Assessment of Quality of Drinking Water of The Educational Institute of South-Punjab, Pakistan

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Abstract

Background: As water is a basic and essential natural resource for all living things, this article addresses the vital need of analyzing its quality. The essay emphasizes the importance of water quality in public health by presenting perspectives from both developed and developing countries. A study was carried out at the biggest university of south-punjab "The Islamia University of Bahawalpur, Punjab, Pakistan". The study covers an important knowledge deficit about Bahawalpur's water quality assessment, offers information to government agencies and academic institutions on WHO compliance, and suggests possible ways to improve the quality of drinking water.

Methodology: The multiple physical, chemical, and biological factors that go into evaluating water quality are highlighted in this article. In addition to the specific indicators evaluated, such as electrical conductivity, temperature, odor, transparency color,total dissolved solids (TDS) taste, total dissolved solids (TDS), pH, UV absorbance, total hardness, sulphates, and chlorides, the methodology section describes the technique used for sample collection and handling. Employing bacterial growth and Gram staining, biological factors were also examined.

Results: The outcomes of this research showed that different university campuses have varied water quality criteria. Especially, sample 2 (Abbasia Campus) had the highest concentration of electrical conductivity at 980 µS/cm; sample 2 also had the highest amount of TDS at 412 ppm; and sample 3 (Baghdad-ul-Jadeed Campus) had the highest level of bacterial contamination.

Conclusion: These parameters demonstrated concerning trends over time, with some of them surpassing acceptable levels. This article emphasizes the necessity of routine maintenance and examination of the water sources. In conclusion, this research contributes valuable insights into water quality assessment, with a specific focus on Bahawalpur, Pakistan. The findings underscore the importance of addressing water quality issues to safeguard public health and ensure access to clean and safe drinking water.

Key word; Cooler Water, Physical Parameters, Water Quality, Chemical Parameters, Biological Parameters, Water Quality Analysis

Introduction

Water, a ubiquitous natural resource, covers two-thirds of the Earth's surface, with almost 4% of the world's land mass being comprised of this vital substance. Water is required for the life of all living things; hence the Earth is not in danger of running out of this essential resource (1). It is a fundamental component of the human body, and even minor fluctuations in its quality can have a significant impact on health (2). The scarcity of freshwater can lead to conflicts, and addressing this issue requires technological, pricing, conservation, and trade measures (3). Lack of admittance to uncontaminated water and cleanliness affects billions of people, causing significant suffering and disease (4). Many choose bottled mineral water over tap water, driven by taste and safety concerns.

Water excellence is a measure of water's aptness for definite uses based on it's physical, chemical, and biological characteristics. Standards from organizations like the WHO (5), EEC (6), and Canadian guidelines (7), as well as Egyptian standards (8), help assess water quality. The purity of water is appraised by examining various parameters like physical, chemical, and biological, which include pH, temperature, color, taste, total dissolved solids (TDS), optical density (OD), and total hardness. It is often stated as "the physical, biological, and chemical characteristics of water, generally in terms of its fit for a specific use (9)." The quality of water encompasses the complex interplay of these attributes, influencing its suitability for specific purposes and its capacity to support societal values (10). Assessment of water quality is crucial to determining its potability, contamination levels, adherence to WHO drinking water guidelines, and the effectiveness of water coolers. These assessments involve different considerations like chemical, physical, and biological, that is temperature, electrical conductivity, transparency, odor, color, taste, TDS, pH, total hardness, chlorides, sulphates, and bacterial growth (9).

The quality of drinking water samples has already been examined in developed countries like the United Kingdom, France, the United States and Germany. For instance, the growth of illnesses like intestinal disease and the hepatitis A virus in the UK has been connected to low-quality water used for lettuce irrigation, which could have catastrophic implications (11). Moreover, it has been shown that contaminated water in the United States can disperse bacteria and pathogens, which can result in dysentery, cholera, and typhoids, among other bacteria-related problems (12). Research findings indicate variations in the bacterial composition of tap water and bottled water. It has been observed that bottled water shows greater bacterial growth when maintained at higher temperatures. (13). Sensitive contamination, comprising different bacteria and elements including lead, nickel and iron, was found in Germany when water quality in public buildings and homes was observed. (14). Japan, Pakistan, and India are examples of emerging nations where similar issues have been studied. Studies conducted in the Okinawa area of Japan discovered higher metal concentrations and linked them to the frequency of sickness (2). Research conducted at Nainital, Uttarakhand, India, revealed the existence of metals, conductivity, alkalinity, and total dissolved solids (TDS) in water samples. Certain samples even exceeded the predetermined limits (15). According to results of another research conducted in Tumkur Taluk, Karnataka, a sizable percentage of the water samples had low quality and needed to be treated before consumption (16). Studies conducted in Pakistan's District Bajaur revealed that the vast majority of water samples were unfit for human consumption because of excessive turbidity, pH levels, and total suspended particles (17).

