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Evaluation of the Physical and Chemical Properties of Drinking Water in Higher Educational Institutions in Islamabad

Mirza Sajid Baig[1], Asim Qayyum Butt[2,4,*], Donghui Shangguan[2,4], Waqas Ahmad[1], Shahbaz Khalid[1], Syeda Aqsa Gillani[3], Ghulam Yaseen[1], Shaukat Ali Khan[1].

[1]Department of Civil Engineering, MY University, Islamabad, 45320, Pakistan.
[2]Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, China.
[3]Department of Civil Engineering, NFC Institute of Engineering and Technology, Multan 59030, Pakistan.
[4]China-Pakistan Joint Research Center on Earth Sciences, CAS-HEC, Islamabad 45320, Pakistan.
* Corresponding author**:** asimbutt7891@mails.ucas.ac.cn

ABSTRACT

Water is one of the necessities and is used for various purposes, from human consumption to industrial use. Over 70% of the Earth's surface comprises water, less than 1% of which is available as freshwater. Approximately more than one billion people lack safe drinking water worldwide. This paper studies the physical and chemical contamination in potable water of Higher Educational Institutions (HEIs) in Islamabad for the extraction of their influence on water quality. Water samples were collected from 18 different Institutions in the city. Samples were analyzed for various parameters, including temperature, taste, color, odor, pH value, total dissolved solids (TDS), turbidity, hardness, alkalinity, and dissolved oxygen (DO). This qualitative analysis strategy adopted to undertake this research has provided valuable data and information. For all the samples, the degree of temperature and measure of color, taste, and odor were unobjectionable. The amount of turbidity, alkalinity, and hardness were satisfactory. The pH also lies within the permissible ranges set by PS: 1932-2010, WHO and IS: (10500-2004) standards. The amount of TDS and DO was also between excellent and fair ranges. The research concluded that all samples' water quality was fit and can be used for drinking in HEIs. The results of this study can enhance the understanding of safe drinking water quality in Islamabad. The adopted methodology and the obtained results can be replicated in other cities of Pakistan where considerable issues of potable water contamination are rising and resource availability is limited.

KEYWORDS: HEIs, pH, Dissolved oxygen, Turbidity, Total dissolved solids.

1. INTRODUCTION

Approximately more than one billion people lack safe drinking water worldwide. In developing countries, about 50% of the water is obtained from boreholes and wells, and more than 1000 million people in Asia depend upon these resources [1]. Many analytical methods are used to check the presence and concentration of harmful material in water [2]. Most of the health issues related to water are the result of biochemical contamination present in it. In addition to the dangerous problems of water pollution in developing countries, water-caused deaths and diseases are also

important worldwide [3]. Drinking water is the cause of many deaths in Pakistan, too. Pakistan, the sixth largest population in the world, is one of the developing countries [4]; [5]. However, as per the survey, polluted water is one of the main threats to people's fitness in Pakistan, killing about 100,000 people a year and over 250,000 children yearly [6]. In 2015, in Pakistan, 311189 people died because of polluted water consumption, and in 2018, 40% of deaths were caused by it [7]. Pakistan falls on number 80 in the list of 122 states that consume contaminated potable water [8]. The water quality in several cities of Pakistan is deteriorating daily due to uncontrolled municipal and industrial wastewater control and excessive use of fertilizers and pesticides [9]. So, large-scale water assessment is the need of the hour to evaluate and treat drinking water in Pakistan that will help produce safe and palatable water.

