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Comparative Study of Physicochemical and Microbiological Parameters of Water from Rawal Dam and its Silt Control Tank

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Abstract— Water plays a vital role on this planet it is a very important factor in the living of almost every species. Water resource has been depleted, exploit, and polluted day by day due to exposure to different hazardous contaminants and misuse of water. Urbanization and increase in population increase the risk of deterioration of water quality of water resources. This study was conducted on physicochemical and microbiological analysis to determine the water quality of Rawal dam, its tributaries, and their comparison with the water quality of the silt control tank of Rawal dam which is the WASA filtration tank. The main objectives of this research water are to access the water quality parameters which are consumed by the public and to find out whether these parameters are complying with the standards given or not. Water samples were collected from the main Rawal dam, and from its tributaries that are entering the dam. All five water samples were analyzed separately to get the results and were compared with water quality standards prescribed by World Health Organization (WHO) and Pakistan Environmental Protection Agency. The samples were collected in sterilized plastic bottles during October and November 2019. Physicochemical and Biological parameters (pH, Temperature, Turbidity, ORP, EC, Salts, Total Hardness, Total alkalinity, Carbonates, Chlorides, Calcium, Magnesium, Total and Fecal coliform) were analyzed at the Chemistry Lab of Bahria University Islamabad campus. Despite, most of the parameters from upstream to the main dam exceeding the standards, most of the parameters of Dam samples and all parameters of WASA water samples were within the permissible limits given by WHO and the Pakistan Environmental Protection Agency. Microbiological analysis showed that the water samples contain high microbial counts of different pathogens like Salmonella, Shigella, and Total Coliforms in the Dam and its tributaries as compared to the WASA filtration plant (silt control tank). It is recommended to the regulatory authorities to analyze, inspect and monitor the drinking water quality regularly and it needs immediate attention of governmental bodies and public participation.

Keywords—TDS, Water Treatment, EC, pH, Rawal Dam

I. INTRODUCTION

Water Resources

The quote 'Water is life' explains water's importance for all aspects i.e., industries, agriculture and livelihood of humans as well as for other creatures on the earth which are connected by this precious boon. All these aspects including human life and health and their economic development are particularly allied with accessibility and use of water. Too little water can mean food insecurity and drought at a time when it is most needed. Too much water in the form of storms and floods can raze an entire population. The water that is contaminated, either from anthropogenically or industrial sources, claims children's lives as well as impacts numerous communities globally. The Global Water Cycle occupies about three-quarters of Earth's surface and is a vital element for life. Water molecules pass again and again through solid, liquid, and gaseous phases during their regular cycling between land, the oceans, and the atmosphere, but the total supply remains almost equal. Three major water resources in Pakistan include i. surface water resources, ii. groundwater resources, and iii. rainfall. All these resources' availability depends on the location, and topography of the area. These three resources shortly described below in the following sections [1].

Surface Water-Resources (SWR)

Indus river and its tributaries including canals, channels, and water courses are the main origins of the SWR in Pakistan. The total length of the Indus is 2900 km, and the drainage area is approximately 966,000 km^2. There are five major rivers on the eastern side of the Indus, known as i. Chenab, ii. Jhelum, iii. Ravi, iv. Sutlej, and v. Beas. Besides these, three other minor tributaries i. Harrow, ii. Soan, and iii. Siran which drains into mountainous areas. On the western side of Kabul River join the Indus. All rivers in Pakistan have individual characteristics. All these rivers start to rise in the spring and early summer seasons, with the monsoon period and also the melting of the snow.

The peak discharge has been calculated in July and August. Less flow rate can be determined in the winter season from November to February months. 1/10th discharge can be calculated only during the summer season. Pakistan only depends on 3 western rivers Indus, Jhelum and Chenab while on the side India diverted the flow of Ravi, Beas, and Sutlej. In 1960, Indus Water Treaty had done to construct several connecting canals, barrages, and dams on the Indus River and its two tributaries Jhelum and Chenab. That transferring at least 20 MAF to water for irrigation purposes. This water is cut off from irrigation networks Ravi, Sutlej and Beas. It mentioned that only the Indus River provide 65% of the total inflow of water, on the next side Jhelum and Chenab share the total water of 17% and 19% respectively [1].

Groundwater Resources (GWR)

Groundwater resources (GWR) of Pakistan are generally existing in the Indus Plain, broadening and lengthening from Himalayan foothills to the Arabian Sea, and are stored inside an alluvial deposit. This Indus plain counted approximately 1600 km long with an area of 21 Mha. It is blessed with an unconfined aquifer which becomes extensively supplied for irrigation purposes. The aquifer assembled due to unswerving recharge from the river flow, precipitation, and seep by the conveyance system of minors, distributaries, canals, watercourses, and application losses in the irrigated lands.

There are counted number 562000 private tube wells which drain water of 38 MAF and 1000 public tube wells drain water from an aquifer which contains about approximately 50 MAF. In Baluchistan, orchards and cash crops are irrigated by using GWR via dug wells and tube wells. Because all the rivers in the province are ephemeral, with seasonal flows only. Hydrologists estimated through current research that about 0.5 MAF already has been used from 0.9 MAF and still 0.4 MAF is available as GWR.

Though, makes misinterpretation, as the aquifers are not unremitting but are inadequate to basins due to geologic settings. It is pointed out that, in two of the basins (Pishin-Lora and Nari) GWR is being overused, beyond its development potential, forming mining settings and causation a huge overdraft of GWR that is menacing to dry up the aquifers in the long term [1].

Rainfall Situation in Pakistan

Generally, from June to September annually 70% of the rainfall occurs in Pakistan. It causes more losses of water into the lower Indus side in the Arabian sea. The regional variations of rainfall in Baluchistan range from 125 mm in the southeast to 750 mm in the northwest. Due to the different arid to semi-arid seasons rainfall is neither adequate nor consistent. Rainfall in huge amounts can cause either flood. The riverine areas, communities, cities along the river, and villages are more affected, spoiled, and devasted socially and economically losses allied with another major menace of seepage losses into the sea which deprives the country economically. July and August are counted as high-intensity rainfall months in the Sindh Plains and then continue decreasing from coastal regions to the central parts of the Sindh province. It has been seen that the southern Punjab and northern Sindh have low yearly precipitation not greater than 152 mm. on the other side, salt ranges regions including Rawalpindi, Jhelum, Mianwali and Attock face severe precipitation above the average 635 mm annually. North-West Frontier Province and northern parts of Baluchistan received high rainfall during the winter season. Thus, winter downpour is generally far-reaching. Therefore, it has been estimated that 2 Mha of the Indus Plain and Peshawar valley received 26 MAF precipitation yearly. Hence, rainfall contribution for crops in irrigated areas is calculated as 6 MAF [1].

