



# Evaluation of the Microbiological Quality of Bathing Waters in the Mamou Region, Republic of Guinea

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author SD contributed to all stages of the process. Authors BSSB, MD and OOB was of paramount importance in the correction, follow-up and publication of this article. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The bacteriological quality of bathing water is a major public health issue. The aim of this study is to assess the correlation between the bacteriological quality of bathing water and the risk of disease outbreaks. The study was prospective in nature, and ran from June to December 2022. Fifty-nine (59) samples were taken from water sources used for bathing. The membrane filtration method and the direct inoculation method were used. In Mamou, the results showed that *E. coli* exceeded WHO threshold values in rivers and streams, with 2/4 (20%) and 8/11 (80%) respectively. Whereas in Pita, Enterococci had exceeded these standards in 25% of backwater and 75% of

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streams, and *E. coli* in 14.28 and 85.71% of rivers and streams respectively. *E. coli* (streams: 66.66% and backwater: 33.33%) and *E. coli* (streams: 83.33% and backwater: 16.66%) values exceeded WHO thresholds in Dalaba. Many sites had bacterial loads above WHO thresholds. This would be an important element to say that these water sources constitute a real public health issue.

**Keywords:** *Bacterial indicators; contamination; bathing water; Mamou.*

## 1. INTRODUCTION

Throughout history, water quality has been an important factor in ensuring human well-being. Today, pollution of the hydrosphere is one of the most serious environmental problems, caused in large part by human activities. Microbiological contamination is a form of water pollution caused by the presence of pathogenic microorganisms such as viruses, parasites or bacteria. These can pose a risk to human or animal health (Ramade, 2008).

Water, a precious resource essential to life, has played and continues to play a fundamental role in the development of societies. Surface water is used for a variety of purposes. According to (Afri-Mehennaoui, et al., 2009), they are the source most threatened by human activities. They are the most exposed to pollution, as they serve as dumping grounds for various types of waste (domestic, agricultural and pastoral) and as collectors of wastewater from built-up areas (Bagalwa, 2013).

Surface waters are the site of abusive discharges of industrial and domestic effluents without prior treatment. These waters are also a place of comfort for people who do not have access to an appropriate defecation system (Saab, et al., 2007, Adjagodo, et al., 2017).

Over the last few decades, environmental protection has mostly been based on a regulatory approach. Today, thanks to a better understanding of receiving environments, we realize that the capacity of these environments to receive discharges from various sources (industrial, municipal, agricultural) must also be taken into account to ensure adequate environmental protection. Pollution, which only a few decades ago was confined to highly industrialized regions, is now becoming a worldwide problem, and one that concerns us all to a greater extent (Adjagodo, et al., 2017, Micha & Moiset, 1982).

In many cases, bathing can present health risks, linked in particular to the bacteriological quality of the water. The main risk is infectious, linked to

the presence of germs that can cause various pathologies (gastro-enteritis, leptospirosis, dermatitis) (Vicente, et al., 2011).

Anthropogenic activities, the environment and the absence of an effective waste management system have been identified as sources of bacteriological pollution at bathing sites in the Coyah Prefecture (Agence, 2019).

The aim of this study is to assess the correlation between the bacteriological quality of bathing water and the risk of disease outbreaks.

## 2. MATERIALS AND METHODS

### 2.1 METHODOLOGY

#### 2.1.1 Study area

The Mamou region lies between 9 and 12° north latitude and 11 and 12°53 west longitude. It is bordered by the regions of Labé (to the north), Kindia (to the west), Faranah (to the east) and the Republic of Sierra Leone (to the south).

The Mamou region covers an area of 17,074 km<sup>2</sup>. In 2016, the population rose to 781,091 (INS, 2018), with women accounting for 54.56%. It is home to the source of the country's main rivers and those of its sub-region, such as the Konkouré, Bafing, Kokoulo and Kaba.

The Institut de Recherche en Biologie Appliquée de Guinée (IRBAG) is located to the west, 6 km from Kindia-Ville and 141 km from Conakry. Its mission is to promote research in medical biology in fundamental and applied fields (study of bacterial, viral, parasitic and other germs).

The study was prospective and took place from June to December 2022. Bathing water was used as biological material, and 59 samples were taken.

#### 2.1.2 Transport

Samples were placed in a specially prepared cooler (minus 10°C) to comply with the chain of custody required by the germs to be studied, then transported to the laboratory where they

were immediately analyzed or stored in a refrigerator at 4°C prior to further analysis.

