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Safety Assessment of Water Purification Plants of Lahore

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Abstract

Water purification plants play an important role in human health and the environment. The Water Purification Plants of Lahore provide an adequate assessment of water to fulfill the needs of drinking water human beings. The current study was conducted to check the quality of drinking water of plants by checking the biological, physical, and chemical properties of different areas of Lahore City. Water samples were analyzed with some metal contents in the samples by using Atomic Absorption Spectrophotometer. Safety assessment of water purification plants covered the inspection survey of those plants installed in three zones of Lahore. A total number of 30 samples were collected from three zones (urban, suburban, and old areas) of Lahore with 10 samples each from a single zone. All water samples of suburban & urban regions were having electrical conductivities more than the permissible limit. The water samples of five suburban areas were high TDS values. All water samples of urban areas and old cities had normal turbidity values except for two locations. Water samples from six urban areas had a total hardness of more than the acceptable limit (66-125 ppm). Waters of five areas had an extremely low value of iron (0.005 - 0.092 mg/l). Various blocks from urban areas were having extremely low values of iron (0.002 – 0.094 mg/l). Seven regions of old city areas had low values of iron (0.004 – 0.078 mg/l). Water samples of old city, suburban and urban areas were having allowed levels of manganese. Five regions from suburban areas had total coliform counts greater than 20 per 100 ml. All samples from urban areas had exceeding total coliform counts except in two blocks. Five regions from suburban areas had total coliform counts greater than 20 per 100 ml. The majority of residents reported typhoid followed by diarrhea, hepatitis, and gastroenteritis during the last three years. Many water purification plants had defective taps, seals, and drainage channels. To avoid waterborne infections, it is critical to maintain adequate hygiene and maintenance for local water purification facilities without changing the chemical composition and nutritional levels of drinking water.

Keywords: Water Purification Plants, Physiochemical Properties, Sanitation Conditions, Health Impacts, Drinking Water, Iron, Coliform, Waterborne Diseases

1. Introduction:

Water Purification Plants are critical to both human health and the environment. Lahore's Water Purification Plants should be evaluated to meet human drinking water demands. The government of Pakistan constructed and installed these purification facilities as part of the Union Council level Pakistan initiative dubbed "Clean Drinking Water for All (CDWA)" to offer the fundamental requirement of water to its citizens. Access to clean and safe drinking water is a basic human need [1]. Humans need a total of 21 mineral elements, including calcium, magnesium, sodium, potassium, and trace minerals. For example, magnesium in water is required for the prevention of magnesium insufficiency [2]. According to the World Health Organization (WHO), safe drinking water keeps nearly 1.5 million people healthy and

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free of disease. Every year, around 5.5 million people die as a result of drinking contaminated water, with the majority of them contracting cholera, which causes diarrhea and is detrimental to human health [3]. Contaminated water is the leading cause of death in humans, along with poor sanitation and the presence of heavy metals such as lead, copper, oxides, calcium, bacteria such as cholera, and water [4]. Different solutions have been developed to reduce water contamination. UV rays, water treatment technologies, reverse osmosis, solar radiation, and filtration techniques are among these technologies [5].

A healthy life requires access to treated and clean water. In Pakistan, 44% of the population lacks access to safe and sanitary drinking water. In rural places, 90% of people are compelled to drink unclean water. Every year, 200,000 children die from diarrheal infections caused by polluted water. As a result, water-borne infections are a major problem in Pakistan, where the annual incidence of mortality is increasing [6]. The problem is exacerbated in underdeveloped nations due to a lack of appropriate management, a scarcity of specialists, and financial constraints. Pakistan, like many other developing countries throughout the world, has acute water constraint and pollution. The precipitation rate in the nation is lower than the evaporation rate. This results in a steady decrease in the amount of water in its rivers and lakes, as well as a decrease in groundwater. The situation is exacerbated further by variables such as prolonged droughts and a lack of new water reservoir building. The majority of drinking water distributed to the public by municipalities is polluted with pathogenic microbes or harmful chemicals. Drinking water in heavily populated cities like as Karachi, Lahore, Rawalpindi, Peshawar, Faisalabad, Kasur, Sialkot, and Gujrat is contaminated as a result of anthropogenic activity and should not be consumed [7-8]. Bacteriological pollution has been identified as the most serious drinking water concern in Pakistan. Waterborne infections cost the United States between $25 and $58 billion per year. Due to waterborne infections, 20-40% of hospital beds are occupied each year. In Pakistan, safe drinking water is only available in 23.5 percent of rural areas and 30 percent of urban areas [9].

The Government of Pakistan ensures that Pakistanis have access to safe drinking water to accomplish UNDP development goals [10]. Project on Clean Drinking Water for All (CDWA) aimed to establish water purification plants in each Union Council to satisfy the Government of Pakistan's targets of providing drinking water with capacities of 200, 1000, and 2000 gallons per hour. The state of Pakistan has approved the NSDWQ (National Standards for Drinking Water Quality) in 1993. The Pakistani government initiates many projects to prevent environmental pollution, such as Cleaner Production in Industry, Common Effluent Treatment Plants, Pollution Charge systems, and self-monitoring and reporting [11]. Lahore is Pakistan's second-biggest city, with a population of around 10 million people. As a result, providing clean and wholesome water to the entire Lahore population is exceedingly challenging. Water filtration facilities have already been erected in Lahore's urban areas such as Model Town Administration has installed water filtration. The Punjab government has established water filtration plants in rural regions to provide clean and wholesome water to the people of Lahore. We should continuously evaluate the safety characteristics of the chosen water purification facilities, such as hazardous metals and total coliforms. The effectiveness of the water purification facilities should be determined by evaluating physio-chemical characteristics like pH, turbidity, electrical conductivity, total dissolved solids (TDS), etc. As a result, the present research was carried out to examine and compare the quality of drinking water. There is no regular maintenance to monitor the pollution status of water purification plants, as far as we can tell. Therefore, the current study was conducted to check the quality of drinking water of plants by checking the biological, physical, and chemical characteristics of different areas of Lahore City. We compared the level of contamination in water samples obtained by the US Environmental Protection Agency (US-EPA) & World Health Organization (WHO). We included a certain number of Lahore's water filtration plants that are installed in three different Lahore zones (suburban, urban, and old areas). We stepped out to evaluate filtration facilities that, if routine maintenance is neglected, might harm public health and lead to hazardous situations. 150 residents were questioned over the course of the preceding three years on their drinking water source, health, and general well-being. A sanitation evaluation was also performed using the observations and investigation of water purification facilities.