Access to safe drinking water

Pakistan is one of them which are threatened countries having the unavailability of safe and clean drinking water. Only 25% of the total population has access to safe and clean drinking water in the country. Uncleaned and contaminated water has a high percentage of TDS, Ph, alkalinity, salts, Hardness and Chlorides which are affecting health-related issues in the public. Now, due to the different wasted water from industries and other effluent mixed in the GWR, therefore GWR quality has been no longer safe and available for drinking purposes. The old and damaged pipelines purification tanks and conveyance lines are in the worst condition and are becoming more dangerous for the natural water and the public. Inefficient methods of treatment of water, and no monitoring plan also made the system worst [2].

Water availability and its demand

Agricultural yield and production highly rely on the availability and accessibility of water either by SWR, GWR or Rainfall. As the population is increasing the water demand is also increasing, while, actually real stories say the availability and accessibility of water are decreasing. The expansion of irrigation activities to improve food, fiber and non-food production could be attributed to several reasons for increasing water strategies to encounter the increasing demand of the rising population.

Another serious problem of salinity has also remained. Salinity arises over the irrigated land due to the absorption of mineral salts from the earth and after evaporation of water salts dry out on the irrigated soil surface which affects agricultural productivity. It has been pointed out that 25% of the cultivated land has been affected due to salinity. The reclamation process of salted soil is very expensive and time-consuming. According to the [3] report that half of the water has been drawn about as much gain from the underground spin aquifer. And by 2025 water demand will be 92% of the entire runoff. It has been estimated that 25% of the water is destroyed due to the saline soil and for irrigation purposes, only one-third of the water is used.

Physico-chemical characteristics

Fresh waterbody including river, lakes, streams, or reservoirs has an individual pattern of physical and chemical appearance and characteristics which are assessed largely by the climatic, geomorphological, and geochemical conditions prevailing in the drainage basin and the underlying aquifer. Water characteristics, such as total dissolved solids (TDS), conductivity (EC), and, provide a general classification of water bodies of a similar nature. Mineral content, determined by the TDSs present, is an important feature of any water body quality resulting from the balance between precipitation and dissolution.

The aquatic environment's chemical quality varies according to local geology, the distance from the ocean, climate, the amount of soil cover, etc. If SWR were not affected by human activities, up to 90% to 99% of global freshwaters, depending on the variable of interest, would have natural chemical concentrations suitable for aquatic life and most human uses [4].

Assessment of Biological characteristics
Biota progress with flora and fauna existing on the water surface can be overseen in the environmental and biological circumstances that can be assessed assortment of different species and also the physical act of separating bacteria. The production of organic matter is mostly in the lakes while limited in the rivers. the subsequent growth of bacteria takes a long time process and can be essential in the groundwater and in the lake waters which are not directly visible in the daylight [4].

Human-caused impacts on water quality
With rising population and industrialization, water requirements have extended along with amplification for higher quality water. The use of water, including water diversion and waste disposal, results in real, and usually very predictable, impacts on aquatic environment quality. Besides these deliberate anthropological activities have incidental and detrimental, or then catastrophic effects on the amphibian environment. Topics involve unregulated land use-cover for suburbanization or deforestation, unintended emission of chemical substances, and leakage from solid waste dumps of unsorted waste or leaching of noxious liquids. Furthermore, excess use of fertilizers has effective impacts on GWR and SWR [4].

Development of dams and their importance
Dams' construction in Pakistan is essential, After the independence of Pakistan, only two major dams were built, although, during the same time, the Indian and Turkish governments built 24 and 65 dams respectively. The deposition of sand in dams is drastically deposited in large amounts not only halting irrigation networks but also lowering energy generation which also affects the growth and productivity of agriculture in the industrial sector. Pakistan's government is working on prospective storage schemes to fulfil our country's future water and energy demand [5].

History of dams in Pakistan
Pakistan's historical Dams history is moderately petite. However, only three dams had built at the creation of Pakistan. In 1890, The Khushdil Khan dam had been created. And Spin Karazi dam was built in Baluchistan in 1913. only Punjab had the Nomal dam located in the Mianwali district. The acute shortage of power and energy Warsak dam had been constructed on the Kabul River near Peshawar district. Two other dams were also constructed namely Mangla and Tarbela with storage volumes of 5.88 and 11.62 MAF. These were part of the Indus basin replacement works [5].

Rawal dam and Rawal Lake Water Treatment Plant (RLWTP)
Rawal lake supplies water to Rawalpindi and Islamabad. This supply has been done firstly by water treatment and known as the Rawal lake treatment plant which is functional under the authority of the Rawalpindi Development Authority (RDA) and operated by the Water and Sanitation Agency (WASA). The catchment area is 275 km^2, including four main streams and 43 small streams that contribute to its storage. The total storage capacity of the lake is 58.5 MCM with live storage of 40 MCM [6]. Korangi river has been used for the disposal of sludge generated from sedimentation tanks and filtration backwash. However, in RLWTP, two main technologies are processing coagulation and flocculation with different phases. Mechanical flash mixer, shaft paddle flocculator and rectangular sedimentation tank process in the first phase. While the second phase consists of the clariflocculator. This effluent is transported to the rapid sand filter for filtration [6]. Below water treatment process can be understood by the flowchart (Figure 1).

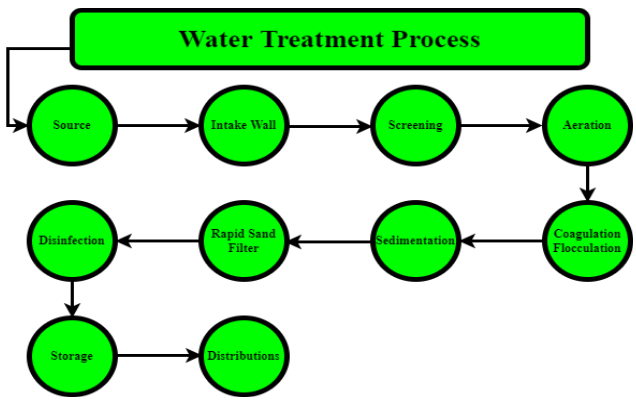

Figure 1. Flow chart diagram of the Water treatment process

Literature review
To examine the physical and chemical limits of water and deposits obtained from Rawal Dam Islamabad, the present analysis has been carried out by [7]. Six samples at different locations were obtained at different periods. According to WHO and TWOR, the findings of the physical and chemical parameters of water obtained from the Rawal dam were in the normal range, suggesting that water from the Rawal dam was convenient. [8] investigated the physical and chemical features along the Rawal dam reservoir catchment area. Samples from key streams, drainage, community, and from the middle of the dam were collected. Using standard methods, the physicochemical parameters were evaluated. The study by [9] recorded the consumptive water quality characteristics and pollution studies showed in Pakistan that reported sewerage water (fecal) mixing with drinking water as the dominant and main pollutant due to poor cleanliness and sewerage system.