Many studies have been presented at the research level on the qualitative assessment of water, which will make public the consequences of this proposed research [10]; [11]. In 2020, research was conducted to check the physical (pH, EC, TDS, total hardness, turbidity) and chemical (Ca, NO3, K, Fe, Zn, SO4, Na, Mg, HCO3, Cl) parameters of bore water samples collected at a depth of 100 and 150ft from the Sindh Industrial and Trading Estate (SITE) zone of Karachi. It was observed that all the parameters other than the pH of the samples were above the requirements of WHO and Pakistani water quality standards [12], [13]. In 2013, in district Mardan Khyber Pakhtunkhwa, Pakistan, various physicochemical parameters, odor, taste, temperature, color, alkalinity, total hardness pH, TDS, EC, HCO3, Mg, Ca, and turbidity, were investigated for 39 potable water samples gathered from groundwater source of 13 union councils. The results showed that the taste of 23%, TDS of 15% of samples, EC of 38% of samples, and hardness of 20% of samples were out of the ranges set by the Pakistani Standards of Water and WHO [14]. In India, the drinking water quality of many lakes was evaluated for physicochemical and biological parameters, i.e., Total Hardness, TDS, DO, Specific Conductance, COD, pH, DO, temperature, TS, and Total Alkalinity by the standard methods. The results for many lakes in Nagpur city, Gorewada Lake, and various other lakes revealed that the majority of the parameters were significantly dominant in the summer as compared to the winter [15], [16],[17].

Farzaneh [18], in 2019, checked the microbial and physical quality of potable water in Maku City (Iran) and also determined the spatial distribution of chemical quality parameters of potable water through GIS during summer and winter. The research conducted for two years showed that all the parameters under consideration for 136 samples from 36 distribution networks during summer and winter were within the standard ranges of WHO and Iranian National Standard, and overall, water was good and safe for drinking. In Bahr Dar City (Ethiopia), microbiological study, i.e., total coliform and fecal coliform by membrane filtration technique, and physicochemical study, i.e., turbidity, EC, nitrate, TDS, pH, sulfate, temperature, free residual chlorine, phosphate, iron, and manganese by the thermometer, EC meter, pH meter, TDS meter, turbidity meter and by standard methods of APHA was conducted to check the water quality. It was found that TC and FC bacteria were detected in all the tap water samples [19].

Water for human consumption must be potable and safe. Potable water is pleasant to drink, conspicuous, and free from tastes, odors, and colors. The contaminated water, whether anthropogenic ally or industrial sources, claims the lives of children and affects the health of

communities worldwide, with far-reaching effects [20]. According to Gillani et al. (2020), more than one billion people lack safe drinking water worldwide. They studied the physicochemical and biological contamination in the potable water of Sahiwal for their exact influence on water quality. For this purpose, the bore and municipal water samples were collected from 6 different city localities. Samples were analyzed for 11 parameters, including temperature recorded by the ordinary thermometer, taste, color, and odor detected by six senses, the value of pH and total dissolved solids (TDS) with the help of a pH meter, and TDS meter, turbidity by using nephelometer, total hardness, alkalinity, and dissolved oxygen (DO) by the titration method. The amount of DO in municipal water samples of Shadman Town and Sadman Town and bore water of Johar Town and Sadman Town samples was found to be less than the required limit set by the WHO [21].

Chandra et al. have conducted a study to assess the drinking water quality of various lakes, i.e., Porur Lake Chennai, Hussain Sager Hyderabad, and Vihar Lake Mumbai in India. For this, water samples were collected from six different sites. Composite samples prepared were analyzed for pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH)and calcium hardness (Ca-H), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (D.O.), sulfate (as a SO_4^{2-}), nitrate (as NO_3) and chloride (Cl^-) levels. Water pollution indicates that these parameters were manifold higher than the prescribed limit by the WHO & BIS standard [22]. Gorde, et al. (2013) presented a study to assess the drinking water quality of various lakes in India. Parameters for the assessment of the water pollution status of the water bodies, the following water quality parameters were analyzed: (1) pH (2) Specific Conductance (3) Temperature (4) Total dissolved solid (TDS) (5) Total Solids (TS) (6) Total Alkalinity (7) Dissolved oxygen (DO) (8) Chemical oxygen demand (COD) (9) Biochemical oxygen demand (BOD) (10) Total Hardness. Hence, the result of water quality assessment clearly showed that most of the water quality parameters were slightly higher in the wet season than in the dry season [23]. Khan et. al. (2012) has explained, that to understand the water quality of Triveni Lake, Physio-chemical parameters were studied and analyzed for one year, i.e., December 2010 to November 2011. Various physicochemical parameters, such as water temperature, air temperature, pH, humidity, conductivity, freeCO_2, total solid, dissolved oxygen, Total alkalinity, Total hardness$CaCO_3$, Ca^{++}, Mg^{++}were studied. The results revealed significant seasonal variation in some physicochemical parameters; most parameters were in the normal range and indicated better lake water quality. It has been found that the water is best for drinking purposes in the winter and summer seasons [24]. Drinking water is the cause of many deaths in Pakistan, too. As per the survey, polluted water is one of the main threats to people's fitness in Pakistan, which kills about 100,000 people year, and over 250,000 children every year. In 2015 Pakistan, 311189 people weed because of polluted water consumption. According to Dawn News, 53,000 children die of diarrhea caused by contaminated water yearly [25].