2. Materials & Methods

2.1. Research Design & Locations:

The inspection of water purification facilities established in three zones of Lahore was part of the safety evaluation. Research work was conducted in the environmental engineering laboratories of NUCES-FAST (National University of Computer & Emerging Sciences) and UET (University of Engineering & Technology), Lahore. The samples were gathered from 30 filtration facilities.

2.2. Water Samples:

To examine the safety of Lahore's water filtration facilities, samples were obtained by dividing the city into three zones: old areas, suburban regions, and urban towns. Before collecting water samples, hands were cleaned with ethanol. Samples were obtained by sampling in clean sterilized 1L bottles. Water samples were taken from the direct source of supply to reduce mistakes and assess the real quality of water utilized. Samples were carefully gathered from the filtration facilities to minimize the impacts of pollution and to assess the real quality of water used for drinking. Before collecting water samples, rust-free taps utilized that had been thoroughly cleansed. A total of 30 samples were gathered from three zones in Lahore, with 10 samples obtained from each zone to cover the whole city (Table 1). Figure 1(a-d) shows the sampling & testing of water from water purification plants. The World Health Organization (WHO) and the Environmental Protection Agency of the United States of America (US-EPA) were used as international criteria for comparison in this study.

(a) Collection of samples (b) Testing samples in the Environmental Lab © Measurements (TDS) (d) Water purification plant

Figure 1: sampling & testing of water from water purification plants (a) Collection of samples (b) Testing samples in the environmental lab (c) TDS measurements, and (d) Water purification plant

2.3. Biological Analysis:

2.3.1 Total coliform count:

The Coliform group includes all rod-shaped, gram-negative, facultatively anaerobic, aerobic bacteria that digest lactose with the production of gas and acid within 48 hours at 350°C. The total coliform test was conducted with the standard method # 9221 C [12]. Autoclave, incubator, sample bottles, fermentation tubes with inverted vials, dilution bottles, and pipettes were all used. As reagents, lactose broth and distilled water were employed. Ten fermentation tubes with inverted vials were set in a rack for potable water. Dispensed enough medium before sterilization to fill inverted vials at least half after sterilization. In an autoclave at 1210C for 15 minutes, sterilize the fermentation tubes containing the medium as well as the other glass gear. As soon as the chamber pressure approaches zero, remove the fermentation tubes from the autoclave. In each tube, 10 ml of sample was dispensed, and inoculation tubes were incubated at 35 0.5 ^{0}C. After 24 2 hours, gently shake each tube to check for gas or acidic development. If no gas or acidic growth was developed after 48 2 hours, re-incubate and re-examine. The presence or absence of gas or acid generation in the fermentation tube was recorded. A negative test is defined as the lack of acidic growth or gas generation after 48 2 hours of incubation. A positive presumptive reaction is the production of gas or acidic growth in the tubes within 48 2 hours. Submit these tubes to the confirmed phase if they have a positive presumptive response. Shook the sample and dilutions thoroughly about 25 times before repeating the procedure for portable or drinking water. [13].

For the verified phase, fermentation tubes with covers, inverted vials, a sterile metal loop (3 mm in diameter), and a spirit lamp were used, along with brilliant green lactose bile broth (BGLB) and distilled water. Dispensed enough medium before sterilization to fill inverted vials at least half after sterilization. All initial tubes exhibiting any quantity of gas or acidic development within 242 or 48 2 hours of incubation for the confirmed phase were submitted. If active fermentation or acidic growth appears in the primary tubes before 24 hours, transfer to the confirmatory medium immediately, ideally without waiting the whole 24 2 hours.

If additional primary tubes indicated acidic development after 48 2 hours of incubation, submit them to the verified phase. To re-suspend the organisms, gently shake or spin the main tubes displaying gas or acidic growth. I took a 3 mm diameter metal inoculating loop and heated it on the spirit lamp until it was red-hot. I let the loop to cool to room temperature before transferring one loop full of culture to a fermentation tube containing vivid green lactose bile broth. The injected BGLB tube was incubated for 48 2 hours at 35 0.50C. A positive verified phase was defined as the formation of gas in any amount in the inverted vial of the BGLB fermentation tube at any time within 48 2 hours [13]. Calculated the MPN value from the number of positive brilliant green lactose bile tubes as follows:

$$\text{MPN/100 ml} = \frac{\text{No. of Positive tube x 100}}{\sqrt{\left(\begin{array}{c}\text{ml of sample in}\\ \text{negative tubes}\end{array}\right) \times \left(\begin{array}{c}\text{ml of sample in}\\ \text{all tubes}\end{array}\right)}}$$

2.4. Physio-Chemical Analysis:

pH & Electrical conductivity (EC): These were measured using a digital multi-parameter meter (model: inoLab Multi 9420 IDS) following the standard method 400-H^+ B) [12].

Total dissolved solids (TDS): Total dissolved solids were measured from standard method # 2540 C with a handheld TDS/temperature meter (model: CON 5/TDS, Eutech, Singapore). The TDS calibration method is the same as the EC calibration method (normal TDS Level is 50ppm to 1000ppm) [12].

Turbidity: The turbidity of drinking water samples was evaluated using a portable turbid meter (model: Turb 430 IR/T by WTW Germany) and used the Nephelometry principle and standard method number 2130 B [12].