No water sample was found to be safe to drink in Karachi, Pakistan, based on examinations of the water quality. Studies conducted in Kohat and Charasadda also showed high levels of pollution, including heavy metals and coliform bacteria. Poor water quality has been linked to a number of illnesses, including cholera, jaundice, typhoid, vomiting, diarrhea, gastroenteritis, dysentery, and even kidney stones. It is a major public health problem in developing nations. However, facilities for treating these disorders are typically inadequate, particularly in rural regions (18).

Three sites were used to gather water samples for a research that evaluated the groundwater quality of Bahawalpur City using WHO standards: Satellite Town, Islamic Colony, and Shahdrah. The study discovered differences in the quality of the water in various places, with Shahdrah having superior water that was mostly sweet-tasting. Satellite Town had both medium and sweet water, while the Islamic Colony had blakish water. Factors like sewer leaks and groundwater pumping were identified as causes of changing groundwater flavor (18). The study also examined the impact of these parameters on water quality, with specific reference to WHO standards. Hardness, chlorides, and sulphates were all within acceptable limits. The presence of sulphate in natural water can vary, but it is generally not harmful to human health. Chlorides levels in Satellite Town exceeded the recommended limit, potentially posing health risks (5, 8, 16, 18-28). In terms of biological parameters, the occurrence of coliform bacteria was detected in some samples of water from coolers in Makkah, indicating contamination (5). Additionally, in the Arthunge VDC of the Myagdi district, total coliform was found in a significant number of water samples, raising concerns about Contamination (23). The study of water sources in rural Kenya showed variations in total coliform levels, with rivers having higher contamination levels than boreholes and rainwater sources. All sources tested positive for total coliforms, with some exceeding national standards (28).

This research aims to evaluate the water quality from specific water coolers at The Islamia University of Bahawalpur, Punjab, Pakistan, to determine its suitability for drinking. Given the university's diverse student population, the presence of harmful bacteria in the water could pose a health risk not only to the university community but also to residents in surrounding areas. This study reports a critical gap in Bahawalpur, mainly within the university. The findings can inform the educational institution about the potability of its water and guide steps to improve water quality. Furthermore, this study offers valuable insights for government authorities to determine whether water quality in the area aligns with WHO standards, prompting potential initiatives to enhance drinking water quality.

Methodology

The study focused on three campuses of The Islamia University of Bahawalpur, Punjab, Pakistan: Khawaja Fareed Campus (KFC), Abbasia Campus, and Baghdad-ul-Jadeed Campus. One water cooler from each campus was chosen for sampling: the canteen in Khawaja Fareed Campus and the parking area in Baghdad-ul-Jadeed Campus. Water samples were collected using a modified grab sampling method. Each sample was collected in clean, dry, presterilized, and labeled bottles containing 50 ml of water. The samples were labeled as Sample 1 (Khawaja Fareed Campus), Sample 2 (Abbasia Campus), and Sample 3 (Baghdad-ul-Jadeed Campus). Samples were placed in cold containers and transported to the pharmaceutical microbiology laboratory of the Khawaja Fareed Campus for analysis.

2.1. Determination of Physical Parameters

Various physical parameters were assessed on the day of sample collection, after 7 days, and after 14 days. The temperature of each sample was measured with the help of a mercury thermometer. The electrical conductivity of water samples was assessed by an Ino-Lab [cond 7110] digital meter. Human senses such as the eye, nose, and tongue were used to modify the 1998 American Public Health Association standard methodology for assessing transparency, odor, color, and taste(23, 29).

2.2. Determination of Chemical Parameters

Chemical parameters were assessed on the day of sample collection, after 7 days, and after 14 days. For the collection of total dissolved solids (TDS), the modified procedure of the refractometry method was followed (30). TDS was calculated for each sample by a TDS-3 digital meter (31). The pH of the water samples was measured by an Ino-Lab [pH 7110] digital meter (32). The calculation of the UV absorbance was observed by placing samples one by one in an uv-spectrophotometer [IRMECO (model 2020)] and setting the wavelength (lambda max) at 190 for the uv-absorbance assessment of the samples (33). It measured the amount of light absorbed or transmitted by a sample.