### 2.1.3 Equipment

Petri dishes approx. 49 mm x 9 mm, sterile distilled water, sterile filter membranes with 0.45 µm pore size and 47 mm diameter, sterile pipettes, autoclave (Pasteur oven), incubator, filtration manifold with funnels and filter holders, vacuum pump, pH-meter paper, refrigerator at 2 - 6°C, 250 ml wide-mouth bottles or flasks with stoppers, disposable sterile gloves, sampling labels, Tryptone-Sulfite-Cycloserine, Mac Conkey Agar, Bile-Esculin-Azide Agar, ColID/PCA, sterile slides, 70% and 95% alcohol, Pasteur pipettes, platinum wires, carboglasses, cooler (sterile), etc. . .

## 2.2 Methods

Membrane filtration and direct plating methods were used. Filter 100 ml of each sample to recover bacteria from a filter. Write the sample numbers and filtered volumes on the Petri dishes.

After filtration, the funnel (cup) is removed and the recovered filter placed on top in a Petri dish (selective culture medium) (first option). Pick up the filter using sterile forceps, place it in a sterile Petri dish and wash with sterile distilled water using a pipette (second option). Finally, take 0.5 microliter through a sterile öse or platinum wire and inoculate in selective culture medium.

Then place the Petri dishes in inverted position in an incubator at 35°C ± 0.5°C or 44°C for 24 hours ± 2 hours as soon as possible after the filtration maneuver. Inverting the Petri dishes prevents condensation on the membranes.

At the end of incubation, a reading is taken and the results are expressed as the number of germs per 100 ml of filtered water (Intestinal Enterococci and *Escherichia coli*). These germs are counted in comparison with current European Union and World Health Organization values, in order to interpret the results and determine the level of bacteriological pollution in the bathing water, and thus assess the health risk involved (ref. Table below).

**Table 1. Proposed guide values (European Union) and threshold values for bathing water (World Health Organization)**

| Indicator germs         | Guide values    | Threshold values not to be exceeded |
|-------------------------|-----------------|-------------------------------------|
| Intestinal enterococci  | 100 germs/100ml | 200 germs/ml                        |
| <i>Escherichia coli</i> | 250 germs/100ml | 500 germs/ml                        |

## 3. RESULTS AND DISCUSSION

### 3.1 Results

**Table 2. Distribution of bacteriological pollution indicator germs by water source in MAMOU Prefecture**

| Water sources | Number of tests | Control bacterial germs |            |            |                |
|---------------|-----------------|-------------------------|------------|------------|----------------|
|               |                 | RSA                     | CT         | IE         | <i>E. coli</i> |
| Flow          | 4               | 4(26.66%)               | 4(26.66%)  | 4(26.66%)  | 3(20.00%)      |
| Streams       | 14              | 13(30.23%)              | 13(30.23%) | 11(25.58%) | 6(13.95%)      |
| Backwater     | 1               | 1(25.00%)               | 1(25.00%)  | 1(25.00%)  | 1(25.00%)      |
| <b>Total</b>  | <b>19</b>       | <b>18</b>               | <b>18</b>  | <b>16</b>  | <b>10</b>      |

From this table, it can be seen that at the rivers, all 4 samples were positive for Sulfite-reducers, Total Coliforms and IE with 26.66% each, and *E. coli* was found in 3/4 of the samples (20%). Streams were the most contaminated, with RSA and TC the most represented, with 13 positive samples (30.23% each), while IE and *E. coli* were present in 11 and 6 samples respectively (25.58% and 13.95%).

#### Legend:

- **ASR**: Anaerobic Sulphite Reducing Agents.
- **TC**: Total Coliforms.
- **IE**: Intestinal Enterococci.
- ***E. coli***: *Escherichia coli*.

**Table 3. Distribution of bacteriological pollution indicator germs according to water sources in the Prefecture of PITA**

| Water sources | Number of tests | Control bacterial germs |            |            |                |
|---------------|-----------------|-------------------------|------------|------------|----------------|
|               |                 | RSA                     | TC         | IE         | <i>E. coli</i> |
| Rivers        | 1               | 1(100%)                 | 0          | 0          | 0              |
| Flow          | 1               | 2(28.57)                | 2(28.57)   | 2(28.57)   | 1(14.28)       |
| Streams       | 24              | 22(32.35%)              | 24(35.29%) | 13(19.11%) | 9(13.25%)      |
| Backwater     | 3               | 1(12.50%)               | 3(37.50%)  | 3(37.50%)  | 1(12.50%)      |
| <b>Total</b>  | <b>29</b>       | <b>25</b>               | <b>28</b>  | <b>17</b>  | <b>11</b>      |

Analysis of samples from rivers, streams and backwater showed the presence of RSA, TC, IE and *E. coli*, while rivers showed the presence of RSA with 1 positive sample, i.e. 100%. The study of the single sample from the rivers showed the presence of RSA, TC, IE and *E. coli*, i.e. 25% each. On the other hand, the 24 samples taken from the streams all gave positive results for TC (35.29%), 22 were positive for RSA (32.35%) and 13 and 9 samples respectively were positive for IE and *E. coli*, i.e. (19.11%) and (13.25%).