Dissolved Oxygen (DO): The dissolved oxygen (DO) was measured from standard method # 2430B with a DO meter (model: DO 200A, Eco-Sense USA) [12].

Total Hardness: The total hardness of the water sample was measured with standard method # 2340 C with EDTA (Ethylene Di-amine Tetra Acetic Acid), titration flask, burette, pipette, and different buffer solutions/indicators. The following formula was used.

$$totalHardnes\sin mg/1asCaCO_3 \quad \frac{mean\,of\ vol\,of\ titrant\,used \quad molarityofEDTA \quad MWof\ CaCO_3 \quad 1000}{vol\,of\ sample\,in\,ml}$$

Molarity of EDTA = 0.01 Mole; Volume of sample used = 25 ml; and MW (molecular weight) of $CaCO_3$ = 100

Alkalinity: It was determined from standard method # 2320 B with the following reagents: standard sulfuric acid (0.02N), methyl orange indicator, phenolphthalein indicator, and sodium thiosulphate (0.1 N). Part A: took 50 m1 samples. Added 2-3 drops of phenolphthalein in a titration flask if pink color is present. Titrated over a white surface with 0.02 N H_2SO_4 to a colorless point. Part B: in the same flask, added 2-3 drops of methyl orange indicator. Titrated with 0.02 N H_2SO_4 until the color changes to orange. Took at least three readings for part A and part B and calculated the alkalinity by the formula given below:

Alkalinity (mg/1) = AxN x 50000) / (ml of sample)

Where, A = Volume of titrant used; & N = Normality of Acid (0.02) or N/50 H_2SO_4

2.5. Detection of Selected Heavy Metals:

Water samples were analyzed with some metal contents in the samples by using Atomic Absorption Spectrophotometer. (Hitachi Polarized Zeeman AAS, Z-8200, Japan) following the conditions described in Horwitz, 2000. The operating conditions of the selected metals: iron and manganese (Fe and Mn) are shown in Table 2. Atomic absorption spectroscopy is an analytical method used to assess the number of metal ions in drinking water samples. The wavelengths of light particularly absorbed by an element correlate to the energy required by an electron to shift from a lower energy level to a higher energy level in this procedure. Various elements' atoms absorb different wavelengths of light. These absorptions were then measured and compared to standards, as well as the amounts of heavy metals identified.

2.6 Inspection Survey:

A survey was conducted among nearby residents (n=150) regarding the source of drinking water, and health status during the last three years. Their responses were recorded with consent. A sanitation survey was also conducted based on the observations and inspection of water purification plants.

Table 1: Number and locations of water purification plants in Lahore.

Sr. No.	Zones of Lahore	Location of water purification plants	Total # of plants installed	No. of functional plants	No. of plants from where samples were taken
1	Suburban Area	S1	2	2	1
2		S2	4	3	1
3		S3	3	2	1
4		S4	2	2	1
5		S5	2	2	1
6		S6	5	3	1
7		S7	2	2	1
8		S8	2	2	1
9		S9	1	1	1
10		S10	2	2	1

11	**Urban Area**	U1	2	2	1
12		U2	3	2	1
13		U3	5	4	1
14		U4	1	1	1
15		U5	6	3	1
16		U6	2	2	1
17		U7	3	2	1
18		U8	1	1	1
19		U9	1	1	1
20		U10	1	1	1
21	**Old Area**	O1	3	2	1
22		O2	2	2	1
23		O3	1	1	1
24		O4	1	1	1
25		O5	2	1	1
26		O6	1	1	1
27		O7	2	1	1
28		O8	1	1	1
29		O9	1	1	1
30		O10	4	2	1

Table 2: Determination of metals by atomic absorption spectrophotometer (AAS)

Elements/ Unit	Wavelength	Silt Width	Lamp Current	Burner Head	Flame	Burner Height	Oxidant gas pressure	Fuel gas pressure
	nm	Nm	mA			Mm	KPa	KPa
Manganese	278.6	0.3	7.5	Standard type	Air- C_2H_2	7.5	160	7
Iron	247.3	0.2	10.0	Standard type	Air-C_2H_2	7.5	160	6

3. Results:

3.1. Physiochemical Properties:

Table 3 & Figure 2 show measurements of the physiochemical properties of all water samples from all zones. The permissible limits are mentioned as per guidelines of the USA EPA (Environment Protection Agency) and WHO (World Health Organization).

3.2. pH and Electrical Conductivity (EC):

In the suburban zone, one water sample had a slightly higher pH value (8.6) and one sample had a slightly lower pH value (6.42). In the urban region, one water sample of one block had a slightly higher pH value (8.62). Two samples of the old city area had slightly higher pH values: 8.61 and 8.46. All water samples of suburban regions were having electrical conductivities (mean: 850.9 µs/cm) more than the permissible limit (i.e., <400 µs/cm). Similarly, all water samples from urban areas had EC values greater (mean: 667.5 µs/cm) than the permissible limit except for one block (394 µs/cm). Six regions of the old city were having high water EC values (434-1505 µs/cm).

3.3. Total Dissolved Solids (TDS):

The water samples of the suburban areas were high TDS values (635-1070 ppm). Among urban regions, water samples all blocks were having within permissible TDS values (mean: 379.2 ppm) except Q-block (597 ppm). Three water samples of the old city areas were having high TDS values (752-1082 ppm).

3.4. Turbidity:

All water samples of suburban areas were having turbidity values within the permissible range (mean: 1.5 NTU) except one location (6.6 NTU). All water samples of urban areas had normal turbidity values (mean: 1.46 NTU) except for two blocks. Similarly, all water samples of old city areas had acceptable turbidity values (mean: 2.05 NTU) except two locations.

3.5. Total Hardness & Alkalinity:

Regions S3 (64.63 ppm), S7 (75 ppm), and S8 (68.67 ppm) from suburban areas had over the permissible limit of total hardness in their water samples. Water samples of six urban areas had a total hardness of more than the acceptable limit (66-125 ppm). Only two water samples from old city areas had a total hardness of more than 60 ppm. The alkalinity of all water samples from all regions was within the allowed limit (less than 200 mg/l).

