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Hydrochemical and Microbiological Assessment of Water Quality in Koudiat Medouar Dam (Northeastern Algeria)

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ABSTRACT

Analyses were conducted to determine the microbiological and physicochemical water quality of the Koudiat Medouar Dam, which is used for irrigation and drinking water production for the city of Banta. These analyses focused on quantifying fecal contamination indicator bacteria, detecting pathogens, and measuring concentrations of certain physicochemical elements in the water. The chemical analysis results indicated that the variation in element concentrations is closely related to factors such as rainfall, geological substrate, and human activities. However, these levels remain too low to cause significant organic pollution, with the exception of nitrite concentrations, which exceeded the World Health Organization (WHO) standard in July. The microbiological analysis revealed slight fecal contamination, identified by the presence of fecal bacteria, as well as other bacteria responsible for waterborne infections. These contaminations are mainly due to wastewater discharges, posing a potential threat to public health and the environment.

INTRODUCTION

All living organisms require water to function, as it serves as a building block, regulates body temperature, facilitates transportation, and has chemical functions of its own. Thus, water is a vital and indispensable element in our lives **(Morales Moreira & Haney, 2024)**. From time immemorial, people have always sought to harness rivers to build their civilizations and serve their cultures. It is a unique source that can be put to many uses. Its importance to the economy is growing all the time, and its demand and supply are becoming increasingly difficult to acquire. All countries will have to face up to the problem of water scarcity sooner or later **(Kettab, 2001)**.

Aquatic ecosystems face escalating pressures from worldwide anthropogenic and natural shifts, encompassing climate change, eutrophication, ocean acidification, and pollution. The microbes residing in water perform numerous biological functions, while also serving as a source for the microbiomes of host animals**(Krotman *et al.*, 2020; Sehnal *et al.*, 2021)**.

The primary risk to human health arises from fecal contamination; fecal indicator bacteria can have substantial numbers, even in the absence of clear fecal sources, and bacteria can operate as both major sources and repositories of these bacteria. This presence degrades the quality of the water **(Monticelli *et al.*, 2019)**. Human fecal matter is generally considered a greater risk to human health, as it is more likely to contain human enteric pathogens. The most important aspect of water quality is its freedom from contamination with fecal matter **(Baghel *et al.*, 2005; Napier *et al.*, 2017; Holcomb *et al.*, 2020)**. Water quality refers to the collection of physical, chemical, and biological criteria that must be met to ensure that the water provided is safe for consumers **(Omer, 2019; Palansooriya *et al.*, 2020)**. The significance of water quality for public health cannot be overstated. Many infectious diseases are transmitted through water via the fecal-oral route **(Shittu et *al.*, 2008)**. Certain physical, chemical, and microbiological standards are designed to ensure water safety for bathing and consumption before it can be deemed potable **(Olorode *et al.*, 2015)**

In Algeria, the demand for water is increasing significantly to meet the combined demand of three often competing sectors (urban, industrial and irrigation) **(Fashagba *et al.*, 2024; Guilal *et al.*, 2022)**. In addition to the scarcity of water, drought has increased, making it essential to mobilize surface water by building dams and hill reservoirs **(Molden, 2020)**. However, demographic growth, industrial development and the modernization of agriculture are leading to a huge problem of deterioration in the quality of these reserves, which are often open-cast. Water quality control plays an important role in public health, as it can cause catastrophic damage to the soil, the human organism and even the health of an entire population **(Shah *et al.*, 2023)**. Given this importance, we focused our work on the artificial aquatic ecosystem of the Koudiat Medouar dam (wilaya of Batna), which was built to boost agriculture in the high plateaux of eastern Algeria and to produce drinking water for the town of Batna, in order to assess the physico-chemical and microbiological quality of the water in this dam and its spatio-temporal evolution. Our approach was based on assessing the physico-chemical quality of the dam's water and determining the microbiological quality of its water (pathogen detection and microbial enumeration: coliform, faecal coliform and faecal *streptococcus* rates).

MATERIALS AND METHODS

1. Study area

The Koudiat Medouar dam is located in the east of the country, at the outlet of the Oued Chemorah sub-watershed, which covers an area of 590km^2. It belongs to the Constantinois High Plateaux (Fig. 1). It lies between the following watersheds: Kebir Rhumel and Seybouse to the north, Medjerdah to the east, Chott Hodna and Chott Melghir to the south, and the Soummam in the west **(Tiri, 2005)**. Administratively, it lies 35km east of the wilaya of Batna, and 7km northeast of the historic town of Koudiat Medouar on the Oued Chemorah. To the east, the sandstone hills of Koudiat Medouar provide the right support **(Benaicha *et al.*, 2022)**. It is bounded by the following municipalities: Chemorah to the north, Toufana to the east, Tazoult and Batna in the west and Arris, Ichmoul to the south (Fig. 1).