The second source of waste is chemical emissions from industrial effluent toxic substances, clothing colors, pesticides, nitrogenous fertilizers, Arsenic, and other chemicals. Periodic monitoring of already existing treatment plants needs to be maintained and updated. Today, the Pakistani government is installing drinking water filters throughout Pakistan. The findings highlighted the need to consider sewerage interference with drinking water as a significant environmental and health problem. [10] has shown that the population has grown enormously in the Rawal Lake catchment area, particularly from 1998-2009. The population statistics showed an increase of 84% compared to 1998 at a growth rate of 5.75% per annum. The trend of land use has changed in the Rawal Lake catchment; from 1998 to 2009, the area under the category of built-up land increased from 14.7% to 23.12%, while the area under forest decreased from 58% to 48%. The average inflows were reduced as compared with the average inflows from previous years, the increase in urbanization in the catchment area is a factor in this decrease in inflows. There is no significant change in the catchment area's rainfall, but the inflows have declined which shows that the inflows are being decreased due to the increase in urbanization.

The rise in urbanization has reduced Rawal Lake's water quality and its two major tributaries i.e., Main Noorpur Shahan, and river Korang. Biologically, water is unfit for human consumption. Total coliform and fecal bacteria are supplementary in the count to the requirements of the WHO. There are also +ve E. coli bacteria institutes in Noorpur Shah Stream and Korang River. The main lake and Korang River water were also found more turbid than the WHO standards. The amount of calcium (Ca^{+}) was detected higher than WHO standards in the case of the Noorpur Shah Stream. [11] concluded that due to various facts and factors, the water quality of all the evaluated sites is declining; most notable are the human-induced activities i.e., irrigation, deforestation, soil erosion, poultry waste, solid waste disposal, and the domestic use of water and discharge to the sites without pretreatment. The sampling sites near populated areas such as the Angoori road and Rawal Lake were to derive to be more contaminated, and in June this load is greater than in April. In June, pollution intensity is due to increased anthropogenic activity, and summer heat and many tourists visit Murree Hills which is the catchment area of all the sampling sites. In addition, the WASA filtration system works effectively, eliminating the number of pollutants from all locations and making the water quality acceptable for drinking. Water samples have higher levels of lead and cadmium toxicity, so irrigation in agricultural fields should be strictly prohibited and the use of agrochemicals strictly controlled. The main line of defence should be the protection of water resources. National standards of environmental quality or the disposal of urban and industrial effluents should be enforced. A standard water quality inspection system should be formulated and implemented. There should be constant monitoring of all critical parameters. Thus, the main focus of our study and targeted objectives are to achieve the water quality of Rawal dam and its silt control tank (WASA) and to compare the quality of Rawal dam water with the WASA filtration plant.

II. MATERIALS AND METHODLOGY

Study Area

The study area of this study was the Rawal Dam, its tributaries (Diplomatic enclave stream, Quaid e Azam university stream, Korang river), and silt control tank WASA (Table 1). Rawal Lake plays a major role in supplying water to the Rawalpindi town and cantonment district. Rawal dam is built on the Korang River and has a 106 square miles catchment area that generates 84,000 hectares of water in an average year of rainfall (Figure 2). Four major streams are contributing to its storage, and 43 are small streams. The total storage capacity is 12994 MG (47.500-acre feet). The warehouse contains 43000 acre-feet which is a total of 11763 MG. While 1752 feet highest flood recorded.

Rawal Lake and its catchment area are important resources for Rawalpindi and the entire region. Full benefits can be taken by the proper management of this resource. The most obvious benefit of the resources is for Rawalpindi to provide water supplies. The lake has been subject to contamination by several sources for the last few decades including poultry waste, human population effluent, recreational activities, hazardous practices in agricultural fields, deforestation, and sedimentation. Due to its effects on human health and aquatic ecosystems, surface water quality is of great importance. Running water is highly vulnerable to contamination due to its role in carrying off urban and industrial wastewater in its vast drainage basins and run-off from agriculture. As well as natural processes, anthropogenic activities deteriorate the surface water and hinder its use for drinking, commercial, farming, recreational or other purposes. In mid-June 2004, Rawal Lake, Islamabad took place [12].

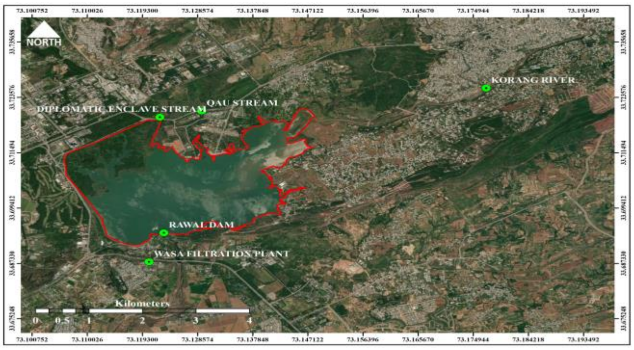

Figure 2. Layout map of study area showing water collection samples with green points

Sample collection

Water samples were collected from Rawal Dam, its tributaries, and the WASA filtration plant. The water samples were collected on a temporal basis in October (before rainfall) and November (after rainfall). The sampling places, names, and location GPS coordinates are given in (Table 1). Two different plastic bottles were used for water samples. Polyethene bottles of 500 ml were used for physical and chemical testing of collected water, and for the biological testing especial designed sterilized sealed bottles of 100 ml were used. Before collecting the samples from sample locations, we washed the polyethene bottles thoroughly and fully occupied them having no air bubbles captivated in the bottles. For biological testing, sealed bottles were completely dipped in water and its seal were opened inside the water so that no external contamination could enter the water sample. After sample collection, the sample bottles were closed properly, shifted to the research laboratory, and stored at room temperature. We analyzed these samples within 24 hours of collection. (Figure 4) shows the pictorial view of sampling and laboratory analysis.

