (DO) was found to be lesser than the dead level range of 5 mg/l attributed to the mixing of sewerage, the presence of contaminants, and the growth of algae/ coliform bacteria, thus causing the death of Fish/ micro-organisms in the reservoir commonly seen in July - August every year in Rawal Lake as shown in Figure 11 (Sana, 2017). Alkalinity was found to be more than the limit of 200 (Table 1).

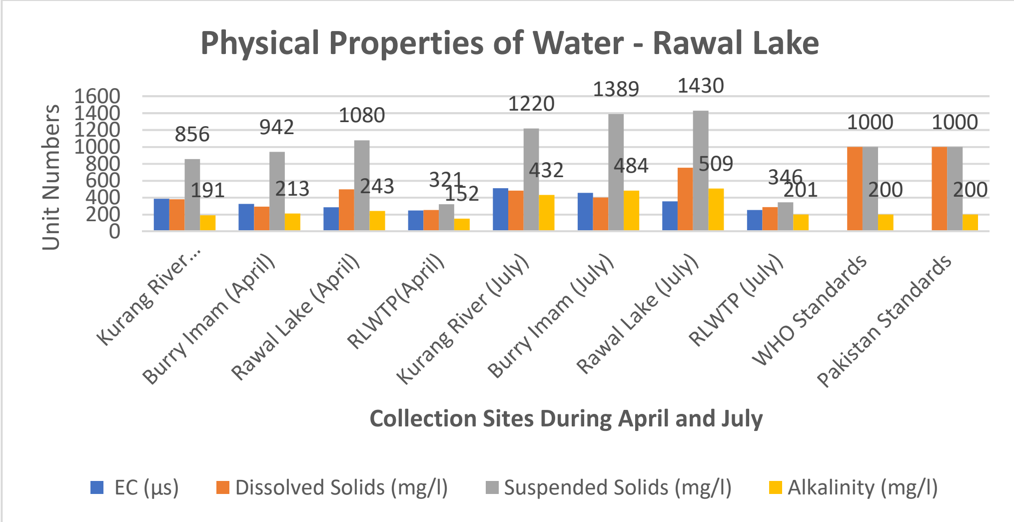

Fig. 10: Physical properties parameters - Rawal Lake

Fig. 11: Dead Fish In Rawal Lake due to contamination/ decreased DO in July 2017 (Sana, 2017).

Comparison of Chemical/ Metal / Microbiological Contamination Parameters

Table 1 shows the results of chemical testing parameters. Chloride and Sulphate were found within the permissible limit. Calcium carbonate almost exceeded the standard limit of 40 mg/l. Nitrite and Nitrates exceeded the limits and elucidated uncontrolled use of chemical fertilisers in the catchment farmlands and mixing of untreated wastewater. Heavy metals, especially Cadmium, Nickel, Lead, Zinc and Copper were observed dangerously high, which can cause fatal diseases like cancer. Table 1 illustrates that faecal coliform bacteria was in alarmingly high numbers, elucidating the disposal of untreated human/animal waste and the sewage mixing in the Lake. However, testing treated water samples for detecting chemicals, heavy metals, and bacteria collected from the Rawal Lake water treatment plant (RLWTP) demonstrated satisfactory/ within-the-range results except for lead particles ($Pb \geq 0.41$mg/l), exhibiting efficient water treatment at the treatment plant. All these results suggest that the quality of Rawal Lake water and its feeding streams is substandard and can cause cancer, stomach ache/ indigestion, bacterial-borne diseases and chemical-related health impacts on the residents/ animals using this water. The treated water was found satisfactory at the Rawal Lake water treatment plant. Still, the likely ingress of polluted drainage/ sewerage water through leaky water supply lines in the distribution system and the direct mixing of untreated water drawn using independent tube wells makes the treated water susceptible to contamination. The treatment of such substandard water is likely to cause a substantial financial impact on the treatment process and the life of the filtration/ treatment equipment. It is essential to incorporate the sustainable integrated water management strategy on the catchment level to stop the contamination of water in the feeding streams to bring in less polluted water in the reservoir along with immediate construction of waste disposal/ treatment plants for Rawalpindi/ Islamabad to prevent mixing of untreated wastewater.

