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Bacteriological Evaluation of Drinking Water Quality from Kabul University Taps

Sayed Arif Ahmadi[1], Mohammad Zaher Sakha[2]✉, Manizha Rahimi[3]

[1,2] Kabul University, Department of Food Technology & Hygiene, Faculty of Veterinary Science, Afghanistan
[3]Kabul University, Department of Preclinic, Faculty of Veterinary Science, Afghanistan

✉E-mail: drzaher1@yahoo.com (corresponding author)

ABSTRACT

Human health is significantly affected by poor-quality drinking water, and water-borne diseases are of the most significant concern. A wide variety of microorganisms contaminate drinking water. Water consumers face substantial challenges due to these pollutants and harmful bacteria. To evaluate the microbiological quality of drinking water samples from different places to identify and count *Escherichia coli* and *Coliform bacteria,* multiple tube fermentation technique tests (most likely 100 ml) were used. Bacteria were identified using their morphological, biochemical, and cultural characteristics. Sixty tap water samples were collected from different locations at Kabul University. Of these, 36 samples (60 %) were positive for *E. coli* and *Coliform bacteria*, and 24 (40 %) were negative. Girls' and boys' dormitories showed the highest bacterial contamination level among the multiple positive water samples collected from different locations. Thirty-one samples (86.1 %) of the water were contaminated with *Coliform*, and five (13.8 %) samples revealed contamination with *E. coli*. Therefore, it is suggested that all drinking water sources should plan and carry out regular bacteriological evaluations, water supply monitoring, regular treatment, and adequate sanitation.

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INTRODUCTION

It is estimated that 80% of diseases worldwide are related to poor water hygiene, and patients with water-related diseases often account for half of hospital beds worldwide (Bourne, 1982). According to a 1985 World Health Organization (WHO) estimate, approximately 1.25 billion people suffer from major water-related diseases at any time (Lewis, 1985). Most international norms and standards state that water meant for human consumption needs to be aesthetically pleasing, safe, and pleasant. This suggests that anything that could pose a health risk, including pathogenic microbes, should preferably be absent from drinking water.

Depending on the regulations and standards, many techniques evaluate whether water is safe, tasty, and visually sound (WHO, 2008).

The United Nations Secretary-General (UNSG) emphasized assessing drinking water quality on World Water Day 2002. According to estimates, more than 5 million people die annually from water-related diseases, 1.1 billion people drink contaminated water, and 2.5 billion people do not have access to adequate sanitation (Hinrichsen & Tacio, 2002). According to the United Nations, the world's population is increasing, yet less fresh water is available. In the next 20 years, most countries in South Asia, Africa, and the Middle East will face a severe water scarcity issue. Like other developing nations, Afghanistan is dealing with severe water scarcity and pollution (Hinrichsen & Tacio, 2002 WHO, 2008). It's well known that freshwater resources make up less than 1% of the world's total water volume, making water a scarce and important resource. Eighty-five percent of water utilization is for irrigation, which is necessary for life and distinct from other biosphere constituents. There isn't a single, worldwide approach to solving the range of issues that can arise, frequently in tandem based on a place. In the upcoming years, the human population will be under extreme stress (Biswas, 1992a).

Water is necessary for life to exist, and everyone must have access to a sufficient (enough, safe, and accessible) supply. Enhancing the availability of clean drinking water can have positive effects on health. The goal should be to provide drinking water that is safe for human use. According to the guidelines, drinking safe water does not pose a severe risk to one's health throughout a lifetime, even for those who may experience varying sensitivity levels at different stages of life. The elderly, disabled people and small children are the groups most vulnerable to water-borne illness, mainly when living in unhygienic places (WHO, 2011).

The degradation of freshwater is a result of the general socioeconomic growth that followed the Industrial Revolution. The water crisis is primarily a result of population pressure (an additional factor is the desire for a higher level of living). By the end of the next century, the population may surpass 10 billion because of its exponential growth (U.N., 1989). Developing nations will experience the majority of the increases. Water "scarcity" may have a 10 times detrimental impact on the current population by 2025, as demonstrated by Kulshreshtha (1993). One of the fundamental alternative strategies for areas like (Kabul) is using underground water artificial recharging; thus, this plan would be a perfect project in the suitable system in the future and will help with water supply (Eqrar, 2008).