Hence, all the studies that were conducted encompass Pakistan, provinces, and major cities, but they have yet to research the higher educational institutions of Islamabad. So, focusing on Sustainable development goals [26], this research is mainly based on qualitative analysis of potable water in Higher Educational Institutions (HEIs) in Islamabad, Pakistan. The innovation of this

research was primarily concerned with collecting water samples to test physical and chemical contamination present in the fresh potable water of Higher Educational Institutions in Islamabad for exactness of their impact on water quality.

2. STUDY AREA

Islamabad is the capital of Pakistan. It is the country's ninth-most populous city, with a population of over 1.2 million people, and is federally administered by the Pakistani government as part of the Islamabad Capital Territory. The DMS latitude and longitude coordinates for Islamabad are 33°44'16.9620" N, 73°5'4.1568" E [27]; [28], explained in Figures 1 and 2.

Figure 1: Study Area: Islamabad (Pakistan), (Source: Google)

Figure 2: Study Area showing HEIs in Islamabad (Source: Google)

3. METHODOLOGY

The methodology adopted during the research work for collecting and analyzing the water samples is summarized in the flowchart shown below in Figure 3. To assess the water quality of tap water

of HEIs of Islamabad city, samples were collected from selected institutions in pre-cleaned plastic bottles. Table 1 shows the Selected institutions and their symbols for graphs.

Table 1: Selected institutions and their symbols for graphs.

University Names	**Representation**
Abasyn University Islamabad	S-1
Preston University	S-2
International Islamic University	S-3
Hamdard University	S-4
National University of Sciences & Technology University	S-5
Allama Iqbal Open University, Islamabad Pakistan (AIOU)	S-6
Comsat University	S-7
Quaid-E-Azam University	S-8
IBADAT International University	S-9
National Defense University Islamabad	S-10
My university	S-11
National University of Modern Languages	S-12
Bahira University	S-13
Air University	S-14
Capital University of Science & Technology (CUST)	S-15
Moinuddin Islamic University Islamabad	S-16
Iqra University	S-17
Wafaqi Urdu University	S-18