**Table 4. Distribution of bacteriological pollution indicator germs according to water sources in the Prefecture of DALABA**

| Water Sources | Number de of tests | Control bacterial germs |           |           |                |
|---------------|--------------------|-------------------------|-----------|-----------|----------------|
|               |                    | RSA                     | CT        | IE        | <i>E. coli</i> |
| Streams       | 8                  | 8(28.57%)               | 8(28.57%) | 8(28.57%) | 4(14.28%)      |
| Backwater     | 2                  | 1(28.57%)               | 2(28.57%) | 2(28.57%) | 1(14.28%)      |
| Dam           | 1                  | 1(33.33%)               | 0         | 1(33.33%) | 1(33.33%)      |
| <b>Total</b>  | <b>11</b>          | <b>11</b>               | <b>10</b> | <b>11</b> | <b>6</b>       |

This table shows that the TC were negative for the dams, while the RSA, IE and *E. coli* were positive with 1/1 sample giving 33.33% each. Samples taken from Backwater were positive for RSA, TC and IE, with 2 positive samples (28.57% each) and 1 positive sample (14.28%) for *E. coli*. As for the streams, it is clear that the control germs are all present, with 8 positive results (28.57%) for RSA, TC and IE and 4 positive results (14.28%) for *E. coli*.

**Table 5. Bacterial load of bathing water (intestinal Enterococci and *Escherichia coli*) in the MAMOU Prefecture**

| Water sources | Positive samples exceeding WHO threshold values |            |                |              |
|---------------|-------------------------------------------------|------------|----------------|--------------|
|               | IE                                              | %          | <i>E. coli</i> | %            |
| Flow          | 2/4                                             | 20.00      | 2/3            | 33.33        |
| Streams       | 8/11                                            | 80.00      | 4/6            | 66.66        |
| Backwater     | 0/1                                             | 0.00       | 0/1            | 0.00         |
| <b>Total</b>  | <b>10/16</b>                                    | <b>100</b> | <b>6/10</b>    | <b>99.99</b> |

Analysis of the data in this table suggests that the backwater have not been contaminated by faecal matter. In some places, samples taken from rivers and streams showed positive results for enterococci (2/4), i.e. 20.00% and (8/11), i.e. 80.00% respectively, and for *E. coli* (2/3), i.e. 33.33% and (4/6), i.e. 66.66%, with values exceeding those of the World Health Organisation.

**Table 6. Bacterial load in bathing water (intestinal Enterococci and *Escherichia coli*) in the Prefecture of PITA**

| Water sources | Positive samples exceeding WHO threshold values |            |                |              |
|---------------|-------------------------------------------------|------------|----------------|--------------|
|               | IE                                              | %          | <i>E. coli</i> | %            |
| Flow          | 0/1                                             | 0.00       | 1/1            | 14.28        |
| Streams       | 6/13                                            | 75.00      | 6/9            | 85.71        |
| Backwater     | 2/3                                             | 25.00      | 0/1            | 0.00         |
| <b>Total</b>  | <b>8/17</b>                                     | <b>100</b> | <b>7/11</b>    | <b>99.99</b> |

**Table 7. Bacterial loads of bathing water (intestinal enterococci and *Escherichia coli*) of the Prefecture of DALABA**

| Water sources | Positive samples that exceeded WHO threshold values |              |                |              |
|---------------|-----------------------------------------------------|--------------|----------------|--------------|
|               | E I                                                 | %            | <i>E. coli</i> | %            |
| Streams       | 5/8                                                 | 83.33        | 2/4            | 66.66        |
| Backwater     | 1/2                                                 | 16.66        | 1/1            | 33.33        |
| Dams          | 0/1                                                 | 0.00         | 0/1            | 0.00         |
| <b>Total</b>  | <b>6/11</b>                                         | <b>99.99</b> | <b>3/6</b>     | <b>99.99</b> |

Table 6 reports that only samples taken from rivers were positive for enterococci, but these samples did not give values higher than the WHO threshold values compared to *E. coli*, for which the thresholds were exceeded (14.28%). However, of the 13 samples from the streams where IE were encountered, 6 gave values above the WHO standards (75.00%) while 6/9 (85.71%) were above the values for *E. coli*. Backwaters, 2/3 (25.00%) with positive samples for enterococci showed values above the health assessment standards proposed by the WHO (2011) and these standards were not exceeded in the sample where *E. coli* was encountered (0/1).