Microbiologically clean water free from human-made chemical contaminants should ideally be supplied by a well-designed water source, while naturally occurring chemical contamination may still be an issue. In reality, the perfect water supply point is rarely reached, and even well-constructed water supply points get worse over time. In addition, during collection, transportation, and storage at home, water from a clean source can quickly become contaminated with microbes. When water leaves a treatment facility in an urban environment, low pressure and leaks in distribution lines can cause the water to become heavily contaminated with fecal bacteria before it reaches the consumer’s tap. It is nearly rare to discover water sources in impoverished countries that consistently offer water free of fecal pollution, especially in rural areas. Even with massive resources devoted to the threat and distribution of drinking water in developed countries, chemical and microbiological pollution can occasionally occur (UNICEF, 2008). Aziz & Rahmatzai (2024), in the 17th district of Kabul City, found that nitrate, sulfate, and fluoride levels were safe.

The basis of ensuring the microbiological safety of drinking water sources is the implementation of several barriers, ranging from catchment to consumer, to stop drinking water contamination or reduce it to levels that are not harmful to human health. Multiple barriers, such as protection of water sources, proper selection and implementation of a sequence of treatment methods, and management of distribution networks (piped or pipeless) to maintain and protect the quality of treated water, all contribute to excellent safety. The recommended course of action is a management strategy that prioritizes limiting or eliminating pathogen entrance into water sources and lowering dependency on treatment methods to eradicate pathogens (WHO, 2011).

Generally, drinking water tainted with human or animal (including bird) excrement poses the highest microbiological dangers. Pathogenic bacteria, viruses, protozoa, and helminths can all be found in feces. The main factors to consider when establishing health-based targets for microbiological safety include pathogens originating from feces (WHO, 2011). Undoubtedly, disinfection is essential for providing clean drinking water. Killing pathogenic bacteria is essential, often done using chemically reactive agents such as chlorine. When treating drinking water, disinfection is an effective barrier to many pathogens, particularly bacteria, and it should be applied to surface water and groundwater that feces have contaminated. A partial defense is offered by residual disinfection. Protect the distribution system against low-level pollution and growth (WHO, 2011).

Unlike those associated with microbiological contamination, health risks related to chemical constituents of drinking water are mainly due to the ability of chemical constituents to have adverse health effects during long-term exposure. The chemical composition of water rarely causes health problems with a single exposure unless there is widespread and unintentional contamination of a drinking water source. Furthermore, empirical evidence shows that in most of these cases—though not all—the water loses its portability due to its unpleasant color, taste, and odor (WHO, 2011). It is essential to assess the health risks associated with naturally occurring radionuclides in drinking water, even though the contribution under normal conditions, the total exposure of drinking water to radionuclides is quite limited (WHO, 2011).

The taste or odor of water should not put off most consumers. Consumers mostly rely on their senses to determine the quality of drinking water. The customer will evaluate the acceptability and quality of the water based on these factors, which include microbial, chemical, and physical components that may alter the water's appearance, taste, or odor. Consumers may see and reject water that is too cloudy, too colored, or has an unpleasant taste or smell, even though these substances may not directly affect health (WHO, 2011). The traits, behaviors, and resistance of the diseases that can be spread by contaminated drinking water are varied and provide broad details on pathogens that are important for managing drinking water supplies.

Epidemiological research and case histories have proven the infections listed as being transmissible by water. The onset of the illness in appropriate hosts is one way to demonstrate pathogenicity. Information is obtained from experimental investigations in which healthy adult volunteers are exposed to known concentrations of pathogens; nevertheless, the data are relevant only to a portion of the exposed population; extrapolation to more sensitive subpopulations is a matter that needs further investigation. Variations in human and animal populations, the reuse of wastewater, alterations in lifestyles and medical interventions, population movement and travel, selection pressures for novel pathogens and mutants, or recombination of already-existing pathogens can all impact the spectrum of pathogens (WHO, 2011).

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The occurrence of water-borne illnesses has both economic and social impacts. Consequently, monitoring the contamination levels and preventing disease outbreaks is vital from economic and public health perspectives. Moreover, the need to assess the microbiological quality of water has become imperative because it directly affects individuals' health. Identifying the connection between pollution and the need to protect human health, recreation, and fisheries production led to the early development of water quality regulations and monitoring methods (Jenkins et al., 1996; USEPA, 2007). The use of certain bacteria as indicators of the potential presence of pathogenic microorganisms in water is the standard means of assessing the microbiological quality of a water body (Payment et al., 1997; El-Abagy et al., 1999; El-Taweel & Stewart, 2007).

