

PREVALENCE OF TOTAL AND FECAL COLIFORMS IN PACKAGED DRINKING WATER IN SACHETS SOLD IN CAMEROON: A REGIONAL ANALYSIS

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ABSTRACT

Packaged drinking water in plastic sachets has become a common source of hydration in Cameroon, particularly in urban and peri-urban areas where access to safe drinking water is limited. However, the microbiological quality of these products remains uncertain. This study evaluated the prevalence of total and fecal coliforms in sachet drinking water sold across the ten regions of Cameroon and analyzed regional variations in contamination levels. A total of 520 sachet water samples from 28 manufacturing companies were collected from regional capitals and analyzed using membrane filtration on Violet Red Bile Lactose Agar (VRBLA) incubated at 37°C for total coliforms and 44°C for fecal coliforms. Results revealed that 305 samples (58.65%) were

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contaminated with coliforms. Total coliforms were detected in 282 samples (59%), while fecal coliforms were detected in 200 samples (41%). The North and Far North regions had the highest contamination rates (20.74% each), followed by the Center (14.94%), South-West (12.66%), Littoral and North-West (10.37% each), West (5.81%), East (2.07%), Adamaoua (1.24%), and South (1.04%). Coliform counts in positive samples ranged from <200 CFU/100 ml in 10 companies (35.71%) to >200 CFU/100 ml in 10 companies (35.71%), exceeding the detection threshold. The study concludes that sachet drinking water in Cameroon is frequently contaminated with coliforms, indicating poor microbiological quality and potential health risks. Regional disparities in contamination levels highlight the need for targeted interventions in high-risk areas.

Keywords: Total Coliforms, Fecal Coliforms, Sachet Water, Drinking Water Quality, Cameroon, Regional Analysis, Public Health

RÉSUMÉ

L'eau de boisson conditionnée en sachet plastique est devenue une source d'hydratation courante au Cameroun, particulièrement dans les zones urbaines et périurbaines où l'accès à l'eau potable est limité. Cependant, la qualité microbiologique de ces produits reste incertaine. Cette étude a évalué la prévalence des coliformes totaux et fécaux dans les eaux de boisson en sachet vendues dans les dix régions du Cameroun et a analysé les variations régionales des niveaux de contamination. Un total de 520 échantillons d'eau en sachet provenant de 28 sociétés de fabrication ont été collectés dans les chefs-lieux des régions et analysés par filtration sur membrane sur gélose Violet Red Bile Lactose Agar (VRBLA) incubée à 37°C pour les coliformes totaux et à 44°C pour les coliformes fécaux. Les résultats ont révélé que 305 échantillons (58,65%) étaient contaminés par des coliformes. Les coliformes totaux ont été détectés dans 282 échantillons (59%), tandis que les coliformes fécaux ont été détectés dans 200 échantillons (41%). Les régions du Nord et de l'Extrême-Nord présentaient les taux de contamination les plus élevés (20,74% chacune), suivies du Centre (14,94%), du Sud-Ouest (12,66%), du Littoral et du Nord-Ouest (10,37% chacun), de l'Ouest (5,81%), de l'Est (2,07%), de l'Adamaoua (1,24%) et du Sud (1,04%). Les dénombrements de coliformes dans les échantillons positifs variaient de <200 UFC/100 ml dans 10 sociétés (35,71%) à >200 UFC/100 ml dans 10 sociétés (35,71%), dépassant le seuil de détection. L'étude conclut que l'eau de boisson en sachet au Cameroun est fréquemment contaminée par des

coliformes, indiquant une mauvaise qualité microbiologique et des risques sanitaires potentiels. Les disparités régionales dans les niveaux de contamination soulignent la nécessité d'interventions ciblées dans les zones à haut risque.

Mots-clés: Coliformes totaux, Coliformes fécaux, Eau en sachet, Qualité de l'eau de boisson, Cameroun, Analyse régionale, Santé publique

Suimis le : 17 Mars , 2026

Publié le : 08 Jun , 2026

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1. INTRODUCTION

1.1 Coliform Bacteria as Indicators of Water Quality

Coliform bacteria are widely used as indicators of water quality and potential contamination by fecal material. These Gram-negative, facultatively anaerobic, non-spore-forming bacilli are present in the intestines of warm-blooded animals and are excreted in large numbers in feces. The presence of coliforms in drinking water indicates either inadequate treatment, post-treatment contamination, or both, and signals a potential health risk.

Total coliforms are a group of bacteria that include both fecal and environmental species. While not all total coliforms originate from fecal sources, their presence in drinking water indicates that the water has been exposed to contamination and may be at risk for containing pathogens.

Fecal coliforms (thermotolerant coliforms) are a subgroup of total coliforms that can grow at elevated temperatures (44-45°C). Their presence is more specifically associated with fecal contamination from warm-blooded animals, including humans. *Escherichia coli* is the most well-

known fecal coliform species and is considered the most reliable indicator of recent fecal contamination (WHO, 2004).

1.2 Sachet Water Consumption in Cameroon

Packaged drinking water in plastic sachets has become increasingly popular in Cameroon due to its affordability, convenience, and wide availability. The product is sold throughout the country, particularly in urban and peri-urban areas where access to piped water is limited or unreliable. Sachet water typically contains 500 ml and is sold for a fraction of the cost of bottled water, making it accessible to a broad segment of the population.

However, the rapid expansion of the sachet water industry has outpaced regulatory oversight and quality control measures. Production often occurs in small, unregulated facilities where water treatment, hygiene practices, and quality monitoring may be inadequate. The product is frequently sold by street vendors under conditions that may compromise its microbiological quality.