The Koudiat Medouar dam was built by the national company COSIDER, with construction starting in 1993 and impoundment in 2002. It's a gravity dam built from materials extracted from local rock, whose trapezoidal mass is essentially made up of sandstone and gravel **(Smatti-Hamza *et al.*, 2020)**. The main aim of the dam is to mobilize the water resources of the Oued Chemorah basin in order to help meet the city of Batna's drinking and industrial water requirements, estimated at 38.10^6 m^3/ year on the one hand, and to develop 15,700ha of farmland in the Batna and Chemorah plains on the other, as well as supplying drinking and industrial water to the towns of Kaïs, Khenchela, Arris and Tazoult, AinTouta and Barika **(Samia, 2009)**. This dam is currently part of a complex system of regulation and diversion works, known as the Béni Haroun transfer system. In addition to its own watershed contribution, this dam receives water from Beni Haroun for distribution to the A.E.P. of a number of towns in the Aurès region and for irrigation **(Mebarki, 2007)**

The watershed of the Koudiat Medouar dam has a low relief in its northern part and a more rugged relief at its southern end due to the Aures massif, which presents a highly varied natural ensemble, subdivided into three very distinct natural environments. This rather flat area, with little relief, occupies most of the basin. With a surface area of 5900ha, this land is used for seasonal agricultural activities. The dam area lies within this zone (Fig. 1).

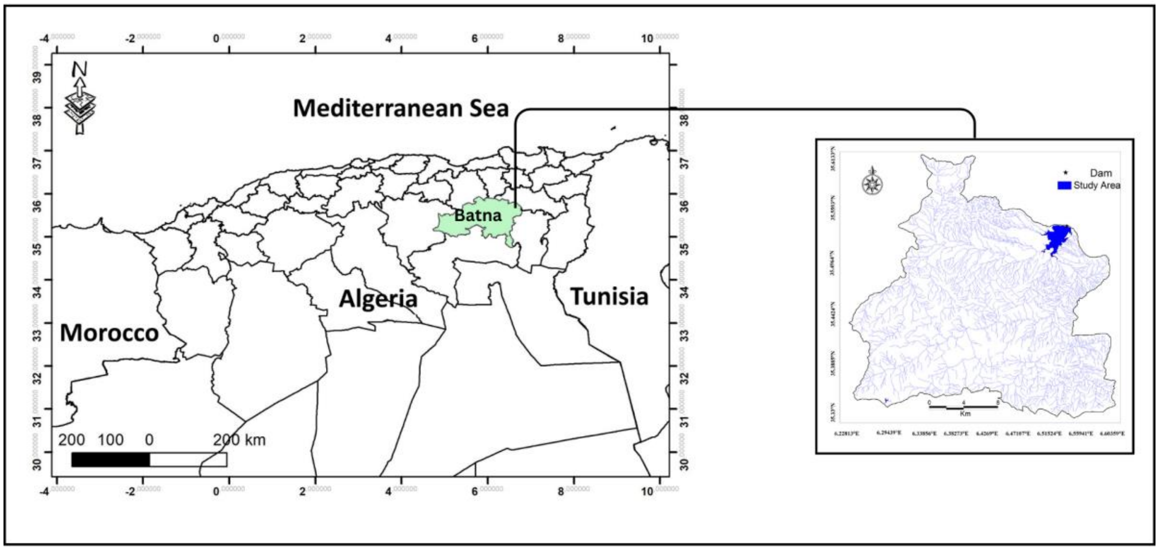

Fig. 1. Location of the Koudiat Medouar Dam

2. Sample collection

To assess the microbiological and physico-chemical quality of the water in the Koudiat Medouar Dam, three sampling stations were selected. Taking a water sample is a delicate operation that requires the utmost care. It determines the analytical results and their interpretation.

3. Physico-chemical analysis

For water sampling, we used one-liter polyethylene bottles. To ensure accurate results, we rinsed the bottles with the water to be tested before filling them to the brim. While samples can be stored for a few days, it's best to conduct the chemical analysis as soon as possible for optimal accuracy.

4. Microbiological analysis

Samples were taken using glass vials previously sterilized by moist heat (autoclave) at a temperature of 120°C for at least 20'. Water samples were taken by extending the bottle to a depth of 30- 50cm. To avoid airborne contamination, once filled, the bottle was capped by immersion.

5. Transport and storage of samples

After sampling, the samples were clearly labelled and were legible and indelible. Samples were accurately labelled with date, time, weather conditions, number and any abnormal circumstances **(Lightfoot & Maier, 2002)** and were sent to the laboratory in a cool box (4°C) for same-day analysis.

6. Bacteriological analyses

Total Germs: We used TGEA medium for inoculation aligned with an incubation at 37°C for 48 hours.

Total and fecal coliforms: We performed a presumptive test using Lactose Broth with Bromocresol Purple (BCPL) and a confirmatory test with indole mannitol medium.

Fecal streptococci: We used Rothe and Eva-Litsky media.

Spores of sulfite-reducing anaerobes: Inoculation was done in Meat Liver agar and incubated at 37°C.

Pathogen detection: Specific techniques were applied for *Salmonella, Shigella, Cholera Vibrio, Staphylococcus aureus, Pseudomonas aeruginosa, and* yeasts like *Candida albicans.*

RESULTS AND DISCUSSION

1. Physico-chemical analysis

Temperature

The variation in water temperature at the dam closely follows that of the season (Fig. 2). Indeed, the highest value (25.6°C) was recorded in July, and the lowest (7.8°C) was in February.