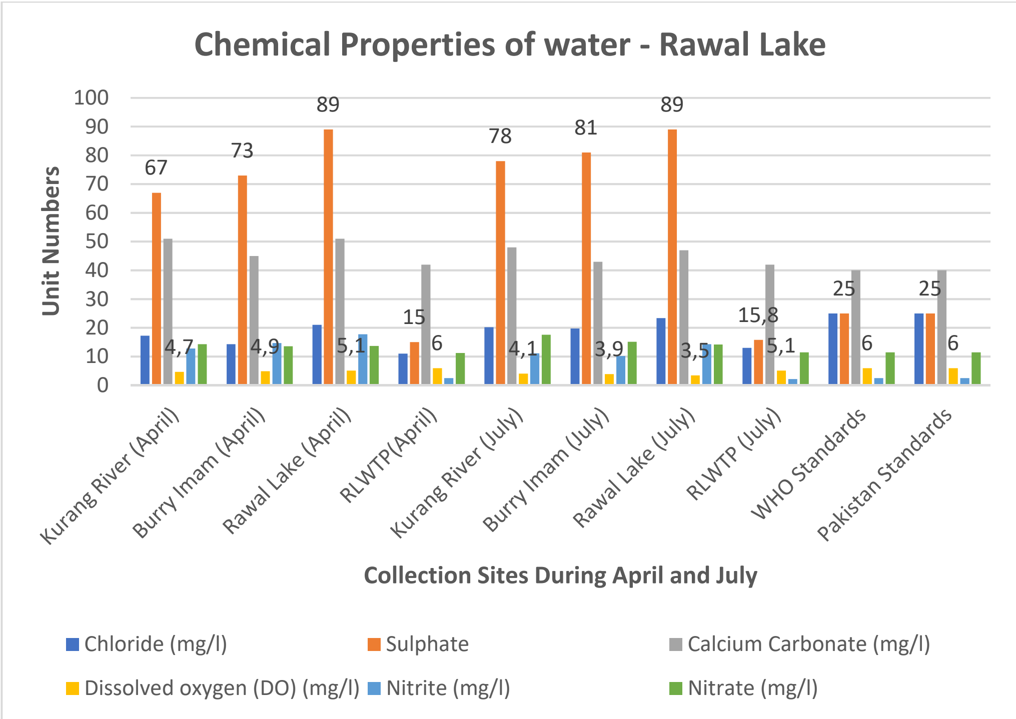

Fig. 12: Comparison of chemical properties of water - Rawal Lake

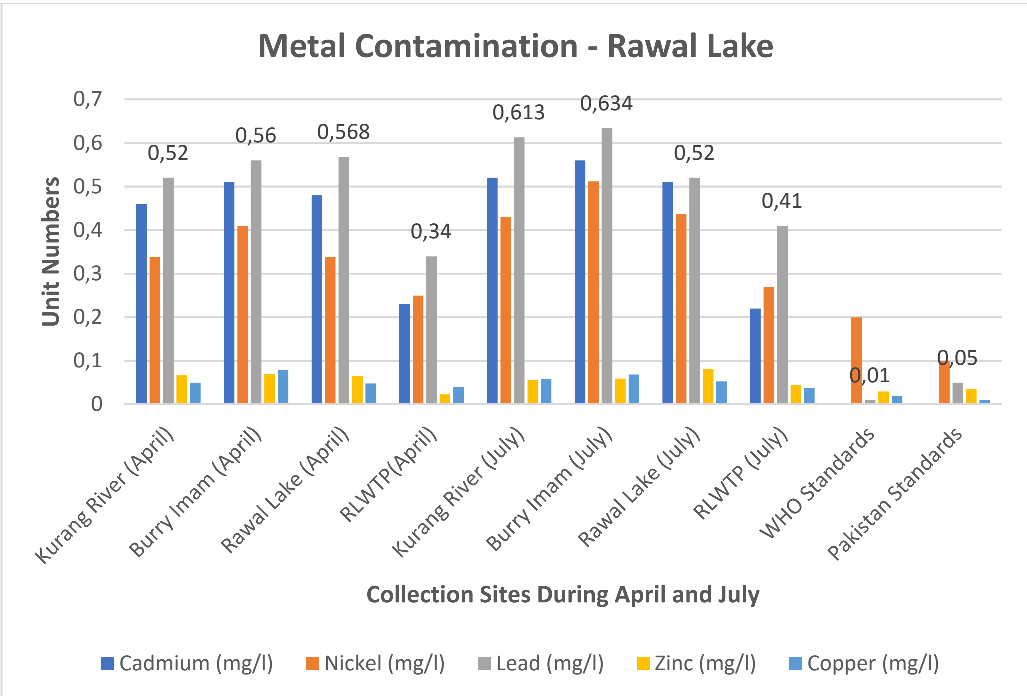

Fig. 13: Metal contamination parameters - Rawal Lake

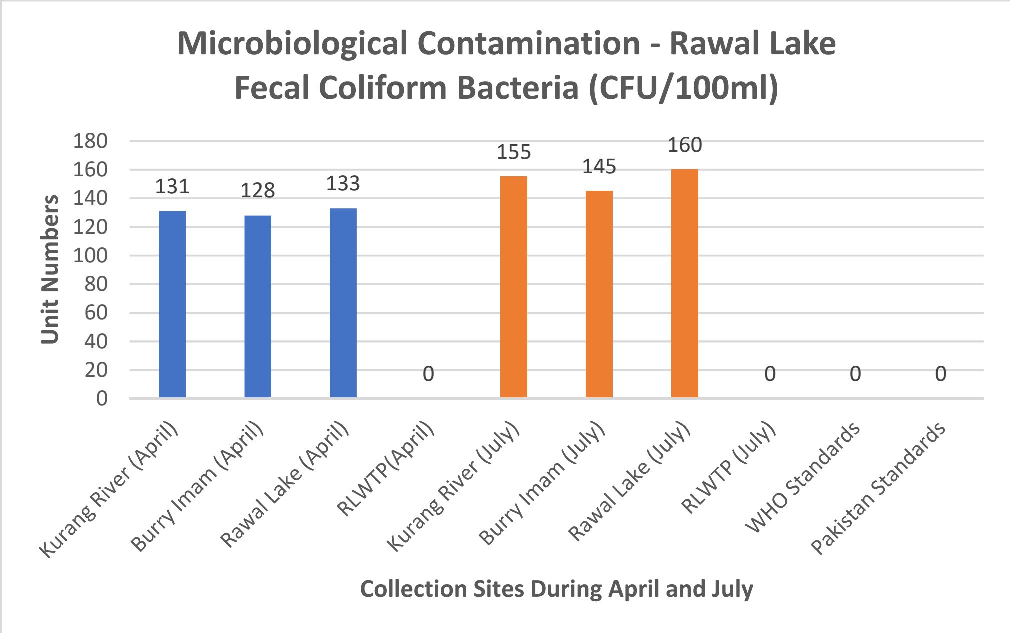

Fig. 14: Microbiological contamination - Rawal Lake

Sustainable Water Management Strategies

Pakistan is facing an acute water shortage due to an increased population and the depletion of water resources to supply adequate drinking water. The phenomenon is more pronounced in the urban areas of Rawalpindi/ Islamabad due to unplanned urbanisation, lack of water storage capacity and illegal/ uncontrolled use of water resources compared to the rural areas. There is a dire need for timely planning of sustainable water management, integrating all the stakeholders and water resources at the catchment level to maintain the required levels of freshwater storage with the desired quality for the present users and future generations. Uncontrolled use of existing water resources versus uncontrolled urbanisation quickly depletes the water available in freshwater streams and underground water. People are withdrawing groundwater illegally for domestic/commercial purposes without any permission/replenishment procedures, resulting in the groundwater table being drawn down. The rapid depletion of water ponds and swift water