2.2.1. Hardness properties: For the calculation of total hardness as Ca and Mg, the modified procedure of the complexometric titration method was followed (34). The measured sample in ml, mixed with sodium hydroxide had a pH of 10. Then ethylene diamine tetraacetic Acid (EDTA) added. Then Eriochrome Black T (EBT) for Ca or Patton Reeder's indicator for Mg were added. It binds to EDTA-Ca and Mg complexes; it changes the color to signal the endpoint of titration. A standard solution of metal ions (zn) was added until the solution changed color. The formula for total hardness is:

$$\text{Total Hardness}\left(\frac{\text{mg}}{\text{L}}\right)$$
$$= (\text{concentration of EDTA(calcium and magnesium complex)})\text{x}\left(\frac{\text{1000 ml volume}}{\text{sample}}\right)$$

2.2.2. Determination of chloride concentration: For the determination of chloride concentration, the modified procedure of the modern method was followed. A few drops of silver nitrate solution (AgNO3) were added to the sample. It reacts with chloride ions to form silver chloride white precipitate. Filtered the sample through filter paper and dried the filtrate in an oven. Weigh the dried filtrate on a balance. By using the formula, the concentration of chlorides was calculated.

$$Chloride\ concentration\ \left(\frac{mg}{L}\right) = \left(\frac{weight\ of\ AgCl\ precipitate}{volume\ of\ water\ sample}\right) x\ 1000$$

2.2.3. Determination of sulphate concentration: For the determination of sulphate concentration, the modified procedure of the colorimetric method was followed (35). A barium chloride solution was added to the sample. It reacts with the sulphates and precipitates as barium sulphate. Then add the calculated amount of hydrochloric acid to prevent the precipitation of other ions. Filter the solution through filter paper and dry it in the oven. Weigh the dried filter. Then, using the formula, the concentration of sulphates was calculated.

$$Sulphate\ concentration\ \left(\frac{mg}{L}\right) = \frac{\text{w1 x 1000 x dilution factor}}{\text{volume of the sample (mL)}}$$

2.3. Determination of Biological Parameters

The biological parameters were assessed using various laboratory equipment and media, including an autoclave, beaker, colony counter, petri plates, loop, dry oven, tripod stand, and more. Nutrient agar media was prepared by the modified procedure of Julius Richard Petri's method (36). The nutrient agar media was prepared by dissolving 2.8 g of nutrient agar in 100 ml of distilled water and boiling it. The nutrient agar media and petri plates were autoclaved. The autoclaved media was then poured 4-5 mm deep over each petri plate and waited for its solidification. After that, 40 µliters of water sample were spread over each solidified agar media petri plate through an L-bar. A triplicate of each sample was prepared. This process was repeated for each water sample. After doing this, these petri plates were incubated for 24 hours, and colonies were counted. To perform the gram staining, the modified procedure of Hans Christian Gram was followed (37). Performed gram staining for each colony from the petri palate by preparing a smear of each colony on a glass slide. Dried the smear and first put a drop of crystal violet and wait for 1 min, then put Gram's iodine over it. wait for 1 minute, then wash with ethanol, pour safranin on a glass slide, wash with distilled water, and wait for drying, then observe it under the microscope through the oil-emerging lens. It shows that the colony is positive (+ve) or negative (-ve). Observations were recorded. Gram staining was performed to identify bacterial characteristics.

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) 2020 and MS Excel 2019 to determine statistical differences between the samples from the different campuses.

Results

At day zero, Sample 2 had the highest temperature (25.36°C), while Sample 3 had the lowest temperature (25.23°C). At day 7, sample 1 had the highest (25.73°C), while sample 2 had the lowest (25.47°C). At day 14, sample 1 had the highest temperature (26.47°C), while sample 3 had the lowest (26.43°C), as shown in Table 1.

Table 1.