Generally speaking, surface water temperature is influenced by air temperature **(Sadani *et al.*, 2005)**. Moreover, low temperatures affect water self-purification. Denitrification reactions cease at 3°C and resume at 5°C **(Qin *et al.*, 2017)**.

pH

The pH scale indicates the acidity or basicity of water **(Fashagba *et al.*, 2024)**. The pH of the dam water varies between 7.5 and 8.3. The highest value was recorded in February. On the other hand, the lowest value was recorded in July. This variability is within the range of potability standards (6.5 < pH < 8.5). The dam water has a pH close to neutral with a slight alkaline character in wet periods.

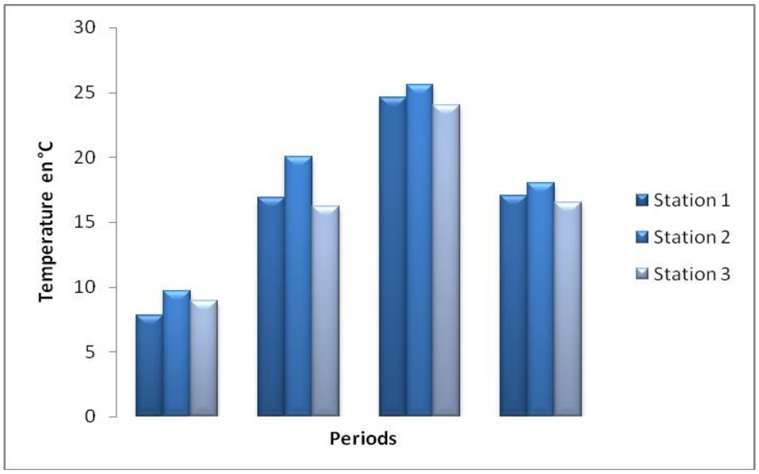

Fig. 2. Spatial and temporal variations in dam water temperature during the study period

Electrical conductivity

Electrical conductivity reflects the degree of overall mineralization **(Ali *et al.*, 2023; Li *et al.*, 2023)**. Total dissolved solids (TDS) or electrical conductivity (EC) can be used to determine the salinity of water. EC is a useful indicator of the salinity of the water or the overall salinity in selenium. It is based on the amount and concentration of disseminated selenium in the water system **(Rusydi, 2018)**.

It is a representation of water's electrical conductivity and is correlated with main ions and TDS concentration. Furthermore, it matters because it affects how the water tastes and whether or not users find it to be drinkable **(Karakaya & Evrendilek, 2010)**. The electrical conductivity of the dam water shows little variation, mainly between February and May. It rises from 909us/ cm (minimum value recorded during July at the second station) to 1140us/ cm (maximum value obtained during the wet period at the Avale section), reflecting the contribution of mineral salts by runoff. The water from the dam has a low conductivity and is therefore highly mineralized.

Turbidity

Most surface waters have a high and variable turbidity, depending on external conditions **(Morrissey *et al.*, 2015)**.

Our results show that measured water turbidity varies significantly from 3.8 NTU recorded during the dry period to 12 NTU recorded during the wet period. Turbidity is mainly caused by particle run-off.

Total hardness (TH)

The hardness of water has a natural character linked to the leaching of the soil through which it flows, and corresponds to the calcium and magnesium content **(Bazambanza *et al.*, 2024)**. The spatiotemporal variability of water hardness is low. These values oscillate between 34°F (minimum value recorded in July) and 40°F recorded in February. According to **Rejsek (2002)**, the water in the Koudiat Medouar Dam is very hard.

Chloride (Cl^-)

The chloride content of water varies enormously, depending mainly on the nature of the ground through which it flows **(Rodier *et al.*, 2016)**. Chlorides can have multiple origins. They may come from marine water intrusion, or as a result of human action such as road salting or contamination by wastewater. They can also result from the dissolution of salts by the leaching of saliferous soils **(Lakhdari *et al.*, 2022)**. Chloride levels in the waters of the Koudiat Medouar Dam vary slightly in space and time. The lowest level was recorded in October at the first station (45mg/ l), while the highest value was measured in May at the second station (60.3mg/ l).

Sulfates (SO^-_4)

They are present in natural waters at highly variable levels, and can be caused by the dissolution of gypsum and the use of chemical fertilizers **(Jin *et al.*, 2020; Moazzami & Hosseini, 2021)**. The spatiotemporal variability of sulfates in Koudiat Medouar Dam water ranges from 87 to 141mg/ l, but overall, they are below the drinking water standard set by the World Health Organization (WHO), which recommends a limit value of 250mg/ l **(WHO, 2017)**. The lowest sulfate concentration was recorded in February at the second station and the highest in May at the same station

Phosphates (PO_4^{-2})

The presence of phosphorus in water is due to natural sources (erosion, leaching), diffuse pollution (fertilizers, leaching) or point-source pollution (effluents, particularly detergent discharges, with which phosphates are still frequently associated) **(Jia *et al.*, 2023)**. Levels above 0.5mg/ L should indicate pollution **(Rodier *et al.*, 2016)**. According to the graph, dam water has variable phosphate concentrations. Maximum values are recorded during the wet season with 0.054mg/ l at the second station, while minimum values are always recorded during the dry season.