Table 1. GPS Coordinates the location of the study area

Sources	GPS Coordinates
Rawal Dam	33°41'38.2"N 73°07'22.5"E
Diplomatic Enclave Stream	33°43'09.2"N 73°07'20.1"E
Quaid E Azam University Stream	33°43'14.6"N 73°07'45.4"E
Korang River	33°43'32.0"N 73°10'37.8"E
WASA Filtration Plant	33°41'15.4"N 73°07'13.5"E

Investigation of Physical, Chemical, and Biological Parameters

(Figure 3) shows a flow chart for tests conducted for investigation of physical, chemical, and biological constraints. Standard procedure was employed for the examination of physical and chemical parameters. Physical parameters including (pH, EC, Salt, Temperature, TDS, etc.) were analyzed by using multi-parameter tester 34, and turbidness was estimated by using an electronic turbidity meter, while ORP was measured by a conductivity meter. On the other side, Chemical parameters were analyzed by using the volumetric titration method. Likewise, Microbiological parameters were analyzed by spread plate count method and by biochemical test i.e., gram staining method.

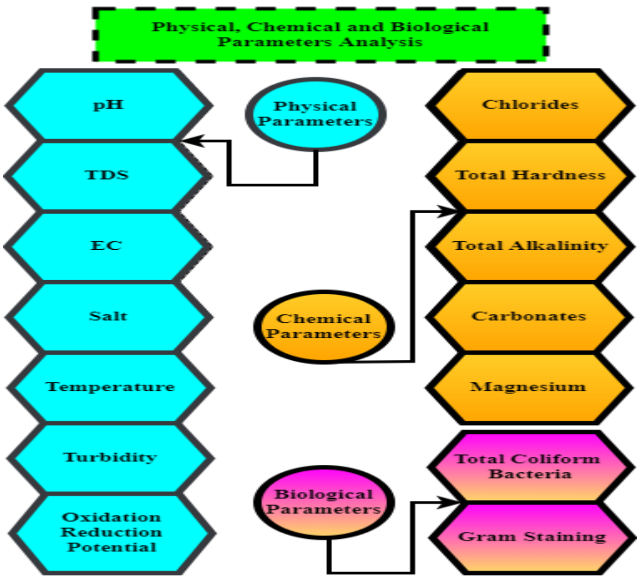

Figure 3. Flow chart diagram for physical, chemical, and biological testing methods

Physical Parameters

pH

Assessment of water quality is essential because of its impacts on the biotic life and chemical processes within a water body. Therefore, Ph is the main factor to assess the weather, and how much water has acids and alkalinity. It measures the solution's acid balance and logarithm negative of the concentration ions at base 10.

The scale of pH indicates (0 - 14). The less numbers indicate an acidic condition in the samples and the higher values indicate alkaline conditions. pH 7 counts as a neutral state of the solution. The pH can be reduced by the dissolved chemical compounds and biochemical processes in the sampled solution. Uncontaminated samples of water, it is regulated mainly by the equilibrium of carbon dioxide, carbonate, and bicarbonate ions. The pH range of 6 to 8.5 is counted as natural water, while lower values can occur for diluted water which is rich in organic content and maximum in eutrophic waters, groundwater brines and salt lakes [4].

Total dissolved solids (TDS)

Inorganic and organic matter existing in water that can pass through the filter of 2 microns is known as TDS. These are the addition of cations and anions in water. TDS will only tell how much the total amount of these ions are present in it but will not tell the relationship between them and nature.

Electrical conductivity (EC)

EC characterizes the ability of water to conduct an electric current. Distinctions in thawed solids, frequently mineral salts are penetrating. The dispersing level shows ions and each ion has an electrical charge on it. The movement of ions and the solution temperature all affect the conductivity. Globally, µS cm-1 is symbolically expressed as a unit of EC. and, for a given water body, is related to the concentrations of TDS and major ions [4].

Temperature

In addition to normal climatic variability, the water bodies undergo temperature variations. Such changes occur seasonally and over 24-hour cycles in some water bodies. Surface water temperature is determined by parameters including altitude, times and day, air flow, cloud cover, and water body movement and depth. Temperature affects biological, physical and chemical reactions and concentrations of many parameters in the waterbody. Hence, its irises with the evaporation and volatilization of substances from the levels of water. Growth rate (significant for bacteria and phytoplankton, that increase their populations shortly) leads to enlarged water turbidity, macrophyte development, and algal buds when nutrient states are appropriate.

Turbidity

The unseen particles to the naked eyes cause the turbidity of water. The measure of the turbidity-by-turbidity meter will tell the quality of water. Different size of particles is suspended in water. Different man-made activities like mining, urbanization, and construction are the reason for turbidity in water. So, therefore, it is one of the important parameters to analyze because many dangerous bacteria attach to particles and may cause serious health issues.

Oxidation-reduction potential

Oxidation-reduction potential also called ORP is a factor that determines the cleanliness of the water and the ability to remove or break down contaminants from water sources. The higher the level of ORP the more water can break contaminants such as microbes.

Salt

The salty nature of water and the presence of dissolved salts is called salt water or saline water. NaCl molecules get separated when salt molecules are dissolved in water and then they become free ions.

Chemical Parameters

Alkalinity

Alkalinity is usually due to the existence of bicarbonates that are formed in responses in the topsoils by the infiltration process. It measures the ability of water to neutralize acids and characterizes its buffer capacity (it is inherent in pH shift resistance). Inadequately protected water can be low or very low alkalinity, and liable to pH reduction. Furthermore, alkalinity measure values ranging up to 400 mg/l CaCO3 can occasionally be found; irrelevant in terms of water quality. The most widely used indicators are phenolphthalein (color change around pH8.3) and methyl orange (color change pH 4.5), resulting in additional terms alkalinity of phenolphthalein and alkalinity of methyl orange; the latter synonymous with total alkalinity. The following (Equation 1) is used for the Alkalinity.

$$TA\frac{1mg}{L}\ \text{for}\ CaCO3=\frac{A\times B\times 1000}{\text{ml of sample}} \quad (1)$$

Where, A = ml of H_2SO_4 used with only methyl orange, B = normality of H_2SO_4, TA = total alkalinity

Carbonates

Carbonates and bicarbonates in the water highly affect the alkalinity and hardness of the water. The rock weathering process is the main term for the production of carbonates and bicarbonates. In areas of noncarbonated rocks, the HCO^3 and CO_3^2 arise entirely from the atmosphere and soil CO_2, however in areas of carbonate rocks, the rock itself contributes approximately 50% of the (CO_3^2) and (HCO^3) present. The amount of (CO_3^2), (HCO^3) and carbonic acid in undiluted water are correlated with pH. During the weathering process, allied with the pH array of surface water from the 6 to 8.2 range, (HCO^3) is the leading anion in the surface water. (CO_3^2) is very rare on the natural water surface due to the reason it hardly crosses pH 9. On the other side, the groundwater can contain (CO_3^2) up to 10 mgl^{-1}. If the focus is on the bicarbonate its range in the surface water is commonly <500 mgl^{-1}, and commonly < 25 mgl^{-1}.

