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Assessment of Free Drinking Water Facilities and Its Potential Health Risks: A Study in the University X

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Abstract

University X offers free drinking water facilities. However, it has a significant problem in accessing safe drinking water. This study aimed to examine the microbial and chemical parameters of the free drinking water facilities at University X. The microbial quality was assessed by evaluating the total coliform bacteria, and the chemical parameter assessment, substances such as nitrate, iron, manganese, hexavalent chromium, and fluoride were analyzed across 12 water samples from various locations within the university. Among these, only total coliform and fluoride levels exceeded the guidelines of the World Health Organization (WHO) and the Indonesian Ministry of Health. An Environmental Health Risk Assessment was also conducted to discern potential health hazards among the 112 respondents. This study found no potential non-carcinogenic health risks associated with consuming water from the facilities. However, a sample in one location tested positive for total coliform, and the nitrate and manganese concentrations in another location did not meet the Indonesian Ministry of Health standards. The findings suggested that the free drinking water provided by University X is safe for consumption. Nonetheless, regular maintenance of the treatment facilities is needed to ensure that water quality remains suitable and clean.

Keywords: assessment, health, microbiology, risk, water

Introduction

Drinking water is an essential human necessity, and the importance of having access to safe drinking water cannot be overstated. According to the World Health Organization (WHO), safe drinking water is defined as water that does not present any health risks and is suitable for lifelong consumption.[1] To ensure that the water quality remains excellent, the processing, packaging, and dispensing of potable water must adhere to stringent hygiene and sanitation standards. Specifically, it must be free from microbiological, physical, chemical, and radioactive contaminants that pose potential health risks.[2] According to Sustainable Development Goals (SDGs) target 6, drinking water management aims to ensure its safe and affordable provision to safeguard human rights.[3] Based on the initial assessment, access to safe drinking water in the city where University X is located was only 15.45%.[4] A recent report on Household Drinking Water Quality Surveillance/*Surveilans Kualitas Air Minum Rumah Tangga* (SKAMRT) in 2020 revealed that only 11.8% of the population had access to safe drinking water.[5]

To determine if water is safe for consumption, it is crucial to examine two common parameters: microbial and chemical. Microbial pathogens, such as fecal coliform microbes, *Escherichia coli*, fecal *streptococci*, *Pseudomonas aeruginosa*, or *Staphylococcus spp*., are frequently found to contaminate drinking water.[6] These pathogens can adversely affect human health, with symptoms such as diarrhea, nausea, and vomiting.[7] In addition to that, chemical contaminants, including chromium (Cr), fluoride (F), lead (Pb), iron (Fe), arsenic (As), and nitrate (NO_3^-), have been detected in many water sources around the world, including India,[8] Nepal,[9] Peru,[10] and Denmark.[11]

Previous studies in Indonesia have consistently demonstrated widespread contamination of drinking water by microbial and chemical pollutants across various regions. For instance, investigations in the Special Region of Yogyakarta Province revealed elevated NO_3^- concentrations in well water, attributed to inadequate sanitation practices.

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The issue of high NO_3^- levels in drinking water is critical and requires further analysis as it poses potential health risks to the community.[12]

University X, the largest academic institution in the country, has been committed to providing free drinking water facilities. These facilities are strategically located in different faculties and public areas to reduce the use of disposable water bottles. However, there is a notable lack of comprehensive assessments or research on the microbiological and chemical composition of the drinking water provided by the university, a critical aspect in mitigating the risks associated with waterborne diseases. Therefore, this study aimed to conduct thorough microbiological sampling and analysis, as well as chemical health risk assessments, on the university's free drinking water facilities. Furthermore, potential health risks associated with consuming the water were evaluated using the Environmental Health Risk Assessment (EHRA).

Method

Twelve water samples were collected from free drinking water facilities available at University X. The variables measured were total coliform bacteria, nitrate (NO_3^-), iron (Fe), manganese (Mn), hexavalent chromium (Cr^{6+}), and fluoride (F). Biological parameters were not included in the risk calculation because drinking water suitable for consumption should have zero biological contaminants, following the Regulations of the Indonesian Ministry of Health and the WHO. These facilities are located in the Faculty of Public Health (A), Faculty of Nursing (B), Faculty of Mathematics and Natural Sciences (C), Faculty of Humanities (D), Faculty of Computer Science (E), Faculty of Law (F), Faculty of Psychology (G), Faculty of Economics and Business (H), Faculty of Engineering (I), Student Activity Center (J), Library (K), and Mosque (L) (Figure 1).