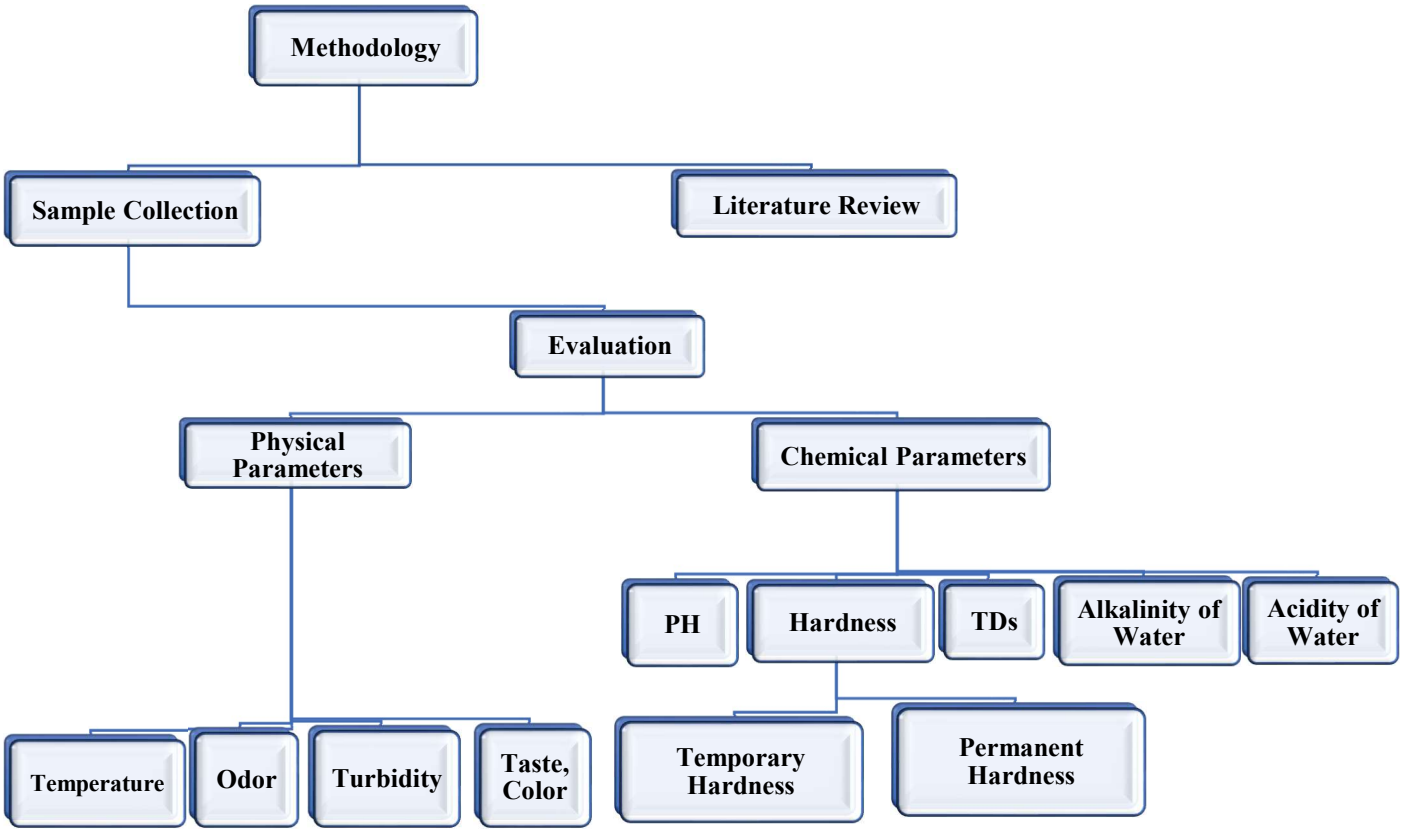

Figure 3: Methodology to complete the study.

As elaborated in Figure 3, eleven parameters were considered, such as temperature, taste, odor, color, turbidity, pH, alkalinity, TDS, total hardness, and DO for analysis of water samples. The apparatus used were a thermometer, nephelometer, burette, flak, measuring cylinder, stirrer, pipette, pH, and TDS meter. The procedure adopted was as follows: the ordinary thermometer recorded the temperature of the water samples. The odor, color and taste were tested by smelling, visualizing and drinking the water samples. The pH value was noted by placing the pH meter into the specimens. The turbidity of the samples was checked by nephelometer with a nephelometric tube inside, filled with the water sample. The amount of light scattering gives the measure of turbidity present in a sample. The amount of Total Hardness, Alkalinity, and Dissolved Oxygen (DO) were investigated in water samples using titration. The difference between the initial and the final reading of the burette filled with the standard solutions gives the amount of that particular parameter in water samples. In the case of Total Hardness, the titrant used was sodium salt of EDTA, with the blue color representing the endpoint of the titration. The standard solution for the alkalinity test was Sulfuric acid, and the endpoint was light orange. For checking the DO of the water samples, sodium thiosulphate was used as a titrant, and the endpoint was yellow. The TDS

present in the water was counted simply by dipping the TDS meter into the water sample. The beneficial and reliable methods for eliminating water contaminations (if present, in any season) were also suggested that can be adapted efficiently by the people at the domestic level. The proposed methods for treating the water samples include boiling, UV radiations, solar radiations and using potash alum.