Table 7 shows that the enterococci values that were obtained from streams and backwaters are higher than the WHO standards with 5/8 (83.33%) and 1/2 (16.66%). In the same sources, *E. coli* also gave values above the threshold values proposed by the same organization.

### 3.2 Discussion

During the study, bacterial germs including: ASR, CT, EI, and *E. coli* were encountered.

In Mamou, all the sources from which samples were taken and where enterococci and *E. coli* were encountered, the values found were largely higher than the standard values (threshold values accepted by the WHO).

Our data were close to those obtained (Diallo, et al., 2022) Ivoire in 2015, which indicated that collectors had bacterial loads well above the threshold of 103 CFU/100 ml set by the guide developed by the world body in charge of the health system in 2006. The same author had indicated that faecal coliforms were the most present. The average fecal coliform (CF) loads of the different sites studied varied from 2.5x10<sup>5</sup> microorganisms/ml collected at Cocody to 2.5x10<sup>6</sup> coliforms/ml on the Ebrié lagoon side. Fecal streptococci were found but with lower concentrations than those of fecal coliforms. Results that differ from those obtained during the current survey.

The high concentrations of faecal streptococci observed from samples taken in Cameroon (Bayoko, 2015) were probably the respective consequences of the discharge of water from the sewers of the University of Ngaoundere, the regional capital of Adamawa located on the shores of Lake Dang (E3), the excrement of raised pigs (Mardock river) and the waste from the municipal slaughterhouse of the city (E9), sewage discharges from the central prison (E12) and the regional hospital (E13) and finally the collected water from the city centre (E15). The presence of fecal streptococci with high concentrations in places brought the results of (Bayoko, 2015) closer to those of the present survey.

The high density of *E. coli*, a more specific indicator bacterium of faecal pollution (Abai, et al., 2014) in the water sample examined, clearly indicated contamination by faecal material and the epidemiological risk posed by their discharge without treatment (CEAEQ, 2000). Certainly, the presence of these enterobacteriaceae, although non-pathogenic in their vast majority, should seriously suspect that of several other pathogenic microorganisms (Servais, et al., 2006, K.P., et al., 2009) such as *salmonella* (typhoid fever) and *Vibrio cholerae* (cholera) (Diallo, et al., 2022). Results similar to those of the present study.

The bacteriological analysis of the water sources studied gave loads higher than the WHO standard (intestinal enterococci: 200 germs/100ml and *E. coli*: 500 germs/100ml) in their majority. The data obtained in Benin from research conducted by (K.P., et al., 2009) are similar to our results.

Analyses of the sample taken from the part frequented by washermen on the Banco River confirmed the presence of the germs targeted by the study. The loadings of *E. coli* (1322 CFU/100ml) and enterococci (2067 CFU/100ml) determined in this portion were above the tolerable thresholds set. The high average loads

of indicators for *Escherichia coli*, faecal streptococci and sulphito-reducing anaerobes, in particular, indicated that the Banco River (in Côte d'Ivoire) is subject to faecal pollution (Dogbè, et al., 2014).

The existence of garbage dumps along watercourses (biomedical, household and other waste), the practice of agriculture (gardening), the practice of livestock farming (extensive and intensive), the connection of toilet evacuation canals and watercourses (installation of toilets along watercourses), open defecation along watercourses, the practice of laundry, the discharge of wastewater without any prior treatment process and runoff (the environment) could be sources of contamination of bathing waters in the Mamou region.

The origin of the pollution can be natural or anthropogenic according to (Awomon, 2020) reported by (Laurent, 2012). Agriculture, which applies in a diffuse way, industries that are the source of very diverse and often localized discharges, and domestic activities or landfills were the sources of anthropogenic pollution (Awomon, 2020, Laurent, 2012, Hounsounou, et al., 2016). According to Hounsounou Espérance O. et al. in (2016), the major factors of contamination of domestic water studied are close to those identified during the study of Mamou's bathing waters.

#### 4. CONCLUSION

The bacteriological indicators of pollution used were all encountered in the bathing waters of Mamou. Of the water sources in which enterococci and *E. coli* have been encountered, the majority have yielded bacterial loads above the threshold values proposed by the WHO. Enterococci and *E. coli* remain the best indicators of old and recent faecal contamination, respectively.

The presence of indicator germs, although mostly non-pathogenic, certifies that of pathogenic microorganisms. Classical bacteriological methods were used.

The results showed that anthropogenic activities, the environment and the lack of an effective waste management system would play a role in the bacteriological contamination of bathing waters in the Mamou Region. It is for this reason that it would be important to integrate this issue as a public health priority.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that no generative AI technologies such as large language models (ChatGPT, COPILOT, etc.) and text-image generators were used during the writing of this manuscript.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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