drainage after the rain due to lack of storage capacity and steep catchment drainage gradient in the hilly areas will result in water scarcity, leading to drought-like conditions soon. Therefore, there is an immediate need to construct small storage ponds at numerous places to store water for the local population at small scales and, if possible, to interconnect all these ponds to each other for uniform distribution/fair replenishment from one place to another. Stringent legal measures/ procedures are required to immediately stop waste disposal in water streams and prevent uncontrolled/ illegal utilisation of water resources/ groundwater. Military Engineering Services Pakistan (2022) elucidated an immediate need to construct several small dams on small rivers/ water streams in the suburbs of Rawalpindi/ Islamabad as a water management strategy to tackle the menace of water shortage (a few have been proposed in Figure 15).

A long-lasting solution can be to utilise a perennial source of freshwater, like a big river flowing near the twin cities of Rawalpindi/ Islamabad, like the Indus River. It is the longest/ biggest river in Pakistan, having a perennial flow all over the year drained from the Himalia/ Qaraquram/ Hindukush mountains ranges in Kashmir, Gilgit, Baltistan and Hunza valley collaborating the waters from numerous water channels/ rivers and glaciers. The long-term water management strategy to supply perennial freshwater to Rawalpindi/ Islamabad is the provision of water from Terbella Dam on the Indus River (the biggest dam in Pakistan, having 14.7 Million acre-feet MAF capacity) just 60 km away from Islamabad, through a water channel or large sized water pipes crossing Margalla hills in a tunnel to supply millions of gallons per day uninterruptedly. Military Engineering Services Pakistan (2022) proposed laying two 80-inch water pipelines taking water from Tarbella dam to two 10 million gallons storage tanks costing around 0.5 billion USD with an approximate 5-7 years completion time. This water supply from Terbella is a real futuristic solution, as depicted in Figure 16. It will help provide 655 MGD of water to twin cities to likely overcome the future/ projected water scarcity issues in the capital/ twin cities of Islamabad/ Rawalpindi, Pakistan (MES, 2022). Pakistan needs to implement integrated water management strategies on catchment levels for all areas/ water streams to overcome the water quality/ scarcity issues in the country, especially in the twin cities of Rawalpindi/ Islamabad; otherwise, it has already entered a scarcity threshold and running fast to reach the drought threshold due to uncontrolled population, urbanisation and a lack of management, resources and strategies.