Parameters	Required to Permissible Limit		
	PS: 1932-2010	WHO	IS:10500-2004
Temperature (°C)	-	7-50	-
Taste	Acceptable	Agreeable	Agreeable
Odor	Unobjectionable	Agreeable	Agreeable
Color mg/l (cobalt scale)	5-25	15	5-25
Turbidity (NTU)	5-10	5	5-10
Dissolved Oxygen (mg/l)	-	3-9	-
Total Dissolved Solids (mg/l)	1000-1500	>600-1000	500-2000
Total Hardness(mg/L)	200-500	150-500	300-600
Alkalinity(mg/l)	400-500	500	200-600
pH	6.5-8.5	6.5-8.5	6.5-8.5

Figure 1: Permissible limits set by PS: 1932-2010(R), WHO and IS: (10500-2004).

4. RESULTS

The integral role of water depends on the quality of the water. According to the research carried out with the analysis of the Higher Educational Institutions (HEIs), the results were monitored for water quality assessment. A total of twelve samples were collected from 18 institutions. The required and permissible limits of different water quality parameters set by PS:1932-2010, WHO, and IS (10500-2004) standards are discussed in the figure below. After performing the entire test, the results were evaluated. The graphical representation of the chemical parameters is provided in Figures 5 to 9.

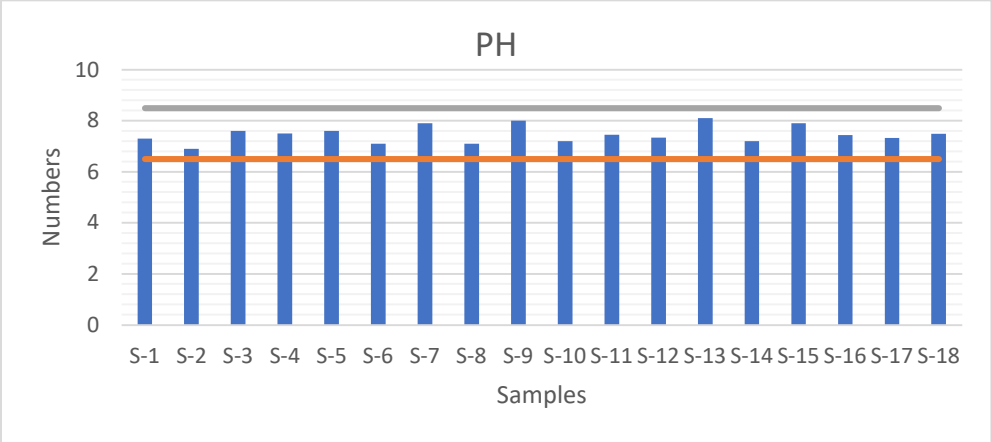

Figure 2: PH Value of Samples

pH of all the samples lies between the lower and upper permissible limits of WHO.