Bicarbonates (HCO_3^-)

In natural waters, alkalinity, expressed as HCO_3^-, varies from 10 to 350mg/ l. **(Rodier *et al*., 2009)**. The spatiotemporal variability of alkalinity in Koudiat Medouar dam water ranges from 144mg/ l (maximum value recorded during the dry period) to 122.4mg/ l (minimum value recorded in February). Their concentration in the water is a function of the nature of the terrain crossed, the water temperature and the pressure of dissolved CO2 **(Hemmati-Sarapardeh *et al.*, 2020)**. In our case, the rise in bicarbonate levels during the dry season is probably due to the geological nature of the terrain crossed and the effect of evapotranspiration, which increases the concentration of bicarbonates in the water.

Nitrate (NO_3^-)

Nitrate levels vary greatly depending on the season and the origin of the water; human activity accelerates the process of nitrate enrichment (fertilizer use and livestock farming) **(Zaryab *et al.*, 2022)**. In the natural environment, its concentration rarely exceeds 0.45mg/ l. Higher values indicate wastewater discharges into surface and groundwater environments, and above all excessive use of fertilizers in agriculture **(Mahjoub *et al.*, 2022)**. Nitrate levels in dam water vary regularly at the three sampling stations. The minimum concentration (0.12mg/ l) was recorded during the rainy period due to the dilution effect, while the maximum (1.19mg/ l) was recorded in July at the first station. However, these concentrations are still below the WHO guideline of 50mg/ l **(WHO, 2017)**. As a result, the waters studied are not at risk of nitrate pollution.

Nitrite (NO_2^-)

Nitrite is rarely found in significant concentrations in natural waters **(Kroupova *et al.*, 2005)**. Our data show that nitrite levels vary from one period to another. The lowest level (0.009mg/ l) was measured in February at the third station, and the highest (0.43mg/ l) was in July at the first station. Higher than the WHO standard of 0.1mg/ l, this increase may be linked to the degradation of organic matter **(Hamaidi *et al.*, 2009)**. It comes either from animal excrement, wastewater discharges or from the rise in temperature, which accelerates the degradation of organic matter by bacterial flora.

Calcium (Ca^{+2})

Calcium concentration is highly variable depending on the nature of the rocks in the watershed; It comes either from the dissolution of carbonate formations ($CaCO_3$) or from the dissolution of gypsum **(Domínguez-Villar *et al.*, 2017; Rakhimova, 2022)**.

The calcium content of dam water varies from station to station during the rainy period, with a maximum value of 96mg/ l at the first station and a minimum value of 78mg/ l at the second station, which may be due to the dissolution of carbonates from the limestone and marl rocks occupying the dam's sub-catchment area. During the dry period, however, the values are fairly close to each other. Calcium values are below the 100mg/ l guide value set by the World Health Organization **(WHO, 2017)**.

Magnesium (Mg^{+2})

Magnesium content depends on the composition of the sedimentary rocks encountered (dolomitic limestones, Jurassic or Middle Triassic dolomites) **(Zhang *et al.*, 2023; Wang *et al.*, 2024)**. In freshwater, Mg^{+2} concentrations are lower than those of Ca^{+2} **(Saunders *et al.*, 2014; Wang *et al.*, 2024)**. Moreover, in dam waters, magnesium content shows little variation, with the highest value recorded in July (45mg/ l) and the lowest at the first sampling point (34mg/ l). The values recorded at all sites are below the maximum concentration set by the WHO (50mg/ l). **(WHO, 2017)**,

Ammonium (NH_4^+)

This chemical form of nitrogen is added to natural waters by animal and human waste **(Kirchmann, 2020)**. According to our results, the ammonium content of the dam water varies from one period to another. The maximum value is recorded during the winter period, which is also due to run-off water carrying large quantities of organic matter. The minimum value is recorded during the dry period at the third station. We also noted that ammoniacal nitrogen is totally absent during the dry period at stations S1 and S2. This absence of NH_4+ could be due to its relatively rapid oxidation to nitrite or nitrate **(Rejsek, 2002)**.

Sulfates (SO_4^-)

They are present in natural waters at highly variable levels and can be caused by the dissolution of gypsum and the use of chemical fertilizers. The spatiotemporal variability of sulfates in Koudiat Medouar Dam water ranges from 87 to 141mg/ l, but overall, they are below the drinking water standard set by the World Health Organization (WHO), which recommends a limit value of 250mg/ l. The lowest sulfate concentration was recorded in February at the second station and the highest in May at the same station.

1.1. Principal component analysis (PCA)

Table (1) shows the correlation matrix. The electrical conductivity (µS·cm–1) shows a positive correlation with NO_3^-(r = 0.85) and No_2^-(r = 0.75), indicating that a significant proportion of the ionic charge is caused by these ions.

There is a correlation between nitrates with nitrites (r = 0.87) and temperature (r = 0.85); magnesium correlates with nitrites (r = 0.81), and also there is a correlation between sulphates on the one hand with chlorides (r = 0.92) and TAC (r = 0.77) on the other.