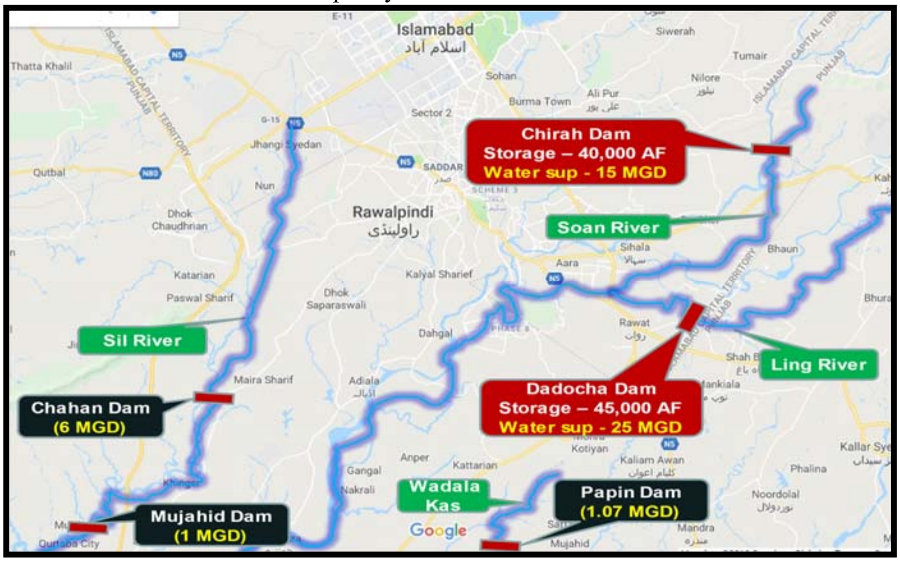

Fig. 15: Proposed small dams in Rawalpindi/ Islamabad as drinking water reservoirs (MES, 2022).

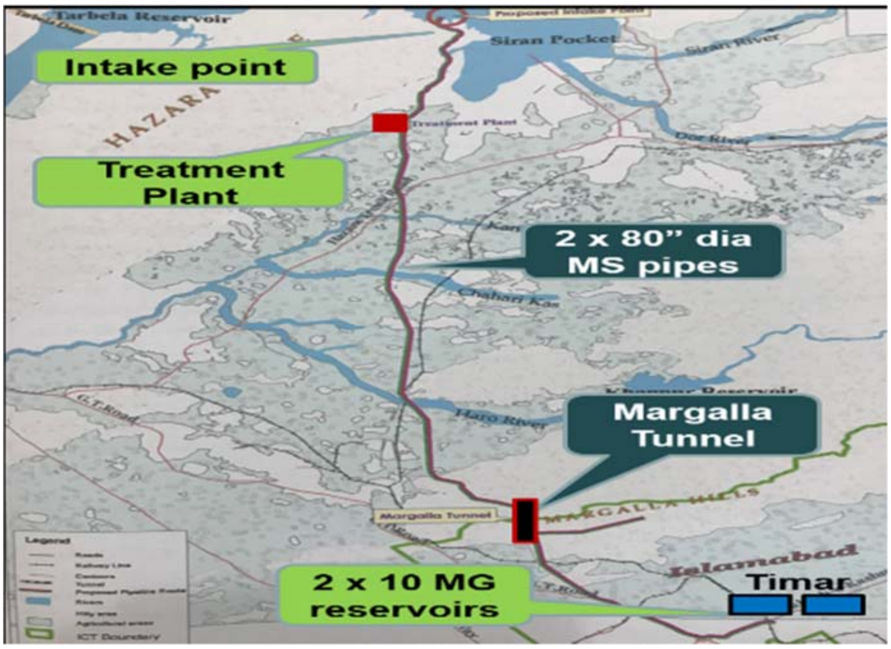

Fig. 16: Proposed water supply scheme to Rawalpindi/ Islamabad from Terbella Dam (MES, 2022).

Conclusion

The quality of water in the streams/ reservoirs in Pakistan, like other developing nations, is considered substandard, exceeding the specified standards of physical/ chemical/ microbiological contaminants. The old water reservoirs have become insufficient to increase population and are projected to be depleted very soon, resulting in future water scarcity/ drought.

Moreover, the absence of proper sewerage/ waste disposal plants/ systems in twin cities causes an issue of mixing human/ animal/ industrial waste into streams/ reservoirs. The substandard water quality problem is causing an extra burden on the cost of water treatment and the supply of unsafe drinking water to the residents. The tap water supplied to Rawalpindi by the water supply department has been declared unsuitable for drinking and insufficient to meet the demand. There is an immediate requirement to implement regulations that prohibit untreated waste/ sewerage by anyone/ industry from being discharged/ disposed of into water streams. Water streams should be preserved as natural assets in line with rules introduced by the European Union water framework directive for Europe. Construction of small dams and provision of water supply lines/ storage from Terbella dam should be prioritised as a long-term solution to tackle the menace of water scarcity.

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