The sample collection and transportation followed the technical regulations of the Indonesian Ministry of Health. The procedures were carried out in the following orders: first, the sample was collected, stored, and carried in a sterile container to prevent contamination; second, the sample was labeled with detailed sample information; third, trained personnel conducted the sampling process; and finally, the sample was promptly delivered to the laboratory for testing.[2] The quality assessment included the microbiological analysis based on ISO 9308-1:2014, which specifies methods for bacterial counting using the membrane filtration method, followed by culturing on chromogenic coliform agar and counting the number of target organisms in the samples.[13]

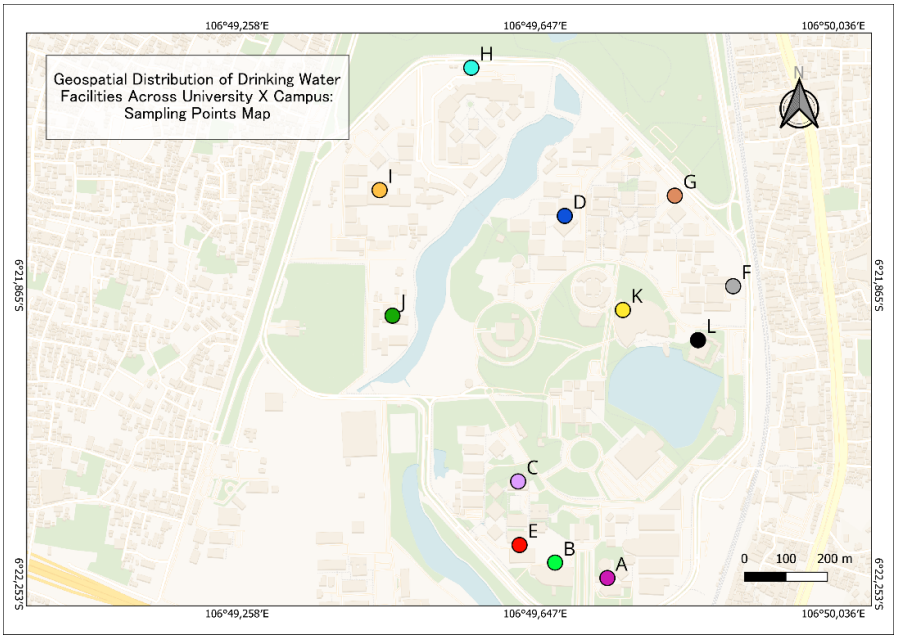

Figure 1. Sampling Points Map (Source: Authors' Collection)

The potential health risks were calculated using the EHRA recommended by the United States Environmental Protection Agency. This study included 112 respondents from University X who met the inclusion criteria: university students and staff (educational and non-educational), aged >18 years, using free drinking water facilities, and willing to be interviewed. The exclusion criteria were students and staff (educational and non-educational) who were pregnant, breastfeeding, or had diabetes. To calculate potential health risks, the chronic daily intake was first determined (Eq. 1) to estimate the average exposure in the body. Next, the risk quotient (RQ) was calculated to determine whether the risk level was safe or unsafe.

$$CDI_{(ingesti)} = \frac{C \times R \times fE \times Dt}{Wb \times Tavg}$$ ..... Eq. 1

The CDI means the chronic daily intake or intake value (mg/kg x day), C means the concentration of the risk agent (Ingestion: mg/L, mg/kg. inhalation: mg/m^3), R means the intake rate (ingestion: liters/day, grams/day. Inhalation: m^3/hour), fE means the exposure frequency (days/year), Dt means the exposure duration (years), Wb means the body weight (kg) and Tavg means the averaging period for carcinogenic or non-carcinogenic effects (days). After obtaining the intake value, risk characterization was conducted by dividing the intake value by the reference dose (RfD) of the risk agent being analyzed.[14] The RfD represents the estimated daily oral intake for the human population (including sensitive subgroups), which is not expected to pose a health risk, even with lifetime exposure.[15] The risk characterization was determined using Eq. 2:

$$RQ = \frac{CDI}{RfD}$$ ..... Eq. 2

Results

Table 1 presents the levels of microbial and chemical parameters of free drinking water facilities in University X. Chemical parameters that exceeded the average were NO_3^- at 21.18 mg/L and Mn at 0.1325 mg/L, while the biological parameters showed 3 colonies/100 ml. Microbiology analysis at location B detected coliform bacteria. In addition, the concentrations of NO_3^- and Mn at location E were found to exceed the chemical quality standards.

Table 1. Microbial and Chemical Parameters of Free Drinking Water Facilities at University X

Characteristics	Mean±SD	Min-Max	WHO reference value[15]	Indonesian MOH reference value[2]
Biological (colony/100 ml)				
Total coliform bacteria	0.25±0.87	0.00-3	0	0
Chemical (mg/L)				
Nitrate	4.70±5.93	0.00-21.18	50	20
Iron	0.01±0.04	0.00-0.1300	0.3	0.2
Manganese	0.01±0.04	0.00-0.1325	0.4	0.1
VI-Valent Chromium	0.00±0.00	0.00-0.0030	0.05	0.01
Fluoride	0.01±0.03	0.00-0.12	1.5	1.5

Notes: SD = standard deviation; WHO = World Health Organization; MOH = Ministry of Health

The calculation of potential health risks among 112 respondents was performed. Table 2 tabulates the characteristics of the respondents. The measurements showed an average body weight of 61.60 kg, an exposure duration of 1.93 years, an intake rate of 1.10, and an exposure frequency of 250 days/year.