Researchers investigated the relationship between the prevalence of enteric disease in Cebu, Philippines, and four bacterial indicators (fecal *Coliform*, *E. coli*, *Enterococci*, and fecal *Streptococci*) to assess the health effects of water sources in developing countries (Moe et al., 1991). Water-borne diseases such as cholera and typhoid are brought on by polluted water or an insufficient supply of safe drinking water, which can lead to a variety of gastrointestinal disorders like dysentery and diarrhea. Clearly, contaminated food and water are the main means of spreading enteric illnesses in humans and animals (Johnson et al., 2003). Water must be treated or purified before being consumed to guarantee the absence of suspended biological agents and to provide clean drinking water. The potable water delivery system must be safe from the public health perspective. Sewage or excrement can contaminate water at its source and almost certainly include pathogenic germs. Poor hygiene and sanitation practices can contaminate potable water systems with harmful microorganisms and *E. coli*. Therefore, to monitor and regulate the quality and safety of drinking water, microbiological analyses of the water should be conducted regularly. There is a direct correlation between human health, nutrition, water, and cleanliness. In Afghanistan, consuming tainted drinking water, neglecting personal and food hygiene, and disposing of human waste and liquid and solid waste improperly are the leading causes of numerous diseases. The present study aimed to evaluate the water quality of the samples collected from the taps at Kabul University.

MATERIALS AND METHODS

Study area: Department of Food Technology and Hygiene, Faculty of Veterinary Science, Kabul University.

Study period: This study was conducted at Kabul University on the source of drinking water to determine the level of bacterial contamination from June to November 2020.

Sample collection: The water taps were sterilized using a cotton swab. The swab was soaked in 70% ethanol before use. Each water tap was left running for three minutes, and the next outflowing water was used for the test. A sterilized 250 ml glass container was carefully uncapped, filled with water, and recapped. The site name and water source information were written over the sample bottle at collection time. To stop bacteriological growth, the water samples were collected and then delivered to the lab in ice-cold containers within 40 minutes of collection time. From June to November 2020, all samples were gathered from Kabul University's various locations (Table 1). This study aimed to detect *E.coli* in collected water samples. The Most probable number, or MPN test with triplicate trial, was performed in this investigation.

Table 1. The number of tap water samples collected from different sites at Kabul University

Sites	Number of samples collected
Faculty of Law	7
Girls' and Boys' Dormitories	8
Faculty of Veterinary Science	7
Chines Department, Faculty of Foreign Literature	7
Faculty of Engineering	7
Faculty of Agriculture	6
Faculty of Economics	6
Central Library, K. U.	6
AC/KU	6
Total	60

AC/KU =Afghanistan Studies Centre/Kabul University

Microscopic study*: *Gram staining described by Merchant and Packer (1967) was used to *identify the* size, shape, and arrangement of *E. coli and Coliform bacteria in water samples.* This study was consistent with Gram$^+$ pink and rod-shaped *Coliform* and Gram$^-$ pink-blue and large rod-shaped microorganisms *E. coli* found singly or in pairs.

***Biochemical tests*:** The Indole Methyl Red Voges–Proskauer Citrate tests (IMViC) described by Cowan & Steel (1985) were used to identify *E. coli* colonies. Both the *methyl red* and *Voges-Proskauer* tests are commonly used in conjunction with the *indole* and *citrate* tests to form a group of tests known as IMViC. The ability of *E. Coli* and *Coliform* to ferment glucose, lactose, and maltose and produce gas (CO_2) was identified. The most probable number (MPN) per 100 milliliters of water was calculated using test results.

Motility tests: The technique outlined by Cowan and Steel (1985) was used to conduct the motility test to distinguish between motile and non-motile bacteria. A pure culture of the organism was allowed to grow in nutrient broth before the test. To prepare the hanging drop, one drop of cultured broth was poured on the coverslip and then placed in the opposite direction over the hanging drop slide's concave depression. Vaseline was applied to the concave depression of the hanging drop slide to improve coverslip attachment and stop fluid evaporation and air currents. Then, the hanging drop slide was checked with oil immersion under a compound microscope. By comparing the motility of the organisms to their movement, the motile and non-motile ones were distinguished.

Identification of *Coliform*: *The drinking water quality was evaluated using the Multiple tube fermentation technique (MTFT)* described by Ellen et al. (2014).