The concentration of (CO_3^2) and (HCO^3) can be projected from the free and total alkalinity. Though, the calculation is valid only for pure water since it takes up that the alkalinity derives only from (CO_3^2) and (HCO^3) [4].

Chlorides

Most of the chlorine occurs in the solution as chloride (Cl-). These chlorides enter into surface water allied with the atmospheric accumulation of oceanic vaporizers, weathering some sedimentary rocks (salt deposits) and industrial surplus wastes, and excess of farming and roads. During the winter season, road salting will significantly contribute to groundwater chloride increases. High chloride concentrations can make water unpleasant, and hence improper for drinking or watering livestock. Chloride concentrations are considerably lower than 10 mg l-1 in pure freshwater habitats and sometimes lower than 2 mg l-1. Higher concentrations can exist in the vicinity of sewage and other waste sources, irrigation drains, intrusions of salt water, arid areas, and west coasts. Chloride determination samples do not need preservation or special treatment and can be kept at room temperature. The analysis can be carried out using normal or potentiometric titration methods. Chloride-sensitive electrodes may make direct potentiometric determinations. The following (Equations 2 & 3),

$$Chloride\ (\frac{mg}{L}\ of\ CL-=\frac{(\text{ml}\times \text{N})\ \text{of AgNO3}\times 1000\times 35.5}{35.5\ Vol.of\ sample} \quad (2)$$

$$Chloride\ (\frac{mg}{L}\ of\ NaCl)=\frac{(\text{ml}\times \text{N})\ \text{of AgNO3}\times 1000\times 58.5}{35.5\ Vol.of\ sample} \quad (3)$$

Hardness

Hardness is a usual characteristic of water which can rise its nutritional value and the suitability of consumers for drinking purposes. In recent years, health education in numerous states has shown that mortality rates from heart disease are lower in hard water regions. Natural water hardness largely depends on the existence of soluble Ca and Mg salts.

The overall content of salts is described as general hardness, further alienated into carbonate hardness (Ca and Mg hydro carbonate concentrations) and non-carbonate hardness (Heavy acid ca and mg salts).

Hydro-carbonates are converted through the boiling of water into carbonates, which frequently precipitate. All through, the boiling process, hydro carbonates are transformed into carbonates that generally precipitate. Carbonate hardness is also recognized as temporary or quiet, while it is called constant hardness residual in the water after boiling. Calcium hardness is generally prevalent (up to 70%); while magnesium hardness can exceed 50-60% in some cases.

Hardness is determined by complex metric titration with EDTA. Assess by either general hardness (via eriochrome black T) or by calcium hardness (via murexide), depending on the indicator used. The durability of mg is determined by the variance between the two determinations. The durability of carbonate is determined by acid-base titration [4]. Ca^{2+} is abundantly present in natural water due to the constant leaching from luck into water. The concentration of water can differ conditional on the concentration of Ca in the water. It is an essential nutrient to the organism so even if it reaches 1500 ppm; it does not have a health hazard. Calcium can be intoxicating the toxicity of Pb, Zn, and KCl but the increased concentration of calcium in water can increase the hardness of water so not applicable for domestic or industrial purposes. Mg+ in natural water is less common than Ca +. The rocks, sewage, and industrial waste are important sources of Mg. If Mg+ concentration exceeds 500 ppm, it will impart an unpleasant taste and will also increase water hardness [13].

Microbiological Parameters

This analysis was carried out by the spread plate count method. This method was done to check the total number of coliform bacteria present in water samples. Three different types of media were used including NA, EMB, and SS agars. For removal of contamination and microorganism sterilization of Petri dishes (Figure 4) were done in an autoclave for 2 hours. Also, the media solution required for samples was sterilized along it in the autoclave. After autoclaving, the media was poured into sterilized dry plates using an aseptic technique in a laminar airflow cabinet, after pouring let agar dry and solidified. A water sample was spread on each petri dish to check the presence or absence of total coliform bacteria, fecal coliforms, Salmonella, and Shigella Bacteria.

Figure 4. shows a pictorial view of the sampling water and laboratory analysis

Gram staining method (GSM)

The GSM highlights the Gram-positive and Gram-negative bacteria. For the method, four reagents were used:

1. Crystal violet,
2. Gram iodine,
3. Decolorizer,
4. Safranine.

(Figure 5) represents the GSM below.

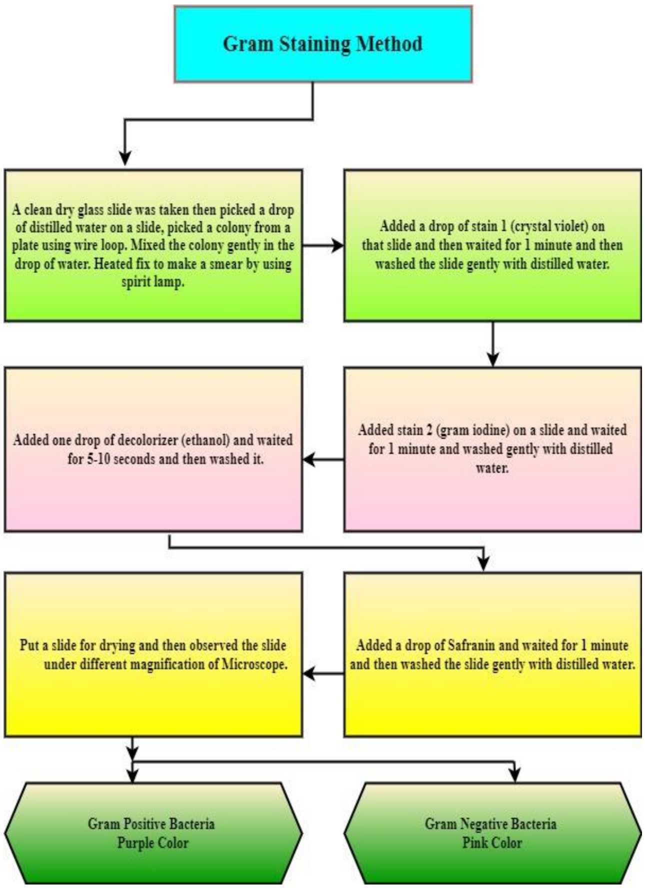

Figure 5. flow chart methodology for Gram Staining Method

III. RESULTS AND DİSCUSSİON

Physico-chemical analysis

In this study, water samples collected from the study area were analyzed, in which various parameters were tested. The physicochemical data of the study area were collected in October and November 2019 and then compared with the standards of WHO and the Pakistan Environmental Protection Agency.

pH

pH indicates the acidity and basicity of water. It also evaluates the acid-base balance of water. pH is determined by the amount of carbon dioxide dissolved in water, which forms carbonic acid. WHO and Pakistan Environmental Protection Agency have recommended a specific range of pH in which water is termed neutral (acid-base balance), the determined range is 6.5-8.5 (Figure 6).