3.6. Iron & Manganese Indications:

Table 4 & Figure 3 show the measurement analysis for the indication of iron and manganese. Waters of S1, S3, S4, S6 and S8 suburban regions had an extremely low value of iron (0.005 - 0.092 mg/l). Water samples from urban and old city areas had an acceptable limit of iron levels. Waters of various urban areas were having extremely low values of iron (0.002 – 0.094 mg/l). Seven regions of old city areas had low values of iron (0.004 – 0.078 mg/l). Water samples of old city, suburban and urban areas were having allowed levels of manganese.

3.7. Total Coliform Counts:

The Maximum Contaminant Level (MCL) for bacteria in drinking water is zero total coliform colonies per 100 milliliters of water as established by the EPA. Five regions from suburban areas had total coliform counts greater than 20 per 100 ml. All samples from urban areas had exceeding total coliform counts except two blocks. Manu locations from old city areas had unacceptable total coliform counts for drinking water. See Table 4.

Table 3: Results from water purification plant physicochemical properties *****

Zone	Sample Location	Sample No.	pH (6.5-8.5)	EC (<400µS/cm)	TDS (Up to 500 ppm)	Turbidity (Up to 5 NTU)	Total Hardness (< Up to 60 ppm)	Alkalinity (Up to 200 mg/l)
Suburban Area (n=10)	S1	WS-1	8.6	538	1070	0.1	33	72
	S2	WS-2	7.81	1270	635	0.1	20.67	58
	S3	WS-3	7.8	1340	675	1.4	64.63	86
	S4	WS-4	6.9	605	303	0.8	21.32	28
	S5	WS-5	8.0	606	302	2.1	28.34	52
	S6	WS-6	7.63	754	374	0.1	26.33	32
	S7	WS-7	7.76	1375	687	6.6	75	62.67
	S8	WS-8	7.1	691	346	0.1	68.67	54.34
	S9	WS-9	7.7	874	437	0.1	46.67	57
	S10	WS-10	6.42	456	728	0.1	32	65.68
	Mean Values		**7.57**	**850.9**	**555.7**	**1.15**	**41.63**	**56.76**
Urban Area (n=10)	U1	WS-11	7.57	727	346	0.1	29	32
	U2	WS-12	7.63	394	597	2.7	78	76
	U3	WS-13	7.88	652	324	0.2	56.34	55
	U4	WS-14	7.85	968	497	0.2	89.32	46
	U5	WS-15	7.72	891	446	0.2	94	57
	U6	WS-16	7.83	716	358	0.1	66.64	46
	U7	WS-17	7.33	698	417	0	125	58
	U8	WS-18	7.81	766	382	5.7	79	39
	U9	WS-19	7.84	431	211	5.4	44.02	33.67
	U10	WS-20	8.62	432	214	0	29.1	48.66
	Mean Values		**7.80**	**667.5**	**379.2**	**1.46**	**69.42**	**49.13**
Old City Area (n=10)	O1	WS-21	6.62	1359	1082	0.1	43	34
	O2	WS-22	7.75	484	842	0.1	29	32
	O3	WS-23	7.7	817	409	0.1	67	66
	O4	WS-24	8.61	1473	236	9.3	28	29
	O5	WS-25	8.46	1505	752	0	41	28
	O6	WS-26	7.77	399	47	0.1	27.68	40
	O7	WS-27	7.79	380	49	5	36	44
	O8	WS-28	7.94	363	48	0.3	52	26.33
	O9	WS-29	7.61	217	104	0.1	82	46
	O10	WS-30	7.92	435	218	5.4	52	62
	Mean Values		**7.81**	**743.2**	**378.7**	**2.05**	**45.76**	**40.73**

KEY: Orange: more than the limit; Yellow: within range; and Green: less than the limit

*Normal values indicated as per WHO and US EPA [14-16]

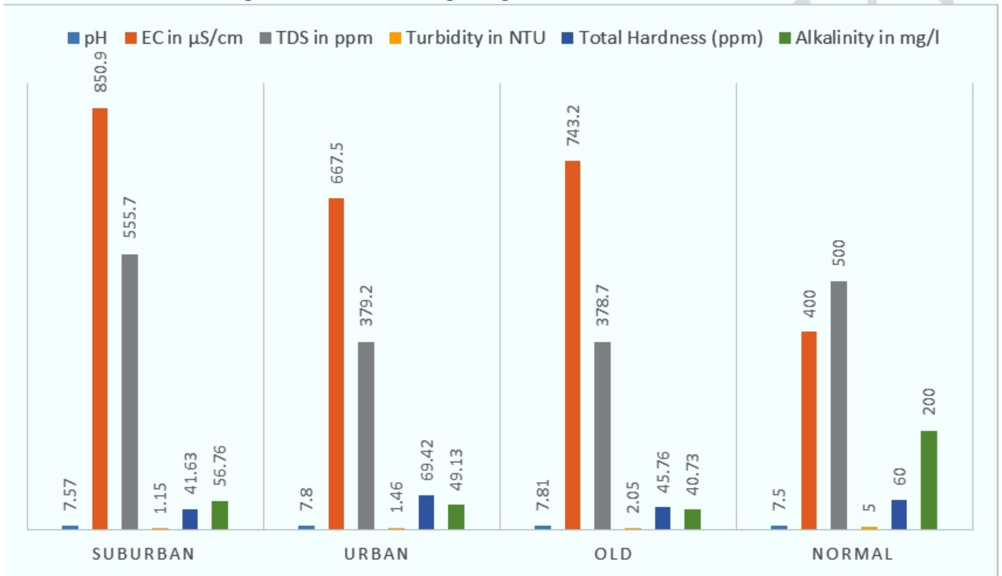

Figure 2. Graphical comparisons between pH, electrical conductivity, total dissolved solids, turbidity, total hardness and alkalinity between drinking waters of suburban, urban and old regions of Lahore