The MTFT was done to identify Coliform in collected tap water from different sites at Kabul University. This test is a presumptive test of water quality. Tests were completed, verified, and confirmed.

i. Presumptive test: to make 100 ml of broth, 3.5g of MacConkey broth was weighed, dissolved, and gently shaked in distilled water. Durham`s tube was inverted in each test tube, and 9 ml of MacConkey broth medium was added. Carefully, air bubbles were extracted from every test tube. Test tubes were autoclaved for 15 minutes at 121°C and 15 pounds of pressure and then cooled to room temperature. Each test tube was filled with one milliliter of water sample. Turbidity was noted when these test tubes were cultured for 24 hours at 37°C. A change in color means the presence of acid—Durham's tube's bottom bubbles, which indicated the gas production. Positive tests were identified by acid and gas production, while negative tests were suggested by their absence.

ii. The test confirmation: The test confirmation was applied using Eosin methylene blue agar (EMB agar). 200ml of EMB agar was prepared by dissolving 3.75g of the media in distilled water. The medium underwent 15 minutes of autoclaving at 121°C and 15 pounds of pressure. Sterilized Petri plates were filled with the medium and left to harden. These plates were injected with a culture obtained from test tubes that was presumed positive. For 24 hours, these test tubes were incubated at 37°C. After incubation, the glittering sheens in pink and green in the cultured plates indicated a positive result. The positive cultures will be streaked on EMB agar during the procedure using the streak plate method. The grown colony on the EMB agar shows typical pink and green after incubation, which indicates the presence of Coliforms.

iii. The test completion: The test was completed using MacConkey broth. The amount was increased to 100ml by weighing and dissolving 3.5 g of broth in the distilled water. Durham's tube was placed inside each test tube after adding 9 milliliters of the medium. These tubes were autoclaved for 15–20 minutes at 121°C and 15 pounds of pressure and then cooled to room temperature. A loop full of streak plate culture was used to inoculate into these test tubes. The temperature in these test tubes was 37°C. Within eighteen hours, a positive sample produces acid and gas inside the test tubes, confirming the successful test.

Statistical analysis

Graph-Pad Prism version 5, as stated by Mutolsky (2007), was used to examine the data obtained from the present study. The P value and significant differences were found using the Chi-test McHugh, (2013).

FINDINGS

In this study, 60 water samples from different locations, as mentioned in Table 1, were collected from water taps on the campus of Kabul University. Figure 1 illustrates that of the 60 water samples collected from various campus locations, 36 (60%) samples were positive for *Coliform* and *E. coli*, and 24 (40%) tested samples were negative; neither *Coliform* nor *E. coli* was found in 24 samples. The highest level of bacterial contamination was found in positive water samples from multiple locations, including the Central Library of KU. Student dormitory, the Chinese Department Faculty of Foreign Literature, the Law Faculty, the Agriculture Faculty, the Veterinary Faculty, the Engineering Faculty, and the Economics Faculty, respectively.

The water quality at the Engineering, Veterinary, and Agriculture faculties' sites was satisfactory compared to the students' dorms. It was discovered that neither the Afghanistan Center at Kabul University nor the central library of KU contained any coliform or *E. coli* contamination (Figure 2).

According to our analysis, the levels of contamination at the law faculty, university dormitory, veterinary science faculty, Chinese department of foreign literature, and engineering faculty varied significantly (CHITEST, $P<0.01$, Fig.2). The levels of contamination were higher in the Chinese department, the law faculty, the dorm, and the economics faculty than in the veterinary and engineering faculties.

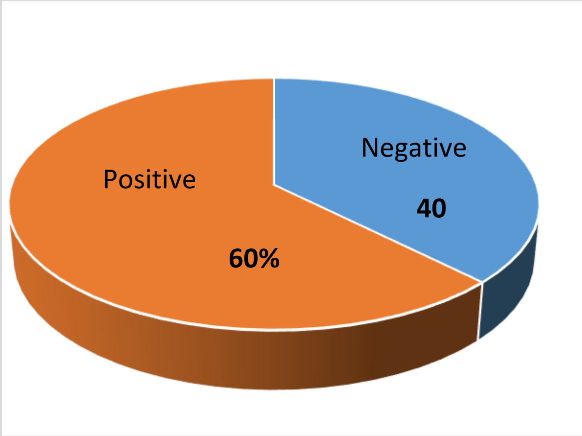

Figure 1: Showing percentage of positive and negative water samples for E. coli and Coliform