The first factorial axis (47.54%) represents a salinity gradient, distinguishing between mineralized waters high in ammonium and phosphorus and those containing nitrite, nitrate, and magnesium. This axis suggests a dual process: an increase in minerality and changes in redox conditions, possibly due to fermentation or redox reactions in the dam water. During certain periods, such as summer, the water becomes concentrated and stagnant, resulting in low redox levels and denitrification, which produces ammonium. Conversely, when the dam is replenished, the water becomes less concentrated, richer in nitrates, and more oxygenated.

The second factorial axis (24.99%) contrasts a chloride-sulphate-phosphate facies in dilute waters with turbid, saline waters that contain ammonium. This axis highlights the difference between waters rich in chloride, sulphate, and phosphate versus those that are turbid and saline. The third factorial axis (12.69%) differentiates between calcium-rich diluted waters and phosphate-rich magnesium waters. It also indicates the release of phosphorus from reducing waters, as observed in the first factorial axis. Mineralized and summer waters are characterized by reduced conditions, leading to the destruction of iron oxides and toxins, and the release of phosphorus. This process contributes to eutrophication in reservoir waters (Fig. 3).

Table 1. Pearson correlation coefcient of the analysed groundwater quality parameters

Variable	EC	Salinity	TDS	Turbidity	TAC	Ca^{+2}	Mg^{+2}	Cl^{-}	NO_3^{-}	No_2^{-}	NH^{4+}	PO_4^{-2}	SO^{-4}
CE(us/cm)	**1.00**	0.56	**0.70**	-0.03	0.24	-0.54	-0.49	-0.02	**-0.80**	**-0.79**	**0.84**	0.59	-0.03
Salinity %	0.56	**1.00**	**0.79**	0.32	0.03	0.14	-0.43	-0.21	**-0.84**	-0.55	**0.84**	-0.10	-0.16
TDS	**0.70**	**0.79**	**1.00**	-0.02	0.37	-0.02	-0.57	0.11	**-0.85**	**-0.81**	**0.82**	0.33	0.26
Turbidity	-0.03	0.32	-0.02	**1.00**	-0.66	0.05	0.59	-0.35	-0.05	0.30	0.08	-0.09	-0.36
TAC	0.24	0.03	0.37	-0.66	**1.00**	0.16	**-0.72**	**0.71**	-0.12	-0.48	0.20	0.31	**0.77**
Ca^{+2}	-0.54	0.14	-0.02	0.05	0.16	**1.00**	0.05	-0.01	0.23	0.33	-0.23	-0.52	0.13
Mg^{+2}	-0.49	-0.43	-0.57	0.59	**-0.72**	0.05	**1.00**	-0.25	0.61	**0.81**	-0.64	-0.02	-0.26
Cl^{-}	-0.02	-0.21	0.11	-0.35	**0.71**	-0.01	-0.25	**1.00**	0.14	-0.18	-0.07	0.49	**0.94**
NO_3-	**-0.80**	**-0.84**	**-0.85**	-0.05	-0.12	0.23	0.61	0.14	**1.00**	**0.87**	**-0.98**	-0.22	0.13
No_2^{-}	**-0.79**	-0.55	**-0.81**	0.30	-0.48	0.33	**0.81**	-0.18	**0.87**	**1.00**	**-0.87**	-0.42	-0.20
NH_4^{+}	**0.84**	**0.84**	**0.82**	0.08	0.20	-0.23	-0.64	-0.07	**-0.98**	**-0.87**	**1.00**	0.26	-0.08
$PO4^{-2}$	0.59	-0.10	0.33	-0.09	0.31	-0.52	-0.02	0.49	-0.22	-0.42	0.26	**1.00**	0.46
SO^{-}_4	-0.03	-0.16	0.26	-0.36	**0.77**	0.13	-0.26	**0.94**	0.13	-0.20	-0.08	0.46	**1.00**

-Values in bold are different from 0 with a significance level alpha=0.05.

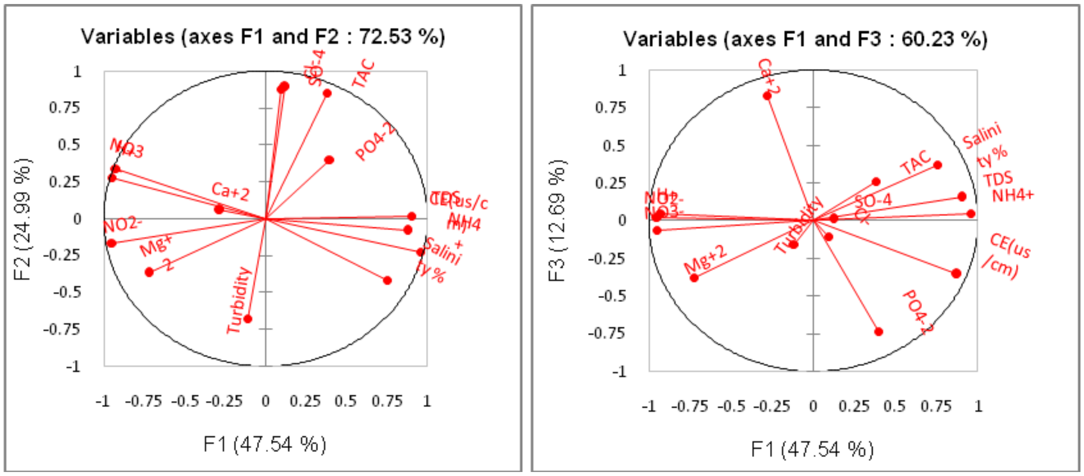

Fig. 3. Factorial plan of the principal component analysis (PCA): a) F1– F2, b) F1–F3; source: own study