Table 4: Analysis of metals and total coliforms from water samples of water purification plants

Zone	Sample Location	Sample No.	Iron (Fe) Normal Range: (up to 0.3 mg/l)	Manganese (Mn) Normal Range: (0.1 – 0.5 mg/l) 0.050 mg/l (secondary drinking water)	Total coliforms Recommended for drinking water: < 0 per 100 ml
Suburban Area (n=10)	S1	WS-1	0.005	0.106	14
	S2	WS-2	0.214	0.105	16
	S3	WS-3	0.012	0.137	0
	S4	WS-4	0.014	0.144	0
	S5	WS-5	0.4	0.112	0
	S6	WS-6	0.043	0.186	12
	S7	WS-7	0.132	0.158	14
	S8	WS-8	0.092	0.143	16
	S9	WS-9	0.174	0.173	0
	S10	WS-10	0.067	0.228	0
	Mean Values		**0.115**	**0.149**	**7.2**
Urban Area (n=10)	U1	WS-11	0.094	0.235	0
	U2	WS-12	0.087	0.13	13
	U3	WS-13	0.052	0.13	15
	U4	WS-14	0.216	0.18	11
	U5	WS-15	0.163	0.20	15
	U6	WS-16	0.117	0.377	13
	U7	WS-17	0.136	0.195	0
	U8	WS-18	0.076	0.18	10
	U9	WS-19	0.002	0.32	11
	U10	WS-20	0.093	0.37	14
	Mean Values		**0.1036**	**0.2317**	**10.2**
Old City Area (n=10)	O1	WS-21	0.12	0.23	0
	O2	WS-22	0.078	0.33	4
	O3	WS-23	0.059	0.15	8
	O4	WS-24	0.04	0.16	9
	O5	WS-25	0.087	0.13	0
	O6	WS-26	0.005	0.042	0
	O7	WS-27	0.026	0.043	0
	O8	WS-28	0.004	0.072	10
	O9	WS-29	0.138	0.51	13
	O10	WS-30	0.492	0.07	0
	Mean Values		**0.1049**	**0.1737**	**4.4**

KEY: Red: More than the limit; Orange: within range; and Green: less than limit

**The Maximum Contaminant Level (MCL) for bacteria in drinking water is zero total coliform colonies per 100 milliliters of water as established by the EPA. [14-16]*

KEY: Orange: more than the permissible limit

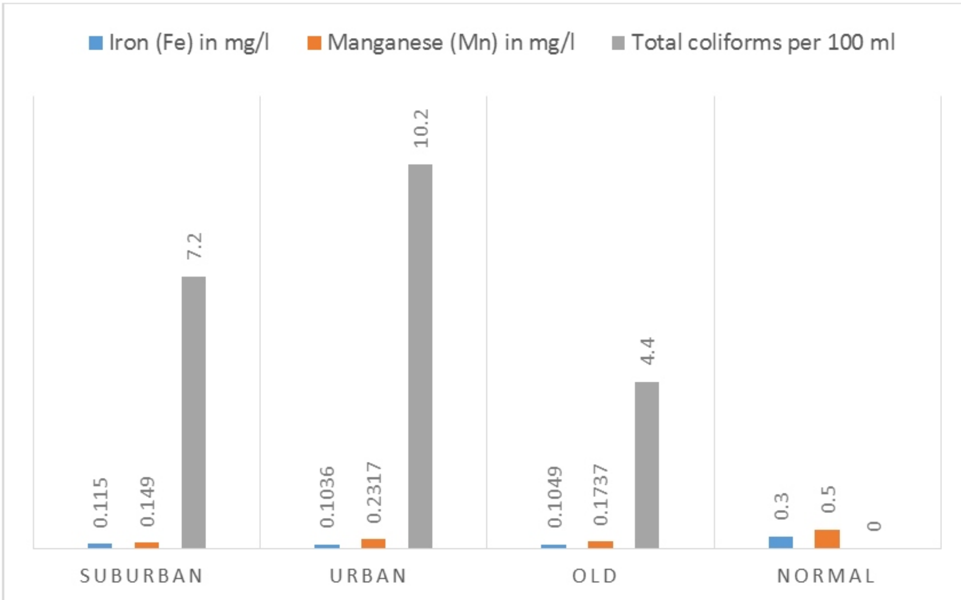

Figure 3. Graphical comparisons between iron, manganese, and total coliforms between drinking waters of suburban, urban and old regions of Lahore

3.8. Survey on Drinking Water Sources and Waterborne Diseases:

A total of 150 responses were collected from residents of mentioned regions and areas. 16% were taking mineral water, and 30% were using tap water for drinking. The majority of people (53.3%) were consuming filtered water from local water-purification plants. The majority of residents (86.6%) reported typhoid followed by diarrhea (83.3%), hepatitis (78%), and gastroenteritis (66.6%) during the last three years. 43% reported that they suffered from dysentery and 30% reported cholera. See **Table 5**.

3.9. Inspection Survey of Water Filtration Plants:

Among old city water and urban water purification plants, four out of ten had defective taps and drainage channels were found broken. Five out of ten plants in old areas were surrounded by garbage, with dirty floors around the taps. Animals had also access to nearby old regions' plants. Water filters were not been frequently replaced in many plants of all zones. Among suburban water purification plants, five out of ten were also surrounded by garbage. Four out of ten suburban plants' walls were not properly sealed, their drainage channels were also found broken. See **Table 6** for details.