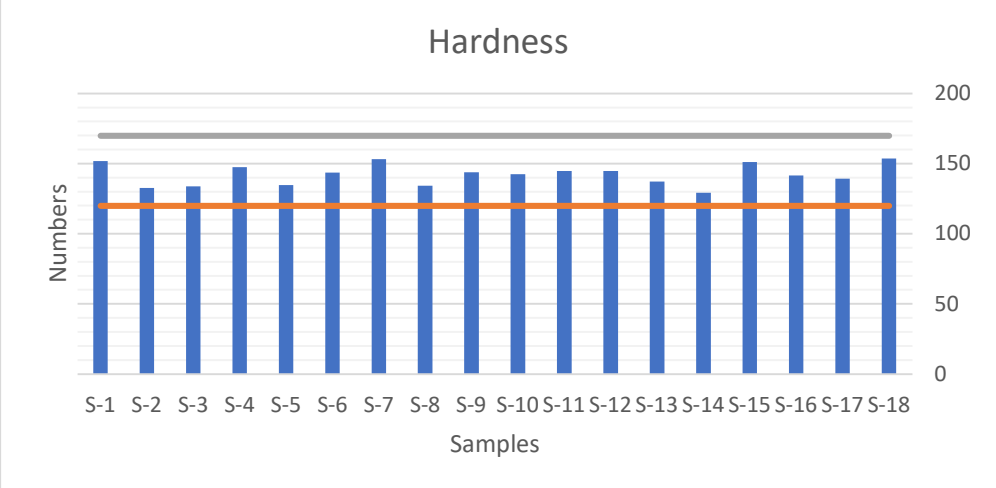

Figure 3: Hardness of Samples

The hardness of all the samples lies between the lower and upper permissible limits of WHO.

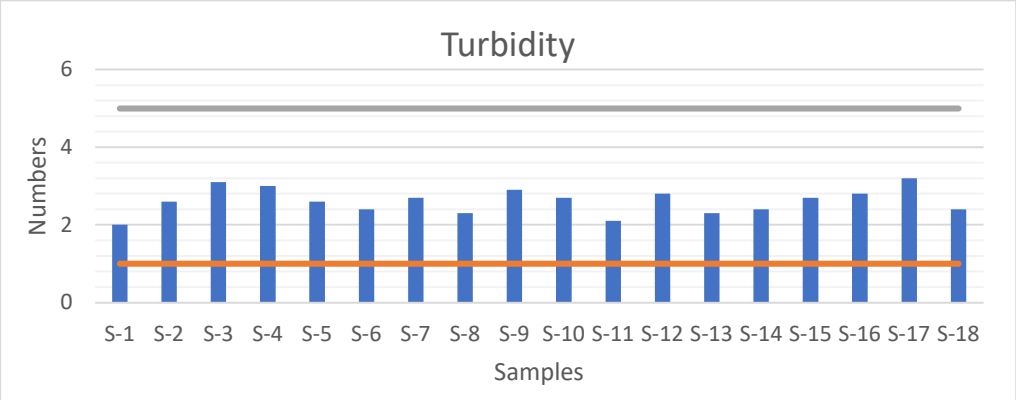

Figure 4: Turbidity of Samples

Turbidity of all the samples lies between the lower and upper permissible limits of WHO.

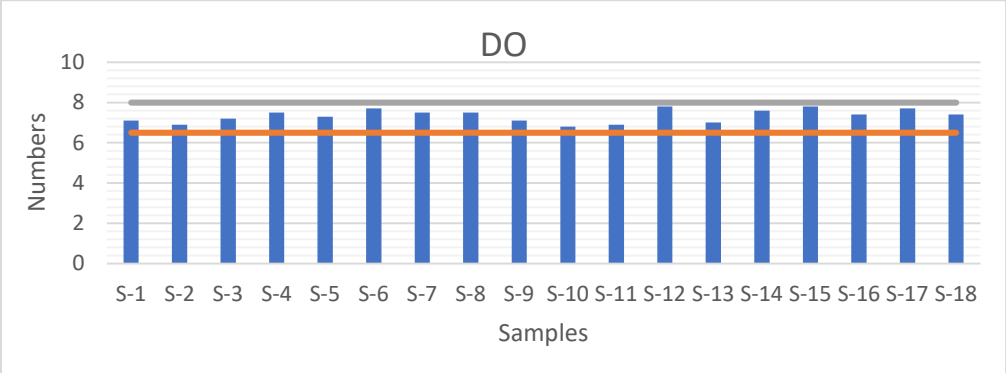

Figure 5: DO of Samples

Dissolved Oxygen of all the samples lies between the lower and upper permissible limits of WHO.