2. Microbiological analysis

The most important parameters for assessing water quality are microbiological indicators of fecal pollution **(Hamzaraj *et al.*, 2023).**

Total germs

Our analyses show that the total number of germs counted at 37°C at the three sampling stations is high, especially during the summer period (Fig. 4). The lowest germ count was obtained in February, probably due to dilution and water temperature.

The highest rates were recorded in July at all stations. Water temperature remains the main factor favoring the growth of these microorganisms. The presence of coliform bacteria in a medium necessarily means fecal contamination. While fecal coliform identification of confirmed total coliforms is required as a component of the completed phase of multiple-tube fermentation method, testing for fecal coliforms directly is not part of procedures for the assessment of drinking water quality **(Cabral, 2010; Korajkic & Harwood, 2016; Banseka & Tume, 2024)**

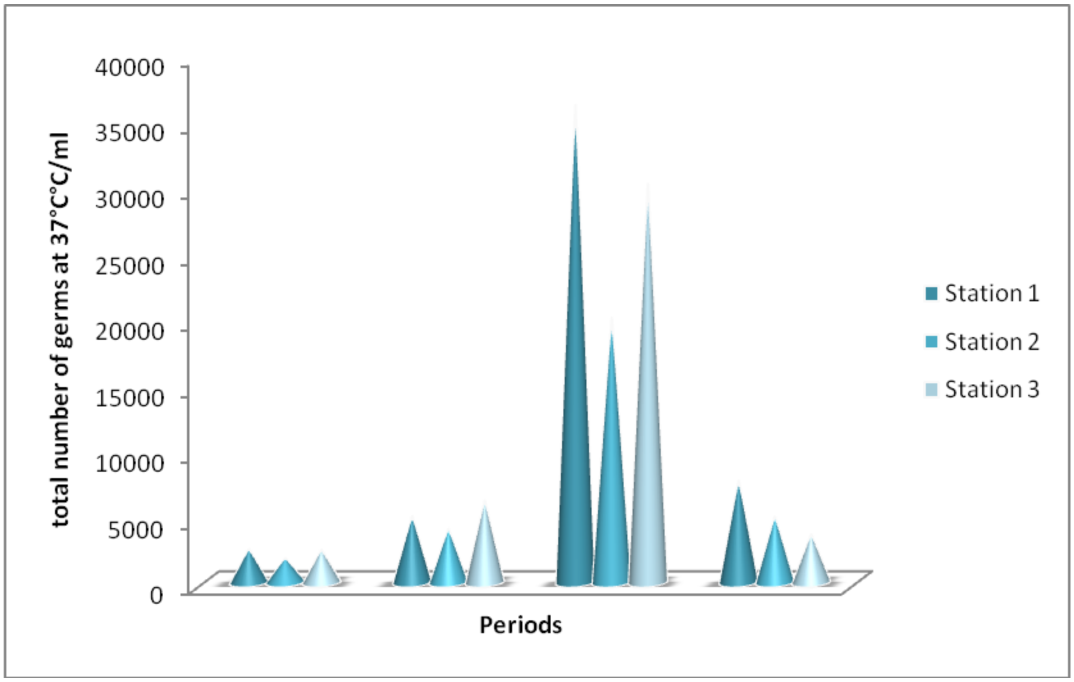

Fig. 4. Evaluation of the total mesophilic flora of the water at 37°C during the study period

Total and fecal coliforms

The presence of coliform bacteria in an environment necessarily indicates fecal contamination **(Khan & Gupta, 2020)**.

The results illustrated in the graph (Fig. 5) show that the concentration of total coliforms (TC) in the dam water differs by station, but overall they are high in relation to the potability guide value (10 TC/100ml) set by the World Health Organization **(WHO, 2017)**.

Samples taken at the first station had a higher number of total coliforms than those taken at the other two stations, especially during the wet season. The period from July to September is characterized by an absence of *streptococci*. The abundance of total coliforms, faecal coliforms and faecal *streptococci* increases considerably during rainy periods, demonstrating the role played by rainfall in the contamination process. Untreated wastewater disposal is also to blame. Soil leaching by run-off water may nevertheless be a main reason for the mobilization of soil biomass **(Gao *et al.*, 2023).**

Throughout the study period and at all stations, the concentration of faecal *streptococci* was lower than that of faecal coliforms, which can be explained by the faster rate of decline of faecal *streptococci* outside the intestines.