Sample ID	**Temperature (°C)**		
	Day zero **Ave.**	**Day 7** **Ave.**	**Day 14** **Ave.**
Sample 1	25.33	25.73	26.47
Sample 2	25.36	25.47	26.4
Sample 3	25.23	25.63	26.23

At day zero, sample 2 had the highest electrical conductivity (980 µS/cm), while sample 1 had the lowest (596 µS/cm). At day 7, sample 2 had the highest electrical conductivity (985 µS/cm), while sample 1 had the lowest (667 µS/cm). At day 14, sample 2 had the highest electrical conductivity (1210 µS/cm), while sample 1 had the lowest (816 µS/cm), as shown in table 2.

Table 2.

Sample ID	**Electrical Conductivity (µS/cm)**		
	Day zero **Ave.**	**Day 7** **Ave.**	**Day 14** **Ave.**
Sample 1	596	667	816

Sample 2	980	985	1210
Sample 3	736	731	914

Table 3 shows that all samples remained transparent at day zero, 7, and 14, with no variations.

Table 3.

Sample ID	**Transparency at day zero, 7 & 14**
Sample 1	Transparent
Sample 2	Transparent
Sample 3	Transparent

No odor was observed in any sample at day zero, 7, and 14, as shown in Table 4, indicating that all samples were odorless.

Table 4.

Sample ID	**Odor at day zero, 7 & 14**
Sample 1	Odorless
Sample 2	Odorless
Sample 3	Odorless

As seen in Table 5, we observed that all samples remained colorless at day zero, 7, and 14, with no change in color.

Table 5.

Sample ID	**Color at day zero, 7 & 14**
Sample 1	Colorless
Sample 2	Colorless
Sample 3	Colorless

In Table 6, All sample were observed to be tasteless at day zero, 7, and 14.

Table 6.

Sample ID	**Taste at day zero, 7 & 14**
Sample 1	Tasteless
Sample 2	Tasteless
Sample 3	Tasteless

At day zero, sample 2 had the highest TDS value (412 ppm), while sample 1 had the lowest (285 ppm). At day 7, sample 2 had the highest TDS value (432 ppm), while sample 1 had the lowest (278 ppm). At day 14, sample 2 had the highest TDS value (774 ppm), while sample 1 had the lowest (522 ppm), as observed in Table 7.

Table 7.

Sample ID	Total Dissolved Solids (ppm)		
	Day zero Ave.	Day 7 Ave.	Day 14 Ave.
Sample 1	285	278	522
Sample 2	412	432	774
Sample 3	314	323	585

At day zero, sample 1 had the highest pH (8.63), while sample 2 had the lowest (7.93). At day 7, sample 3 had the highest pH (9.30), while sample 2 had the lowest (8.7). At day 14, sample 2 had the highest pH (8.31), while sample 1 had the lowest (8.03), as shown in Table 8.

Table 8.

Sample ID	pH		
	Day zero Ave.	Day 7 Ave.	Day 14 Ave.
Sample 1	8.63	8.72	8.03
Sample 2	7.93	8.7	8.31
Sample 3	8.37	9.30	8.16

All samples exhibited UV absorbance (λmax), within the expected range at day zero, 7, and 14.

Table 9 shows that sample 2 had the highest total hardness as Ca & Mg (332.80 mg/L), while sample 3 had the lowest (167.30 mg/L).

Table 9.

Sample ID	**Total Hardness as Ca & Mg (mg/L)**
Sample 1	201.60
Sample 2	332.80
Sample 3	167.30

In table 10, sample 3 had the highest concentration of chlorides (78.70 ppm), while sample 1 had the lowest (52.47 ppm).

Table 10.

Sample ID	**Chlorides (ppm)**
Sample 1	52.47
sample 2	68.21
Sample 3	78.70

Sample 2 had the maximum amount of sulphates (420 ppm), while sample 3 had the lowermost (280 ppm). As shown in the table 11.

Table 11.

Sample ID	Sulphates (ppm)
Sample 1	370
Sample 2	420
Sample 3	280

After 24 hours, sample 3 had the maximum number of colonies (65), while sample 1 had the lowest (2). After 48 hours, Sample 3 had the maximum number of colonies (1460), while Sample 1 had the lowest (65). Table 12 displays the subsequent results.

Table 12.

Sample ID	No. of Colonies	
	After 24 hour Ave.	After 48 hour Ave.
Sample 1	2	65
Sample2	7	392
Sample 3	65	1460

After 48 hours of incubation, Gram staining identified a variety of bacteria in each sample, including mixed and positive strains as well as negative strains.

Discussion

Water's superiority, which may be defined by chemical, physical, and biological factors, is essential for human use. In order to determine which water samples were best, we examined a number of factors in our study.