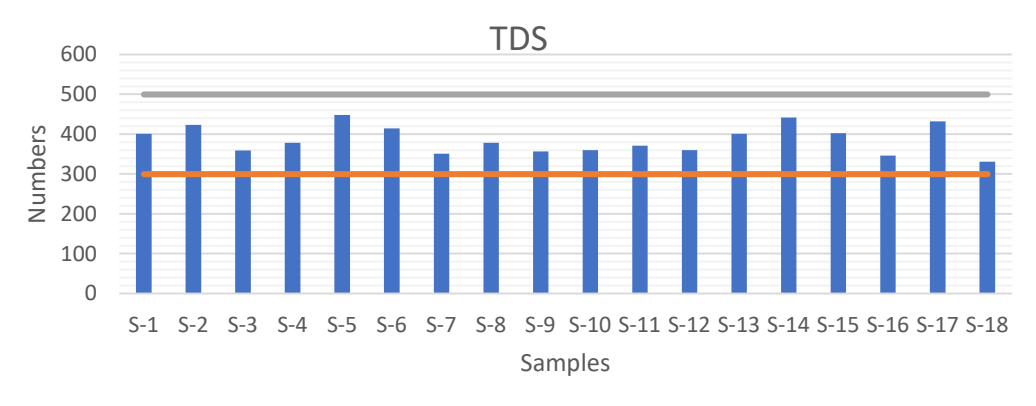

Figure 6: TDS

TDS of all the samples lies between the WHO's lower and upper permissible limits.

All parameters are elaborated in tabular form in the table below, showing the final results as safe or unsafe. The summarized results are in Table 2.

5. DISCUSSIONS

Worldwide, there are about a billion people who do not have access to clean drinking water. Approximately half of the water in developing nations comes from wells and boreholes, and over a billion people in Asia rely on these resources. Pakistan, which has the sixth-largest population in the world is among the developing nations where the public's access to clean drinking water is severely limited. The assessment of the chemical and physical characteristics of water in Pakistani higher education institutions in Islamabad was the main focus of the study. The temperature was measured using an ordinary thermometer; taste, color, and odor were detected using the six senses; the total dissolved solids (TDS) and pH values were determined using a TDS meter and a pH meter; turbidity was measured using a nephelometer; total hardness, alkalinity, and dissolved oxygen (DO) were determined using the titration method. The qualitative analysis approach used in this study has produced insightful data and insights. The temperature as well as the measurements of color, taste, and odor for each sample were all acceptable. Turbidity, alkalinity, and hardness levels were all within acceptable ranges. The pH also lies within the permissible ranges set by PS: 1932-2010, WHO and IS: (10500-2004) standards. The amount of TDS and DO was also between excellent and fair ranges.

6. CONCLUSIONS

The temperature, color, taste, and odor were unobjectionable for all the samples. The water's turbidity, alkalinity, and total hardness were also within an acceptable value. The pH also remained within the permissible ranges set by different standards PS: 1932-2010, WHO and IS: (10500-2004) standards. The number of TDS in water was also within the excellent to the fair ranges. The collected Sample from Higher Educational Institutes lies within the allowable limits of WHO & Pakistan water management. It is concluded from the results that the water Sample collected from Higher Educational Institutes lies within the permissible limits recommended by WHO & Pakistan Water Management. The study is limited to only analyzing the samples collected from the mentioned HEIs. The study can be replicated for further analyses.

Table 2: Summarized results for all the selected HEIs after Evaluation.