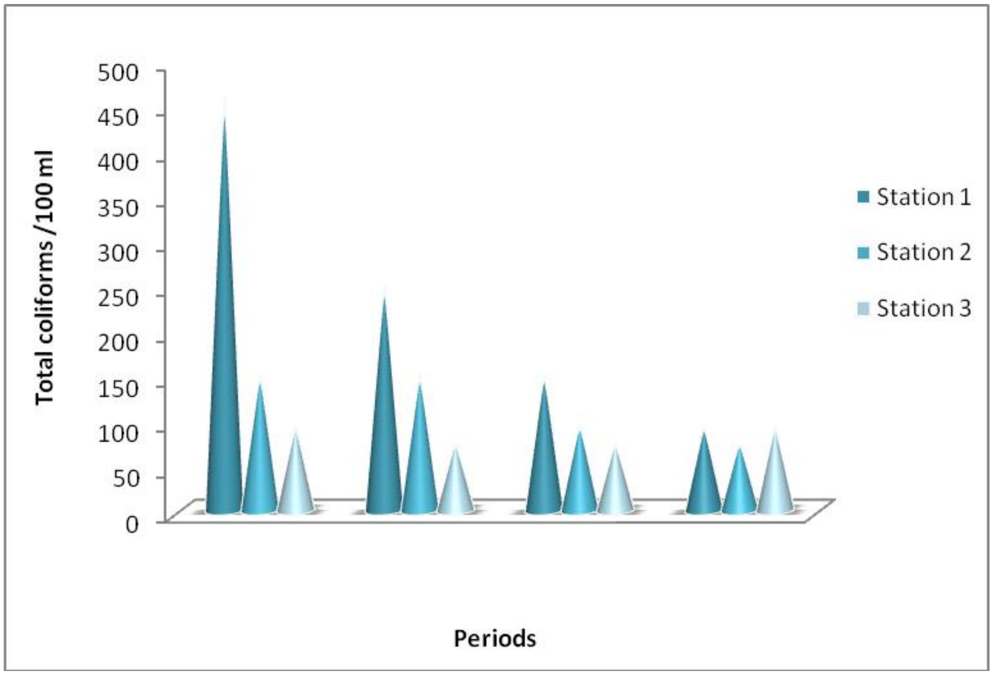

Fig. 5. Variation in the number of total coliforms in dam water during the study period

Fecal *streptococci*

The number of fecal *streptococci* in water is related to the concentration of fecal matter in the water. These bacteria are highly sensitive to physico-chemical variations in the environment, and often indicate recent contamination.

Examination of Fig. (6) shows that the number of fecal *streptococci* in dam water is extremely variable in the three sampling stations, and sometimes exceeds the guide value for drinking water. (0 SF /100ml) set by the WHO **(WHO, 2017)**.

The highest concentration of fecal *streptococci* in dam water was 15 SF/100ml for the sample taken during the wet season. This is probably due to the leaching of nearby soils laden with faecal matter or to wastewater discharges.

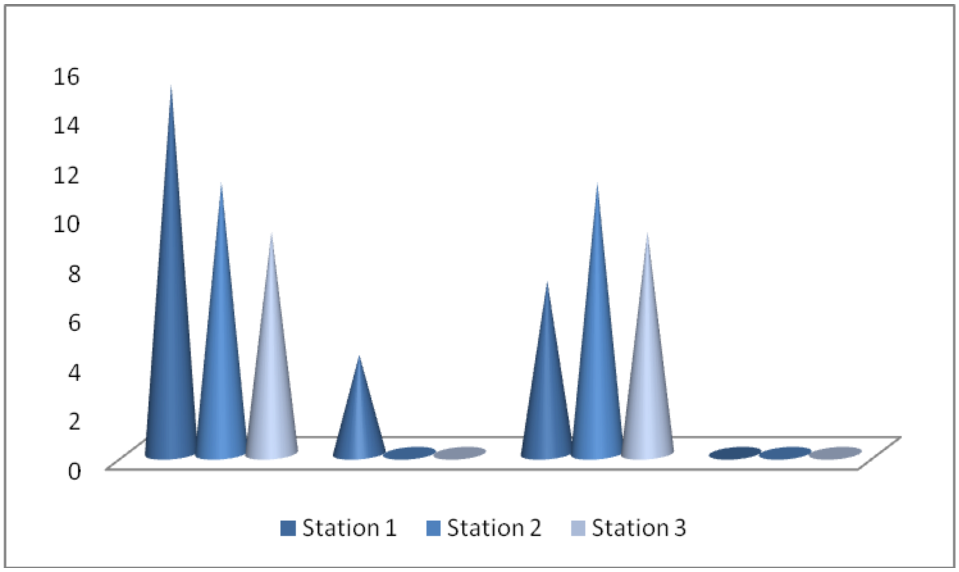

Fig. 6. Variation in the number of faecal *streptococci* in water during the study period

Sulfite-reducing anaerobes (SRA)

Anaerobic sulfite-reducing bacteria are commonly used as indicators of clostridial contamination in meat products **(Prevost *et al.*, 2013)**. The spores of sulfite-reducing anaerobes (SRA) are generally indicative of past contamination. Negative results indicate the absence of sulfite-reducing genera, *Clostridium* sp.