Table 5: Survey for the source of water intake and waterborne diseases from local residents

Survey Inspection question (Total=150)	Frequency	Percentage
Drinking water:		
Mineral	25/150	16.6%
Tap water	45/150	30%
Filtered water	80/150	53.3%
Any of the following infectious diseases reported in your family during the last 1-3 years?		
Diarrhea	125/150	83.3%
Dysentery	65/150	43.3%
Cholera	45/150	30%
Hepatitis	117/150	78%
Typhoid	130/150	86.6%
Gastroenteritis	100/150	66.66

Table 6(a): Survey on the inspection of water filtration plants of Old City (responses=10)

Sr. No.	Survey inspection question (Total=10)	Proportion (YES)	Proportion (NO)
1	Is any tap leak or defective?	04	06
2	Any pipe leak at the site?	03	07
3	Does the animal have access to the sampling site?	04	06
4	Any garbage around purification plants?	05	05
5	Plant floor dirty around the tap?	05	05
6	Any latrine beside the purification plant?	03	07
7	Walls of the plant sealed?	02	08
8	Roads or garbage beside filtration plants?	05	05
9	Are any flies around the sampling site?	03	07
10	The drainage channel is broken?	04	06
11	Do the filters change frequently?	03	07
12	Any sewer water near the filtration plant?	03	07
13	Does any tap defective by toxic chemicals?	03	07

Table 6(b): Summary of survey inspection data of water filtration plants in Urban Areas (responses=10)

Sr. No.	Survey inspection question (Total=10)	Proportion (YES)	Proportion (NO)
1	Is any tap leak or defective?	04	06
2	Any pipe leak at the site?	03	07
3	Does the animal have access to the sampling site?	03	07
4	Any garbage around purification plants?	04	06
5	Plant floor dirty around the tap?	02	08
6	Any latrine beside the purification plant?	01	09
7	Walls of the plant sealed?	03	07
8	Roads or garbage beside filtration plants?	04	06
9	Are any flies around the sampling site?	02	08
10	The drainage channel is broken?	03	07
11	Do the filters change frequently?	05	05
12	Any sewer water near the filtration plant?	01	09
13	Does any tap defective by toxic chemicals?	01	09

Table 6(c): Summary of survey inspection data of water filtration plants in Suburban Areas (responses=10)

Sr. No.	Survey inspection question (Total=10)	Proportion (YES)	Proportion (NO)
1	Is any tap leak or defective?	03	07
2	Any pipe leak at the site?	02	08
3	Does the animal have access to the sampling site?	02	08
4	Any garbage around purification plants?	05	05
5	Plant floor dirty around the tap?	03	07
6	Any latrine beside the purification plant?	01	09
7	Walls of the plant sealed?	04	06
8	Roads or garbage beside filtration plants?	05	05
9	Are any flies around the sampling site?	03	07
10	The drainage channel is broken?	04	06
11	Do the filters change frequently?	04	06
12	Any sewer water near the filtration plant?	02	08
13	Does any tap defective by toxic chemicals?	01	09

4. DISCUSSION:

The current study assessed the quality of plant drinking water by examining the biological, physical, and chemical features of various regions (urban, suburban, and old areas) in Lahore City. We also assessed the safety and cleanliness of water treatment plants. All water samples from suburban areas had electrical conductivities that were above the allowable limit. Similarly, except for the one block, all water samples from metropolitan areas showed EC values more than the allowable limit. Six areas of the old city have high water EC values. TDS levels were high in water samples from five suburban regions. Except for one block, all metropolitan locations' water tests had TDS levels that were within acceptable limits. Three water samples from the old city neighborhoods had elevated TDS levels.

Three suburban zones had overall hardness levels that exceeded the allowable limit. Water tests from six metropolitan locations exhibited overall hardness levels that exceeded the permissible limit. Iron levels were exceptionally low in the waters of five suburban areas. Iron levels in water samples from metropolitan and old city districts were within permitted limits. The major blocks of water in the urban area of had extraordinarily low iron levels. Iron levels were low in seven old city locations. Five suburban zones reported total coliform levels of more than 20 per 100 ml. Except for two blocks, all urban samples exceeded total coliform levels. Five old city neighborhoods have inadequate total coliform levels in their drinking water. Concerning the incidence of water-borne infections, 150 responses were gathered from people of the aforementioned regions and territories. The vast majority of individuals drank filtered water from nearby water-purification plants. During the previous three years, the majority of inhabitants reported typhoid, followed by diarrhea, hepatitis, and gastroenteritis. Many water treatment plants featured faulty taps, seals, and drainage pipes. Many were surrounded by trash and had filthy flooring. The quality of water from selected water purification plants was partially satisfactory. To overcome the problems of water quality in Lahore. The drinking water is highly affected by bacteriological contamination and the quality of drinking water purification plants can be improved by new filters installing at the sites with proper timing before the contamination factor is high to avoid the spread of contamination. Bacterial contamination in rural locations is typically higher in rural Punjab than in metropolitan areas, where 91.30 percent and 95.83 percent of tap and home water samples, respectively, were found to be infected with bacteria, compared [17-18]. The major reason for the prevalence of waterborne infections in Pakistan is the pollution of drinking water with industrial wastes and municipal sewage, along with a lack of water disinfection methods and quality monitoring at treatment facilities [19-20]. Local authorities should monitor purification plants. Rusting pipelines should be renovated. Sufficient distance between sewerage and water filtration plants.

Overall, the Most out-of-limit parameters were EC, followed by total hardness and TDS. The majority of water samples were deprived of adequate levels of iron. Several drinking water samples from plants were having exceeded the total coliform cells (per 100 ml). More water in urban areas was found hard. According to a WWF report, pollution and toxic metals were common in local streams, resulting in poor water quality that authorities could not authorize for human consumption. PCRWR (Pakistan Council for Research on Water Resources) conducted a study to assess the status of water quality in Pakistan and discovered that only 12-17 percent of water in Pakistan is safe for drinking purposes, and many companies selling mineral water bottled frequently in our local market have a poor quality that people continue to purchase at high rates [21-22]. As a result, polluted water is the primary cause of the development of water-related disorders in the country. Some major water contaminants such as radio-active that is soluble in water, inorganic pollutants (salts, acids, and toxic metals), pathogens (viruses and bacteria), and anions & cations (phosphates, nitrates, sulfates, Ca^{2+}, Mg^{2+}, and F^-) have been identified. In Pakistan, the main hazards to water are bacterial pollution and toxic metals [17]. The potential drinking water in Pakistan is significantly polluted with bacteria, which may create health concerns, and microbiological analysis of water is the result of total and fecal coliforms. The presence of coliforms indicates that the waste contains human/animal diseases [21]. Most people use contaminated water due to the unavailability of safe drinking water in developing countries and almost 9000 million peoples have no access to this safe drinking water which can cause waterborne disease [23].