Total Dissolved Solids (TDS)

The standard limit for total dissolved solids in Pakistan Environmental Protection Agency is 1000, while the standard for TDS in WHO is not specified/ defined. The TDS concentration in water samples of DAM, DE, QAU, KR, and WASA are 244, 322, 283, 337.5 and 305 ppm respectively lies within the range given for TDS in water samples (Figure 7).

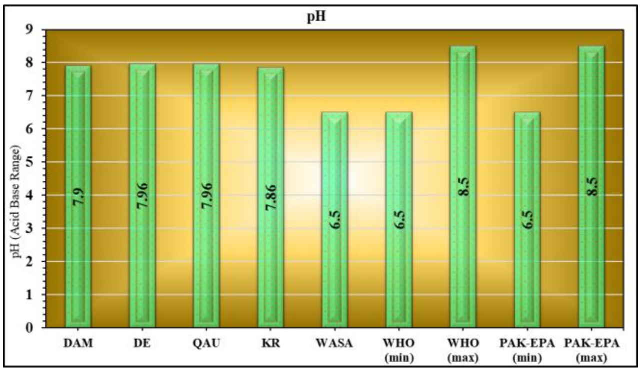

Figure 6. pH of water samples compared with standards

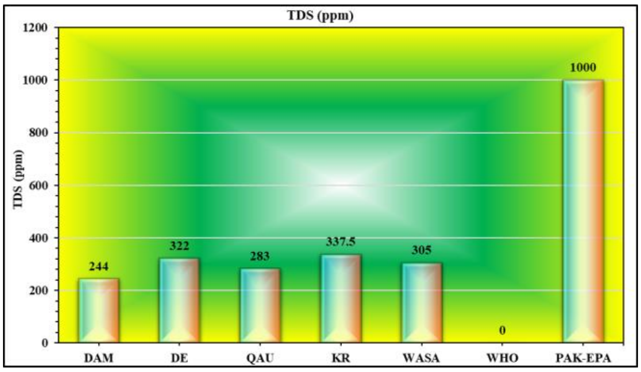

Figure 7. Total dissolved solids of water samples compared with standards

Electrical Conductivity (EC)

Electrical conductivity determines the concentration of electrolytes in water containing mineral salts. The results showed that the electrical conductivity of water samples obtained from DAM, DE, QAU, KR, and WASA is within standard limits of WHO and Pakistan Environmental Protection Agency which is equal to 600 µs/cm (Figure 8).

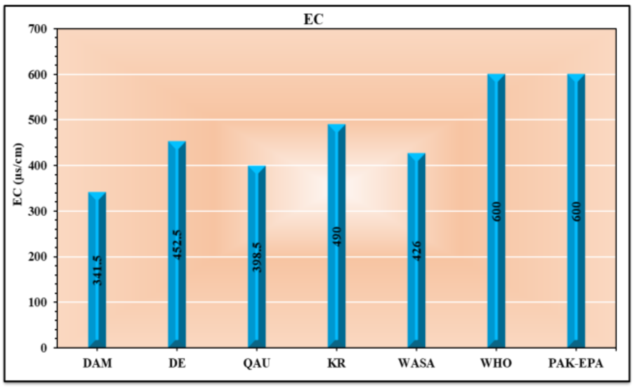

Figure 8. Electrical conductivity of water samples compared with standards

Salt

The standard Concentration of salt content given by WHO and the Pakistan Environmental Protection Agency is 250 mg/L. The concentration of salts in the dam was 175.5 mg/L that were within the permissible limits. Similarly, the salt content of DE, QAU, KR, and WASA are 238, 205.5, 246, and 250 mg/L respectively (Figure 9). The value of the KR sample is within the standards of WHO.

Oxidation Reduction Potential (ORP)

The ability of water to clean up all the contaminates by eliminating them by redox reaction known as ORP. WHO and Pakistan Environmental Protection Agency did not define any specific limit for ORP. DAM contains more able to clean the water while other samples such as DE, QAU, and KR are followed by each other in ORP. The ORP value of WASA is 17mV (Figure 10).

Turbidity

Turbidity should not exceed more than 5 NTU according to the standards of WHO and the Pakistan Environmental Protection Agency. The value of turbidity in DAM is within the given limit which is 4.44 NTU, while values of DE and QAU are also within the limits. The value of turbidity in KR is extremely higher than the given limit which is due to its dirty and turbid water, while the value of WASA is 6.08 NTU which is slightly higher than the value of standards (Figure 11).

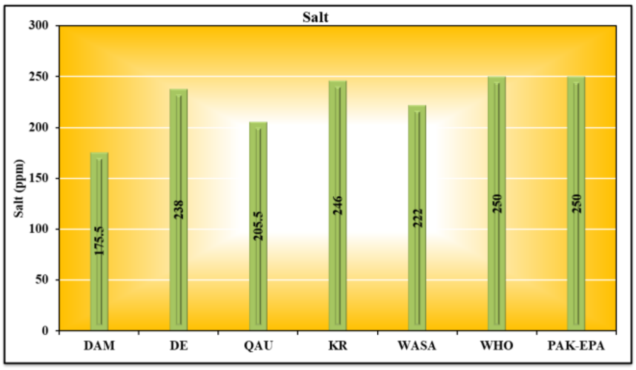

Figure 9. The salt content of water samples compared with standards

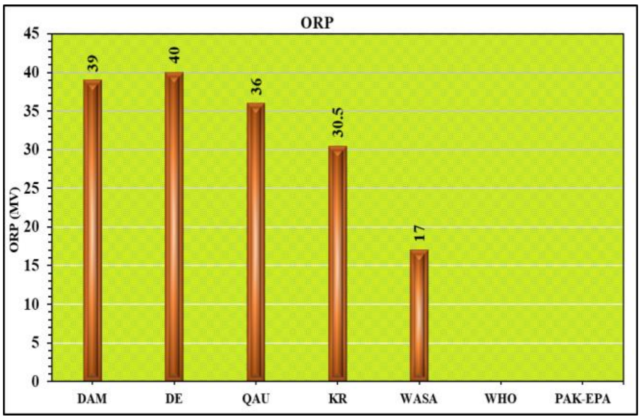

Figure 10. The oxidation-reduction potential of water samples compared with standards

Magnesium

The magnesium concentration results were compared with the given standards of the Pakistan Environmental Protection Agency showed there was not any standard set by WHO. As the graph shows only the water collected from the WASA filtration plant is within the permissible limit, while the other water sample collected from the DAM, QAU, DE, and KR are approximately equal to or above the given limits.