An essential physical characteristic is temperature, and we discovered that all samples had an average temperature of 25.3°C. Temperature differences in water coolers have been documented in earlier research, ranging from 5°C to 29.9°C (29).

Electrical conductivity (EC) is another key factor, and we observed variations from 596 µS/cm to 980 µS/cm at day zero. In contrast, a previous study in Saudi Arabia reported a range from 91 µS/cm to 432 µS/cm, with a WHO standard of 400 µS/cm. On day 7, the EC ranged from 667 µS/cm to 985 µS/cm in our research. On day 14, the EC values varied from 816 µS/cm to 1210 µS/cm. Our results differ from these previous studies (29).

Transparency remained consistent in our study, in line with previous findings that water samples sealed in airtight containers maintained their transparency (38). Odor, color, and taste assessments were all favorable, with samples remaining odorless, colorless, and tasteless throughout the study.

Total Dissolved Solids (TDS) varied, with values fluctuating from 285 ppm to 412 ppm at day zero. Although previous studies reported TDS variations from 58 ppm to 276 ppm, our results compiled with WHO standards. At day 7, TDS values ranged from 278 ppm to 432 ppm in our samples. These results were in line with WHO standards and differed from previous studies. On day 14, TDS values ranged from 522 ppm to 774 ppm, not aligning with previous research (5).

pH levels varied from 7.93 to 8.63 at day zero, within the WHO standard range of 6.50 to 8.50. However, at day 7, the pH ranged from 8.1 to 9.30, not complying with the previous pH range of 6.10 to 8.30, which was attributed to the presence of low concentrations of chlorine and phosphates. At day 14, pH levels ranged from 8.03 to 8.31, still in line with previous studies pH range (5).

UV Absorbance (λmax) remained within the expected range of below 190.

Total hardness values fluctuated from 167.30 mg/L to 332.80 mg/L, in line with previous studies and WHO standards (18).

Chloride concentrations ranged from 52.47 ppm to 78.70 ppm, in line with previous studies and WHO standards (5).

Sulphate concentrations ranged from 280 ppm to 420 ppm, within WHO standards (18).

Bacterial colony counts varied between samples, with samples 1 and 2 having lower counts of 2-11 per 50 µliter after 24 hours of incubation and higher counts of 41-553 per 50 µliter after 48 hours. In contrast, sample 3 showed higher initial counts of 58-74 per 50 µliter and even higher counts of 1383-1537 per 50 µliter after 48 hours. This is a significant deviation from a previous study where colony-forming units (CFU)/mL ranged from 0-50 (8).

Gram staining of grown bacterial colonies after 48 hours revealed significant differences in the composition of colonies between samples, contrasting with previous studies (5).

Conclusion

In conclusion, this study aimed to evaluate the superiority of water by assessing various physical, biological, and chemical parameters, with a focus on compliance with WHO and Egyptian standards. The analysis revealed that most considerations were within satisfactory limits at the start of the study on day zero. However, as time progressed, some concerning trends emerged.

The electrical conductivity of water samples was either near or exceeded the WHO standards at day zero, 7, and 14, indicating potential concerns regarding water salinity. Total Dissolved Solids (TDS) concentrations remained within limits at day zero and 7 but exceeded the permissible level at day 14, suggesting an increase in dissolved substances over time. pH values were generally within the limits set by WHO, except for a slight elevation at day 7, which may not be of significant concern.

The hardness of water, as measured by the concentration of calcium (Ca) and magnesium (Mg), met Egyptian standards, reflecting an acceptable mineral content. However, the concentrations of sulphates in the water exceeded both WHO and Egyptian standards, raising potential health concerns. On the other hand, chloride levels remained within acceptable ranges.

The most alarming finding was the increase in colony-forming units (CFU) of coliform bacteria, indicating the presence of these injurious microorganisms in water. While the water appeared safe for immediate use at day zero, our research suggests that it becomes unsafe for consumption after a single day, as the bacterial contamination exceeded permissible levels after 48 hours of incubation.

These findings underscore the impact of regular monitoring and care of water sources to confirm the delivery of safe and potable water. Further research and actions are necessary to address the issues of increasing TDS, sulphates levels, and coliform contamination, with the goal of providing a consistent supply of sanitary and harmless water for the well-being of the community.

Declarations

Ethical Approval

There are no ethical issues involved in this study.

Funding

Not applicable.

Availability of data and materials

All data is available in the manuscript.

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