There are two kinds of drinking water. One is surface water, and the other is groundwater, of which groundwater meets 65 percent of water demands. With a rise in population and industry, the need for groundwater grows by the day. As the population grows, drinking water becomes more polluted due to the mixing of chemicals and waste materials. Contamination sources include soil surface leaching, human waste, animal waste, industrial waste, farm waste, agricultural waste, and sewage water. Water supply to urban areas is a major issue, particularly in large cities like Karachi, Lahore, and Peshawar. The primary issue in communities is a lack of water distribution infrastructure [24]. Water quality in Europe is deteriorating as a result of industrialization. Nitrate content and turbidity are growing as industry and agricultural activities expand, posing a danger to water quality [25]. It was said that nitrogen and turbidity of water rose mostly during heavy rains and could not be regulated permanently. Threats to water quality include bacterial pollution, harmful metals such as arsenic, iron, cadmium, and nickel, pesticides, and in certain locations nitrates and fluorides within Pakistan [17]. Iron is a major element required by our body. The presence of adequate amounts of iron in the diet is necessary to carry out the proper physiological functioning of our body. The basic physiology of living things depends on iron (Fe), one of the most prevalent metals on earth. Both its lack and excess can be damaging to both plants and animals [17]. In our study, some water samples from purification plants contained less Fe levels than was necessary. In the underdeveloped world, iron deficiency and anemia are widespread conditions. To prevent and manage iron deficiency and iron deficiency anemia, a recent study assessed the viability of iron fortifying household drinking water. Hemoglobin levels rose when iron-fortified water was consumed. In less developed countries, adding iron to home drinking water can be a cheap and efficient option to treating anemia and iron deficiency [26]. Results of previous research imply that increased manganese and iron levels in drinking water are linked to a decrease in birth weight in term-born babies. However, further individual-level epidemiologic studies are required to learn more about the causes of certain pregnant women's higher sensitivity [27].

Hamid et al. (2013) [28] evaluated the Water and Sanitation Agency's supply of drinking water (WASA). They revealed that, in general, all physicochemical parameters fell within Pakistan's Drinking Water Quality Standards (DWQS), both at the source (tube well) and the point of use (tap), with the exception of the arsenic and fluoride levels, which were found to be higher than both the National Standards and WHO Standards. As few samples exhibited very high levels of bacteriological contamination, there is an urgent need to address bacterial contamination in drinking water. Polluted samples, however, produced better results after using a disinfection process using a microwave and/or traditional heating techniques. On a broader scale, more efficient chlorination facilities that are operational at water sources while water mains and sewer. Abbas et al. (2015) [29] assessed the quality of drinking water at the source and throughout the distribution system, and they examined the hydrochemical properties and formation processes of groundwater. Trace levels of Cr, Fe, Cu, Zn, and Pb were found at various concentrations. A bacteriological study revealed that 42% of samples, particularly dispersed groundwater samples, did not adhere to WHO recommendations and were dangerous for consumption (12% from the source and 55% from distribution). The likely causes of the elevated arsenic concentrations found in Lahore include reductive dissolution and pH-dependent desorption.

Haydar et al. (2009) [30] conducted research to assess the water quality provided by the Water and Sanitation Agency (WASA), Lahore. For this, a section of southern Lahore was chosen. Eight home connections (two from each tubewell) and four separate water sources (tubewells) were used to provide a total of twelve sampling stations. Each sample was examined for two bacteriological parameters (total coliform and fecal coliform) and four physicochemical parameters (pH, turbidity, hardness, and total dissolved solids). The results were compared to World Health Organization (WHO) drinking water standards. The study's findings showed that the physical, chemical and bacterial quality of water at sources was good. Although the physicochemical quality of the water in the distribution system was good, 50 to 62.5% of the tests had bacterial contamination before the monsoon. After the monsoon, this number grew to 75%. Water main leaks and cross-connections between sewers and water mains because of their closeness were potential sources of pollution. To stop bacterial contamination, it is advised to perform mandatory chlorination at water sources while keeping acceptable residuals at the consumer's end. Municipal waste disposal facilities seriously endanger the environment and the population in the area. One of the most significant threats comes in the form of ground water contamination caused by leachate percolation in soil, which renders the water hazardous for drinking as well as some home applications. It is advised that a thorough investigation of the research area's ground water contamination levels, leachate assessment, and environmental impacts be conducted [31]. Pakistan, which was previously a country with plenty of water, is now water-stressed and is rated 80th in the world for having access to safe and clean water. About 75% of the population lacks reliable access to clean drinking water, which is a factor in 40% of fatalities and 30% of communicable illnesses in the nation. According to reports, hundreds of youngsters in Pakistan pass away each year from illnesses that may have been avoided. The health of children is negatively impacted by both a lack of access to clean water and an inadequate intake of critical nutrients. As a result, the current state of water quality has resulted in enormous public expenses, including premature mortality, infant deaths, economic and financial costs associated with diseases linked to inadequate sanitation, environmental costs, and other welfare costs [32-35].