Calcium

The limits given by Pakistan Environmental Protection Agency for calcium concentration are less than 200 mg/L, but there is not any limit given by WHO. Calcium concentrations of all the water collected from the study location lie within the permissible limit given by Pakistan Environmental Protection Agency (Figure 13).

Total Alkalinity

The limit of total alkalinity given by WHO does not exceed more than 200 mg/L, but Pakistan Environmental Protection Agency has not given any standard for alkalinity. Total alkalinity in water samples lies within the permissible limits given by WHO at all locations. See all the results in (Figure 14).

Sodium Chlorides

Sodium chlorides determine the measure of salts (NaCl) in water. Pakistan Environmental Protection Agency and WHO have given limits for salt in water, which should not exceed more than 250 mg/L. The chloride concentration in all water samples collected from the study area is within the permissible limit given by Pakistan Environmental Protection Agency and WHO (Figure 15).

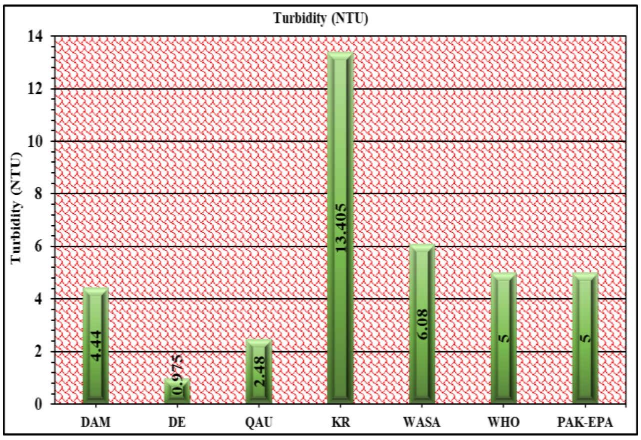

Figure 11. Turbidity of water samples compared with standards

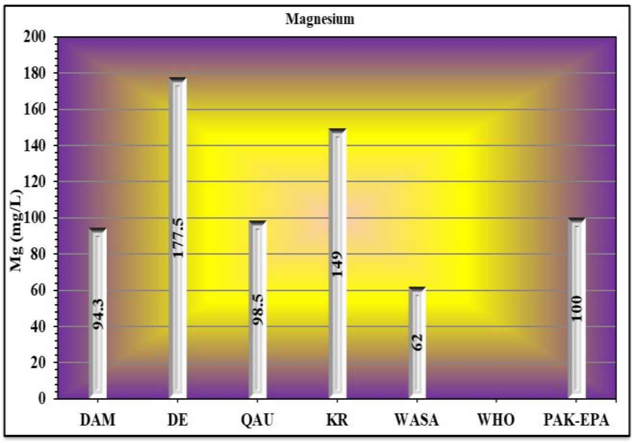

Figure 12. The magnesium content of water samples compared with standards

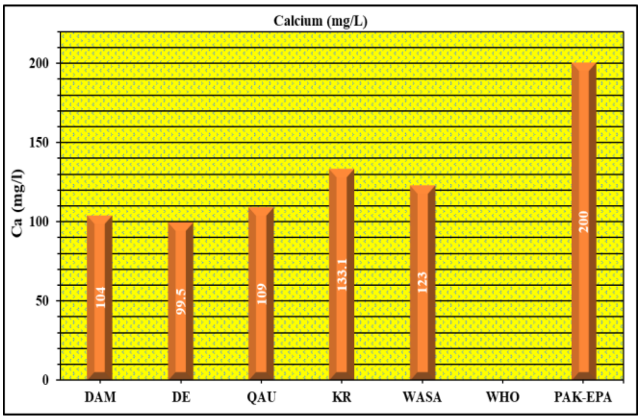

Figure 13. Calcium content of water samples compared with standards

Total hardness

Pakistan Environmental Protection Agency has given the limit of total hardness in water which should not exceed more than 250 mg/L, WHO has not given any standard related to the total hardness. Only the total hardness of DAM water and water collected from WASA lies within the permissible limits and all the other samples have a total hardness more than the given limits of the Pakistan Environmental Protection Agency expressed in (Figure 16).