Table 2. Anthropometric Characteristics of Respondents

Variables	Mean±SD	Min-Max
Wb (kg)	61.60±4.81	55.55-69.42
Dt (years)	1.93±0.57	0.86-2.84
CDI (mg/kg x day)	1.10±0.28	0.84-1.76
fE (days/year)	250±0.0	250-250

Notes: SD = standard deviation, Wb = body weight, Dt = duration of exposure, CDI = chronic daily intake, fE = frequency of exposure

Table 3. The Chronic Daily Intake, Reference Dose, and Risk Quotient of the Chemical Parameters

Location	Parameters	CDI	RfD	RQ
A	NO_3^-	0	1.6	0
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
B	NO_3^-	0.002	1.6	0.001
	Fe	0.00019	0.007	0.027
	Mn	0	0.14	0
	Cr^{6+}	0.000004	0.003	0.001
	F	0.0002	0.06	0.003
C	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
D	NO_3^-	0.006	1.6	0.004
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
E	NO_3^-	0.024	1.6	0.015
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
F	NO_3^-	0	1.6	0
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
G	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
H	NO_3^-	0.001	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
I	NO_3^-	0.010	1.6	0.006
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
J	NO_3^-	0.010	1.6	0.006
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
K	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0

Location	Parameters	CDI	RfD	RQ
L	NO_3^-	0.003	1.6	0.002
	Fe	0	0.007	0
	Mn	0.0001	0.14	0.0004
	Cr^{6+}	0	0.003	0
	F	0	0.06	0

Notes: CDI = chronic daily intake, RfD = reference dose, RQ = risk quotient, NO_3^- = nitrate, Fe = iron, Mn = manganese, Cr^{6+} = hexavalent chromium, F = fluoride

Table 3 presents the CDI, RfD, and RQ from chemical parameters. The results showed that the RQ values of NO_3^-, Fe, Mn, Cr^{6+}, and F were all less than one. This indicated that the free drinking water facilities of University X did not pose any health concerns and were thus deemed safe for consumption. Moreover, the combined risk also showed RQ<1.

Discussion

This study found that inadequate equipment maintenance is determined to be one of the critical contributors to this contamination. This finding aligned with Sulistiawan's study, which demonstrated that the lack of maintenance for filter devices can reduce the water filtration efficacy.[16] On top of that, the surrounding conditions of the water sources, especially groundwater, are inhabited by various types of bacteria, such as fecal indicator bacteria, pathogenic bacteria, human enteric viruses, and parasitic protozoa.[17,18] The biological quality of drinking water should be free from coliform bacteria contamination. Hence, to achieve this goal, the raw water must be sanitized to ensure its cleanliness for consumption.[19] Among the chemical parameters examined, this study's analysis revealed that the NO_3^- and Mn levels surpassed the threshold values set by the Indonesian Ministry of Health.

The EHRA findings indicated the absence of potential health hazards, as the calculated values did not exceed the threshold of 1. Thus, this study suggests that drinking water offered by the facilities at the University of Indonesia poses no discernible health risks. However, despite the significance of this investigation, several limitations should be acknowledged. First, not all chemical parameters were analyzed. Second, the sampling process was conducted only once; therefore, future studies are recommended to perform repeated assessments.

Conclusion

Based on the microbial and chemical parameters examined at free drinking water facilities at University X, positive total coliform is detected in one location, and nonstandard nitrate and manganese concentrations are detected in another location. However, the risk quotient value of the chemical parameters of the free drinking water facilities is considered safe. It is anticipated that constant monitoring, routine maintenance of the free drinking water facilities, controlled cleaning, regular water quality checks, and ongoing evaluations will significantly reduce contaminants. This study can serve as part of a prevention program for those responsible for drinking water facilities at University X and other educational institutions.

Abbreviations

WHO: World Health Organization; EHRA: Environmental Health Risk Analysis; RQ: risk quotient; RfD: reference dose; SD: standard deviation; Wb: body weight; Dt: duration exposure; CDI: chronic daily intake; fE: frequency of exposure.

Ethics Approval and Consent to Participate

This study has been approved by the Research and Community Engagement Ethical Committee of the Faculty of Public Health Universitas Indonesia (Letter of Approval Number 587/UN2.F10.D11/PPM.00.02/2023).

Competing Interest

There is no conflict of interest in this study.

Availability of Data and Materials

Available on request.