Punjab has a framework for controlling the quality of its drinking water, and the province is expected to put policies and rules into place to reduce the negative impacts of groundwater contamination on public health. In 2012, a thorough investigation on the quality of Punjab's water was carried out by the Public Health Engineering Department (PHED) in association with UNICEF. In total, 46,000 samples were gathered from 23,000 various rural Punjabi regions. The findings revealed that 32.7% of people drink bacteriologically unsuitable water, while roughly 36.3% use chemically tainted water. The worst outcomes were seen in Gujrat, Gujranwala, and Narowal, where more than 80% of water tests revealed severe fecal pollution and over 60% of water samples failed to meet chemical compliance [40]. The primary cause, according to Daud et al. (2017) [35], is the discharge of industrial effluents into surface water bodies, where the inorganic pollutants then reach groundwater sources. Additionally, fecal pollution of drinking water sources was also brought about by septic tank leaks, open sewers, abandoned boreholes, and corroded drinking water pipelines. Gujranwala, Gujrat, Narowal, Lodhran, and Sahiwal were found to be the most afflicted districts in Punjab according to the overall bacteriological and chemical state of water quality [36]. Recent research by Akhtar et al. (2019) [37] found that 71% of Mianwali's water supply systems were bacteriologically unfit and contaminated with fecal coliform bacteria, posing a risk to human health. Due to the diverse structural and functional impacts of consuming polluted water, including cytotoxicity, mutagenicity, carcinogenicity, infectious diarrhea, vomiting, stomach discomfort, dysentery, cholera, enteric fever, etc., continuous monitoring of drinking water quality is crucial in these locations [38]. In Gujranwala district, Pakistan, Mazhar et al. (2019) [39] evaluated the groundwater's suitability for potable use, looked at the spatial distribution patterns of water quality parameters, and determined the prevalence of waterborne diseases among the locals and the health risks associated with drinking groundwater. 97.5% of the water samples were confirmed to be polluted with bacteria.

By assessing physical, chemical, and biological (total coliform) quality criteria, research evaluated the drinking water quality of canals, shallow pumps, dug wells, and water supply systems from the administrative districts of Thatta, Badin, and Thar. For turbidity, coliform, and electrical conductivity, all water was above WHO MPL. Limits for TDS, alkalinity, hardness, and sodium were exceeded in shallow pumps and dug wells. In shallow pumps in the Badin district and shallow wells in the Thar district, sodium was a serious concern. Iron was a significant issue in all of the water bodies in the Badin area, with levels ranging from 50% to 69%, and to some extent in the Thatta open seas. Other factors including pH, copper, manganese, zinc, and phosphorus were within the World Health Organization's recommended permitted range. In the research region, prevalent illnesses included gastroenteritis, renal, skin, and kidney disorders, as well as diarrhea and vomiting [40].

Everywhere in the globe, everyone has a basic human right to access clean drinking water. This basic entity is at risk due to rising population and human activity. In underdeveloped nations where there is little monitoring or maintenance, the situation is even worse. In order to assess the state of the water quality, Sohaila et al. (2020) [41] monitored filtration systems for drinking water in two inhabited cities in Pakistan. Water quality index (WQI) > 100 was observed in 32 out of 53 samples in Rawalpindi and 26 out of 32 samples in Islamabad, indicating poor water quality. In Rawalpindi and Islamabad, respectively, the hazard index of arsenic was determined to be 1 in both adults and children. 38 filtration facilities out of the 53 that were observed are determined to deliver contaminated drinking water. For the little subsurface water to be sustainable, proper management must be used. This study would serve as a foundation for future work on the effects of urbanization and land use change. information needed to create policies. Children are particularly more vulnerable to health risks. Incorporating microbiological (bacteriological) elements allowed researchers to assess the health hazards posed by water pollution. For the little subsurface water to be sustainable, proper management must be used.

According to the World Health Organization (WHO), water safety plans (WSPs) can assist water providers in identifying possible risks associated with drinking water and allow improvements in public health outcomes. Muoio et al. (2020) [42] presented a method for identifying gastrointestinal illnesses linked to drinking water use in order to assess the health risk associated with turbidity in finished water. The findings of several epidemiological studies and three-year time series turbidity data from three different drinking water treatment plants (WTPs) in Tuscany (Italy) have been used to assess the health risk associated with tap water turbidity and to determine the relationship between drinking water turbidity and gastroenteritis incidence. In the three WTPs, the turbidity variation that occurred in the treated water over the observation period indicated an incremental risk from 9% to 27% compared to the baseline value. A treatment train (clari-flocculation, sand filtration, activated carbon filtration, and multi-step disinfection) decreases risk by more than 600 times, according to an evaluation of the risk reduction caused by each treatment stage. By taking into account time series data on turbidity at WTPs, this method is a valuable tool for water providers to evaluate health risks and make decisions about risk management strategies [42].

The recent analysis discovered that there was no routine maintenance available to prevent water purification plant contamination. The current study was created to evaluate the safety of these water purifying facilities. Data on water-related illnesses in Pakistan are rare due to a lack of practice in keeping records. The greatest serious hazard to public health is bacterial pollution of water. Coliform was found in numerous samples analyzed. Sanitary inspection data indicated that the three largest causes of bacteriological contamination at consumer locations were tap leakage, the presence of rubbish across purification plants, and water collecting surrounding sampling sites. The drinking water obtained from selected water purification plants was of poor quality. To monitor water quality in the country, rules and infrastructure exist but are not effectively implemented. The two main sources of water pollution in Pakistan were an untreated industrial and municipal waste.

5. Conclusion and Recommendations:

Maintaining proper hygiene and keeping up with local water purification facilities is essential to preventing waterborne diseases while preserving the chemical makeup and nutritional value of drinking water. It is crucial to maintain the water properties' permissible limits to control contaminants of any kind. Overall, TDS, total hardness, and EC were the most out-of-limit metrics. The majority of water samples lacked sufficient iron levels. Several plant drinking water samples included more coliform cells than normal (per 100 ml). Urban regions have more hard water than rural areas. It was observed that there is no regular maintenance to check the contamination status of water purification plants. Awareness campaigns on drinking unsafe drinking water cause diseases should be launched. The quality of drinking water purification plants can be improved by new filters installing at the sites with proper timing before the contamination factor is high to avoid the spread of contamination. There are not many studies available on risk analyses on local water purification plants, therefore we recommend more studies.

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