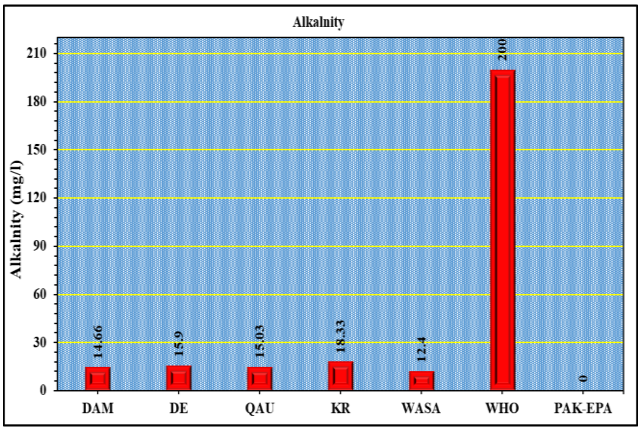

Figure 14. Total alkalinity of water samples compared with standards

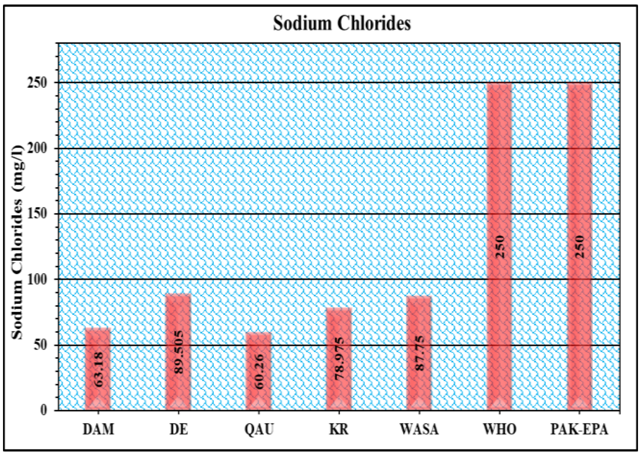

Figure 15. The chloride content of water samples compared with standards

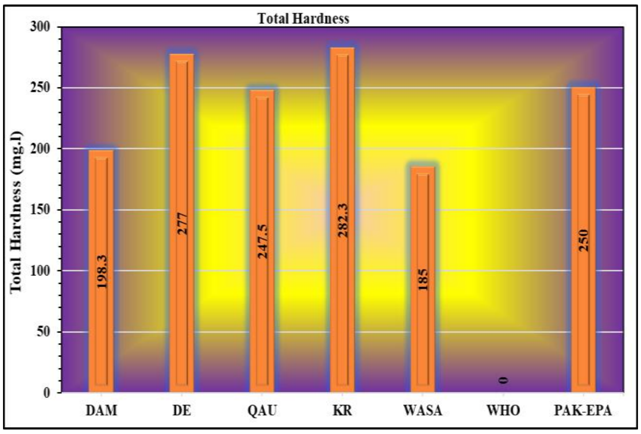

Figure 16. Total Hardness of water samples compared with standards

Table 2. Mean concentrations of physicochemical parameters in water samples

Parameters	DAM	DE	QAU	KR	WASA	WHO	PAK-EPA
Ph	7.9	7.96	7.96	7.86	6.5	6.5-8.5	6.5-8.5
TDS (ppm)	244	322	283	337.5	305	NSRD	1000
EC (µs)	341.5	452.5	398.5	490	426	600	600
Salt (ppm)	175.5	238	205.5	246	222	250	250
Temperature (°C)	17.05	17.2	17.45	17.3	14.4	NSRD	NSRD
Turbidity (NTU)	4.44	0.975	2.48	13.405	6.08	5	5
ORP (mV)	39	40	36	30.5	17	-	-
Total Alkalinity (mg/L)	14.66	15.9	15.03	18.33	12.4	200	-
Total Carbonates (mg/L)	19.185	18.485	19.415	24.715	26.12	-	-
Calcium (mg/L)	104	99.5	109	133.1	123	-	200
Magnesium (mg/L)	94.3	177.5	98.5	149	62	-	100
Sodium Chlorides (mg/L)	63.18	89.505	60.26	78.975	87.75	250	250
Total Hardness(mg/L)	198.3	277	247.5	282.3	185	-	250

Microbiological Analysis

Microbiological analysis exhibited that the bacteria are present in all water samples except in the sample of the WASA filtration plant. According to the WHO and PAK-EPA standards, there should not found any bacteria in the drinking water. A water sample from WASA complied with the standards while other water samples (DAM, DE, QAU, and KR) contain bacteria that are gram-positive during October while some samples contain gram-negative bacteria in November. Gram staining results determined that diverse bacteria are present in samples collected from the study area because EMB and SS Agars showed the growth of gram-positive bacteria as well. E-coli indicates fecal contamination in water samples its existence is shown by gram +ve results of gram staining. A gram-positive result shows the presence of E-coli along with other pathogenic bacteria inhabiting the water reservoirs. These values are supported by the existence of *salmonella* and *shigella* in the bacterial count at all sites except the WASA filtration plant. Only the water of WASA is acceptable for drinking purposes because there were not any pathogenic bacteria found. In (Table 3), Gram +ve bacteria containing Bacillus, Listeria, Staphylococcus, Streptococcus, Enterococcus, and Clostridium. Gram -ve contains cyanobacteria, spirochetes, green sulfur bacteria, and most Proteobacteria.

Table 3. Microbial counts of water samples compared with WHO standard

Name	DAM	DE	QAU	KR	WASA	WHO
NA	74	467	373	261	2	0 CFU/100mL
EMB	2	40	30	70	0	0 CFU/100mL
SS	2	27	57	118	0	0 CFU/100Ml

Table 4. Gram staining results of water samples

Sample locations	Gram Staining Result	
	Oct	Nov
DAM	Gram-positive	Gram-negative
DE	Gram-positive	Gram-negative
QAU	Gram-positive	Gram-negative
KR	Gram-positive	Gram-positive
WASA filtration plant	-	Gram-positive

IV. DISCUSSION

The findings showed that all the physicochemical and biological parameters are within the prescribed limits of the Pakistan Environmental Protection Agency and WHO standards of drinking water quality. The water quality of the Korang River (KR) is not that good and concentrations of certain parameters exceeding from the given limits. This is due to the increase in urbanization/population around the river Korang. All the sewage waste is being disposed of directly into the river without any treatment. Similarly, the Korang River contains high microbial counts due to sewage waste which can pose serious health issues to humans or other species. Other than that, the investigation found that the maximum parameters were under the limits given by WHO and Pakistan Environmental Protection Agency. The comparison of results with the WASA filtration tank showed that the water coming from the DAM is being filtered and sediments are being settled down in the tank. In this way, filtered water is supplied to the population for drinking purposes. All deviations from the given limits are because of the high concentration of sediments and salts which increase the hardness of water and eventually impact the quality of water and the health of the consumer. The main reason for these deviations is unplanned urbanization and poor sewage system.

V. CONCLUSION

In this study, the collected water samples of Rawal dam, its tributaries (QAU, DE, and, KR), and the WASA filtration plant were analyzed for physical parameters (ph., temperature, EC, turbidity, ORP, salt), chemical parameters (chlorides, magnesium, calcium, total hardness, total alkalinity, and carbonates) and microbiological parameters (total coliforms bacteria, gram staining). All obtained results are within the permissible limits of WHO and Pakistan Environmental Protection Agency standards. The results show that the quality of water of the WASA filtration plant is very good compared to the water of the Rawal Dam and its tributaries. All the obtained results of water quality of WASA filtration plants were lower than that of Rawal dam water. From the obtained results of physicochemical and biological parameters of collected water, it was shown that the water quality of Korang River is very bad. The tributary of the Korang River is the main source of the polluting water of Rawal Dam. The main reasons are the increase in urbanization and the damaged sewage system.

VI. RECOMMENDATİONS

- ✓ Our study recommended that there is a need to place a proper check and balance on the spread of urbanization and discharge of effluents in the Rawal dam tributaries.
- ✓ The residential wastewater/ sewage water must be collected at a specific area where it is to be treated before being discarded directly into the stream.
- ✓ EPA and other authorized agencies should inspect and monitor all the parameters of the water of the WASA filtration plant regularly before supplying it to the consumer and should ensure the health of consumers.
- ✓ Further detailed and authentic studies and research should be carried out on microbial characteristics of water quality and the risks they pose to human health.

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