Sr. No.	University Name	Sample Code	Coordinates	Sample	Temperat	Color	Odor	Taste	Hardness	Turbidity	pH	Acidity	Alkalinity	Do	TDS	Recommendation
01	Abasyn University Islamabad	S-1	33.6555° N 73.1556° E	Tap	22°	Color	Odor	Tasteless	151.8	0.7	8.3	×	✓	4.5	401	**Safe**
02	Preston University	S-2	33.6762177 73.0652214	Tap	24°	Color	Odor	Tasteless	132.6	1.0	8.5	×	✓	4.1	423	**Safe**
03	International Islamic University	S-3	33.6594682, 73.0236016	Tap	23°	Color	Odor	Tasteless	133.9	1.1	8.3	×	✓	4.8	359	**Safe**
04	Hamdard University	S-4	33.645828, 73.15681 9	Tap	23°	Color	Odor	Tasteless	147.4.3	1.2	8.3	×	✓	5.9	178	**Safe**
05	National University of Sciences & Technology University	S-5	33.64273405, 72.99310836	Tap Water	23.1°	Color less	Odor less	Tasteless	134.8	0.9	8.42	×	✓	5.3	448	**Safe**
06	Allama Iqbal Open University, Islamabad Pakistan	S-6	33.680705, 73.05482	Tap Water	24.1°	Color less	Odor less	Tasteless	143.5	1.4	8.43	×	✓	6.1	414	**Safe**
07	Comsat University	S-7	33.6575717, 73.1578001	Tap	22°	Color	Odor	Tasteless	153.2	0.8	8.4	×	✓	4.7	550	**Safe**
08	Quaid-E-Azam University	S-8	33.7489278, 73.137693	Tap	22°	Color	Odor	Tasteless	101.9	0.6	8.50	×	✓	5.4	377	**Safe**

09	IBADAT International University	S-9	33.5711548, 73.2360173	Tap	22.4°	Color	Odor	Tasteless	143.8	1.9	8.4	×	✓	5.8	307	**Safe**
10	National Defense University Islamabad	S-10	33.7216140, 73.022101	Tap	22.4°	Color	Odor	Tasteless	142.5	1.1	8.35	×	✓	5.7	329	**Safe**
11	MY University, (Japan Rd.)	S-11	33.574007, 73.212636	Tap	22.9°	Color	Odor	Tasteless	120.7	0.9	8.45	×	✓	5.4	170	**Safe**
12	National University of Modern Languages University	S-12	33.67217 73.05400	Tap Water	21.6°	Color less	Odor less	Tasteless	144.8	0.8	8.33	×	✓	5.0	360	**Safe**
13	Bahira University	S-13	33.715677, 73.029135	Tap	21.8°	Color	Odor	Tasteless	137.3	0.7	8.3	×	✓	5.3	401	**Safe**
14	Air University	S-14	33.7140815, 73.024589	Tap	23.6°	Color	Odor	Tasteless	129.2	1.3	8.3	×	✓	6.1	442	**Safe**
15	Capital University of Science & Technology	S-15	33.546777, 73.18408	Tap Water	22.3°	Color less	Odor less	Tasteless	91.3	1.5	8.5	×	✓	4	402	**Safe**
16	Mohiuddin Islamic University Islamabad	S-16	33.559069, 73.19515	Tap	23.4°	Color	Odor	Tasteless	101.6	0.8	8.43	×	✓	5.7	346	**Safe**
17	Iqra University	S-17	33.66446, 73.045339	Tap	21.2°	Color	Odor	Tasteless	179.3	1.3	8.32	×	✓	4.6	492	**Safe**

18	Wafaqi Urdu University	S-18		Tap W.	22.9°	Color	Odor	Tasteless	173.7	0.4	8.48	×	✓	5.3	331	Safe

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Authors' Declaration:

The authors declare that they have no competing financial interests. The authors have no conflict to disclose.

Authors Contribution:

The first author (MSB) performed all the review work and prepared the writing material with input and guidance from D.S. and AQB. The sample collection and testing were done by M.S.B and W.A., while S.K, G.Y, S.A.G, and S.A.K contributed to the discussion of findings and shared the writing of the paper with the first author. All authors have read and approved the manuscript.

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