Results of pathogen testing

Pathogens were detected on several culture media (Fig. 7) using the streak seeding method, and biochemical tests were used to identify them. The results are summarized in Table (2).

From a microscopic point of view, cytological examination revealed a significant presence of Gram-negative rods, while Gram-positive *cocci* were poorly represented.

For confirmation of *Staphylococci* the following two tests were applied to white colonies on Chapman.

- Staphylocoagulase test: Result is negative, staphylocoagulase negative.
- Catalase test: Result is positive, catalase positive.

The staphylococcal tests identified non-pathogenic *Staphylococcus* species.

Table 2. Macroscopic and microscopic appearance of colonies

Culture medium	**Macroscopic colony observation**	**Microscopic colony observation**
Nutrient agar (GN)	Circular, smooth, flat, shiny transparent, 2 mm in diameter. Irregular, smooth, flat, yellow 1 mm in diameter.	Isolated bacilli or in chains, Gram-negative.
MacConkey	Elevated rose, shiny smooth, circular, 1mm to 2 mm in diameter.	Isolated bacilli, Gram-negative
Hektoen	Green or bluish, circular, wavy, bossy, rigorous, slightly whitish transparent. Salmon yellow, bulging, smooth, 1 mm in diameter	Isolated bacilli, Gram-negative
Liver Meat (VF)	Negative culture	/
GNAB	Negative culture	/
Sabouraud	Negative culture	/
Chapman	Small, smooth, bulging, with regular contour, white in color	Grouped cocci, Gram-positive
SS	Negative culture	/

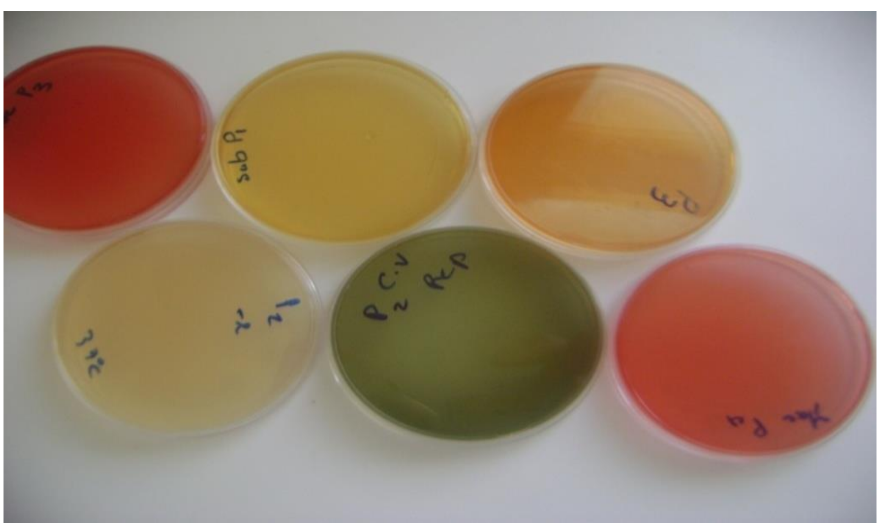

Fig. 7. Agar media used for pathogen detection

Germ identification by API20E

This type of identification was applied to germs isolated on Mac Conkey and Hektoén. Biochemical identification enabled us to identify the following bacterial species: (Fig. 8).

- *E. coli*
- *Seratia odorefira 1*
- *Entérobacter intermedius*

At the third station, we also isolated and identified a pathogenic species during the summer period: *Pseudomonas aeruginosa*. The presence of this bacterium in fairly high concentrations is synonymous with a potential health risk.

A. Seratia odorefira 1

B. Entérobacter intermedius

A. Pseudomonas aeruginosa

Fig. 8. Results of some biochemical identifications by APi20E

CONCLUSION

The findings indicate that the microbiological and physico-chemical quality of the dam water frequently fails to meet current standards. Microbiological analyses show that the water is contaminated with fecal germs, including total coliforms, fecal coliforms, and fecal *streptococci*. This contamination is particularly severe during the wet season, surpassing the potability standards set by the World Health Organization (WHO). The primary sources of this bacterial contamination appear to be wastewater discharges and soil leaching. Although pathogenic microorganisms such as *Salmonella*, *Staphylococcus aureus*, *Vibrio cholerae*, and *Candida albicans*, as well as anaerobic spore-forming bacteria, were not detected, the presence of *Pseudomonas aeruginosa* poses a significant risk to local residents and water users. From a physico-chemical perspective, the water exhibits spatiotemporal variations in the parameters measured. The dam water has a near-neutral pH with a slight alkaline character and is hard with high mineral content. Levels of bicarbonate, chloride, sulfate, phosphate, calcium, and magnesium vary with the sampling season and the nature of the terrain, but remain within WHO drinking water standards. Nitrate, ammonium, and phosphate levels are low, adhering to drinking water standards. However, nitrite concentrations exceed the WHO standard of 0.1 mg/l, indicating the influence of domestic wastewater discharges. If local authorities do not implement effective environmental policies, the dam’s water quality is expected to deteriorate further.

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