Authors' Contribution

Research conceptualization: IAZL, BW, MNIA; Methodology design: IAZL, BW, MNIA, SF; Data collection: MAA, NF, KMH, FA; Data analysis: IAZL, ASH; Manuscript drafting: IAZL, MAA, NF; Manuscript review and editing: BW, FK, SF; Supervision and project administration: MNIA, GL; Funding acquisition: BW, MNIA, SF, GL.

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References

1. World Health Organization. State of the world's drinking water: An urgent call to action to accelerate progress on ensuring safe drinking water for all. Geneva: World Health Organization; 2022.
2. Menteri Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2023 Tentang Peraturan Pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 Tentang Kesehatan Lingkungan. Jakarta: Kementerian Kesehatan Republik Indonesia; 2023.
3. United Nations. Report: State of the world's drinking water. New York: United Nations; 2022.
4. Pemerintah Kota Depok. Percepat akses air minum hingga sanitasi aman, USAID-IUWASH dan Pemkot Depok bahas RKT ketiga. Depok: Pemerintah Kota Depok; 2023.
5. Directorate General of Disease Prevention and Control. Annual Report Drinking Water Quality Monitoring Year 2022. Jakarta: Ministry of Health of the Republic of Indonesia; 2022.
6. Wibuloutai J, Thanomsangad P, Benjawanit K, et al. Microbial risk assessment of drinking water filtration dispenser toll machines (DFTMs) in Mahasarakham Province of Thailand. Water Supply. 2019; 19 (5): 1438–1445. DOI: 10.2166/ws.2019.016.
7. Park J, Kim JS, Kim S, et al. A waterborne outbreak of multiple diarrhoeagenic *Escherichia coli* infections associated with drinking water at a school camp. Int J Infect Dis. 2018; 66: 45–50. DOI: 10.1016/j.ijid.2017.09.021.
8. Naz A, Mishra BK, Gupta SK. Human health risk assessment of chromium in drinking water: A case study of Sukinda Chromite Mine, Odisha, India. Expo Health. 2016; 8 (2): 253–264. DOI: 10.1007/s12403-016-0199-5.
9. Chaulagain R, Chhatkuli A, Shrestha AR, et al. Mean fluoride concentration in drinking water sources of a municipality: A descriptive cross-sectional study. J Nepal Med Assoc. 2022; 60 (255): 947–951. DOI: 10.31729/jnma.7898.
10. Ferro P, Farfan-Solis R, Blanco-Shocosh D, et al. Determination of inorganic chemical parameters in drinking water in districts of the province of Puno in the region Puno-Peru. Heliyon. 2023; 9 (5): e15624. DOI: 10.1016/j.heliyon.2023.e15624.
11. Schullehner J, Hansen B, Thygesen M, et al. Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study. Int J Cancer. 2018; 143 (1): 73–79. DOI: 10.1002/ijc.31306.
12. Fathmawati F, Fachiroh J, Sutomo AH, et al. Origin and distribution of nitrate in water well of settlement areas in Yogyakarta, Indonesia. Environ Monit Assess. 2018; 190 (11): 628. DOI: 10.1007/s10661-018-6958-y.
13. International Organization for Standardization. ISO 9308-1:2014: Water quality—Enumeration of Escherichia coli and coliform bacteria. Geneva: International Organization for Standardization; 2014.
14. Rahman A. Modul Pengajaran: Analisis Risiko Kesehatan Lingkungan (ARKL). Program Studi Sarjana Kesehatan Lingkungan, Fakultas Kesehatan Masyarakat, Universitas Indonesia; 2020.
15. World Health Organization. Guidelines for drinking-water quality: fourth edition incorporating first addendum. 4th ed. Geneva: World Health Organization; 2017.
16. Sulistiawan A. Preventive maintenance pada mesin filter air dengan menggunakan metode age replacement sebagai pengoptimalan biaya down time di CV. Segar Murni Mojokerto. JTM J Tek Mesin Unesa. 2014; 3 (2): 1-10.
17. Huwaida RN. Faktor-faktor yang mempengaruhi Escherichia coli air bersih pada penderita diare di Kelurahan Pakujaya Kecamatan Serpong Utara Kota Tangerang Selatan tahun 2014 [Undergraduate Thesis]. Jakarta: Universitas Islam Negeri Syarif Hidayatullah; 2014.
18. Sinreich M, Pronk M, Kozel R. Microbiological monitoring and classification of karst springs. Environ Earth Sci. 2014; 71 (2): 563-572 DOI:10.1007/s12665-013-2508–7.
19. Rapeepan Y, Piyabhorn P, Phatcharaporn P, et al. Microbiological quality of drinking water and food in a rural community. Nat Environ Pollut Tech. 2023; 22 (4): 2273–2278. DOI: 10.46488/NEPT.2023.v22i04.056.