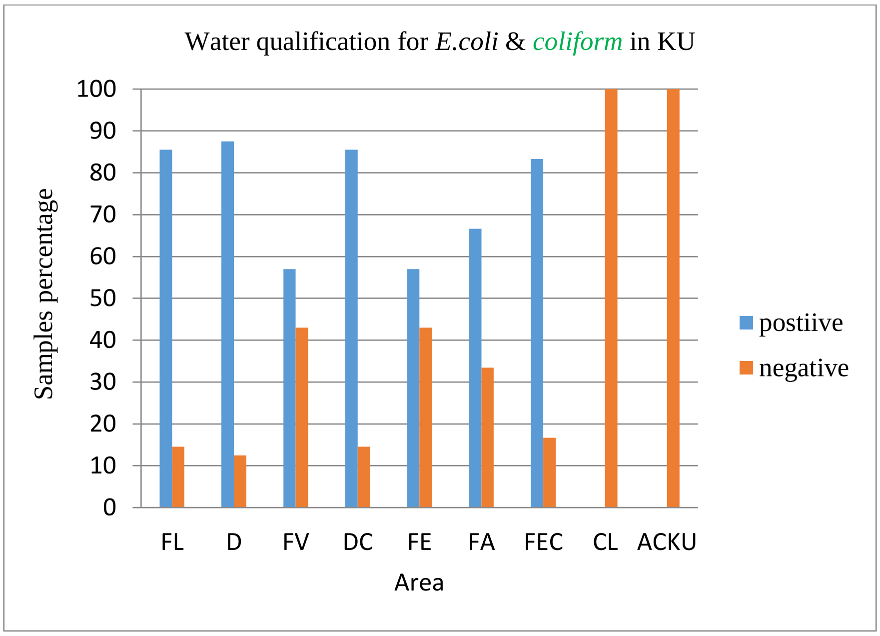

Figure 2: The presence of E. coli and Coliform in water samples at the different areas of KU:
Faculty of Law (F.L.), Dormitory (D), Faculty of Veterinary (F.V.), Department of Chinese (D.C.), Faculty of Engineering (F.E.), Faculty of Agriculture (F.A.), Faculty of Economy (FEC), Central Library (CL) and Afghanistan Center at Kabul University (ACKU).

DISCUSSION

Lack of access to safe and clean drinking water is the leading cause of enteric diseases, which cause human health problems in certain countries. Water is essential for survival, so it is expected to be pure and free from bacterial contaminants and other impurities. Even if it seems clear, water may not always be safe to drink. Water that is fit for human consumption needs to taste well, be safe to drink, and be suitable for household use. Therefore, one primary source of infectious diseases is drinking water. However, the most crucial factor in guaranteeing public health is water filtration. High levels of *Coliform* and *E. coli* were found in the water; nevertheless, according to international guidelines, drinking water should not contain any *E. coli*. Our study confirmed the high total *Coliform* counts reported by several authors in various Indian waters during pre- and post-monsoon seasons (Radha et al., 2007).

The Kabul's city groundwater varies significantly in quality. Groundwater quality is good in a few restricted regions, with no harmful components and a low concentration of dissolved solids. However, in certain areas, excessive dissolved solid concentrations and certain elements at concentrations that appear toxic to humans and even crops make untreated groundwater marginal or unfit for use in agriculture and public supplies. Regarding sustainable water conservation and sanitation, Afghanistan is among the world's poorest nations (Eqrar, 2008).

According to Blanco et al. (1993), in nations with inadequate environmental hygiene, *E. coli* is the most prevalent entero-pathogen that causes endemic diarrhea in both adults and children. Our research is similar to that of Thakur et al. (2012). Seventeen water samples were taken from various sources for their investigation. Those samples had 52.94% unsatisfactory, 11.76% satisfactory, 29.4% excellent, and 5.88% suspicious results with *E. coli* and *Coliform*. Enteric bacteria are regarded as indicator organisms for water pollution. For many years, fecal pollution in water has been detected by *Coliform* and *E. coli*. Normal bacteria are more prevalent than bacteria that cause disease in the digestive tracts of both humans and animals.

CONCLUSION

Tap water is easily contaminated either at the source or during pipeline transit. Water contamination can also come from other sources, such as the air and soil. This study showed differences in the microbiological characteristics of water samples from various Kabul University sites. Most locations fulfilled the microbiological requirements suggested by the WHO for more safety. Some places, though, fell short of the WHO's recommended level. Uncleaned drinking water can lead to several chronic health issues and water-borne infections. Therefore, everyone on Earth must have access to clean water. For this reason, proper water purification is essential to prevent health problems. Consequently, it is suggested that all drinking water sources should plan and carry out regular bacteriological evaluations, water supply monitoring, regular treatment, and adequate sanitation.

Conflict of interest: The authors declare no conflicts of interest.

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