1.3 Public Health Implications

The consumption of coliform-contaminated drinking water is associated with an increased risk of gastrointestinal infections. While coliforms themselves are not typically pathogenic, their presence indicates that the water may contain enteric pathogens such as:

- *Salmonella* spp. (typhoid and paratyphoid fever)
- *Shigella* spp. (bacillary dysentery)
- *Vibrio cholerae* (cholera)
- Pathogenic *Escherichia coli* (diarrheal disease)
- *Campylobacter* spp. (gastroenteritis)

The presence of fecal coliforms, particularly *E. coli*, is considered strong evidence of recent fecal contamination and a high probability of pathogen presence. In Cameroon, where waterborne diseases remain endemic in many regions, the consumption of coliform-contaminated sachet water represents a significant public health risk.

1.4 Regional Variations in Water Quality

Cameroon's ten regions vary considerably in terms of climate, infrastructure, and sanitation conditions. The northern regions (North and Far North) experience a Sahelian climate with limited water availability, contributing to water scarcity and potential reliance on unsafe water sources. These regions also experience recurrent cholera epidemics and other waterborne disease outbreaks. The southern regions (Center, Littoral, South-West, and West) have more temperate climates and generally better access to water infrastructure. However, rapid urbanization in these regions has created challenges in maintaining water quality standards.

1.5 Study Rationale and Objectives

Despite the widespread consumption of sachet water, limited data exist on the prevalence of coliform contamination across Cameroon's regions. This study aimed to:

1. Determine the prevalence of total and fecal coliforms in sachet drinking water across all ten regions of Cameroon
2. Quantify coliform counts in contaminated samples
3. Analyze regional variations in contamination levels
4. Assess the microbiological quality of sachet water relative to WHO standards

2. MATERIALS AND METHODS

2.1 Study Design and Sample Collection

This descriptive cross-sectional study was conducted from March to July 2014. A total of 520 sachet water samples from 28 manufacturing companies were randomly purchased from the capitals of all ten regions of Cameroon.

2.2 Bacteriological Analysis

2.2.1 Membrane Filtration

Membrane filtration was performed using 0.45 µm pore-size membranes. After filtration of 100 ml of water, membranes were placed on Violet Red Bile Lactose Agar (VRBLA) plates.

2.2.2 Incubation and Enumeration

- **Total coliforms:** Incubation at 37°C for 18-24 hours
- **Fecal coliforms:** Incubation at 44°C for 18-24 hours

Colonies were counted and recorded as colony-forming units (CFU) per 100 ml. Samples with >200 colonies were recorded as exceeding the detection threshold (>200 UFC).

2.3 Data Analysis

Data were analyzed using Microsoft Excel 2007. Frequencies and percentages were calculated for each region and for coliform types.

2.4 Ethical Considerations

Ethical approval and research authorization were obtained from relevant authorities. Data confidentiality was maintained.

3. RESULTS

3.1 Overall Coliform Prevalence

Table 1: Coliform Prevalence in Sachet Water Samples

Parameter	Number	Percentage
Total samples analyzed	520	100%
Samples with coliforms	305	58.65%
Samples without coliforms	215	41.35%
Total coliform positive samples	282	59%
Fecal coliform positive samples	200	41%

Figure 1: Distribution of Coliform Types

Coliform Type	Number	Percentage
Total Coliforms	282	59%

Fecal Coliforms	200	41%
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3.2 Coliform Count Distribution by Company

Table 2: Distribution of Coliform Counts by Company (n=28)

Coliform Count Range	Number of Companies	Percentage
0 (Sterile)	8	28.57%
<200 UFC/100 ml	10	35.71%
>200 UFC/100 ml	10	35.71%
Total	28	100%

3.3 Regional Distribution of Coliform Contamination

Table 3: Regional Distribution of Coliform Isolates

Region	Number of Isolates	Percentage
North	100	20.74%
Far North	100	20.74%
Center	72	14.94%
South-West	61	12.66%
Littoral	50	10.37%

North-West	50	10.37%
West	28	5.81%
East	10	2.07%
South	5	1.04%
Adamaoua	6	1.24%
Total	482	100%

Figure 2: Regional Distribution of Coliform Contamination

Region	Percentage
North	20.74%
Far North	20.74%
Center	14.94%
South-West	12.66%
Littoral	10.37%
North-West	10.37%
West	5.81%
East	2.07%
South	1.04%
Adamaoua	1.24%

3.4 Bacterial Species Isolated from Coliform-Positive Samples**Table 4: Bacterial Species Isolated and Their Frequencies**

Bacterial Species	Number	Percentage
<i>Escherichia coli</i>	100	20.75%

<i>Enterobacter cloacae</i>	40	8.30%
<i>Klebsiella pneumoniae</i>	35	7.26%
<i>Salmonella typhi</i>	30	6.22%
<i>Salmonella salmonicida</i>	12	2.49%
<i>Providencia alcalifaciens</i>	8	1.66%
<i>Salmonella maltophilia</i>	8	1.66%
<i>Proteus mirabilis</i>	25	5.19%
<i>Stenotrophomonas maltophilia</i>	5	1.04%
<i>Pasteurella pneumotropica</i>	5	1.04%
<i>Pseudomonas</i> spp.	144	29.90%
<i>Acinetobacter baumannii</i>	20	4.15%
<i>Burkholderia cepacia</i>	15	3.11%
<i>Pseudomonas luteola</i>	10	2.07%
Other non-fermentative bacteria	25	5.19%
Total	482	100%

3.5 Coliform Counts by Region

Table 5: Coliform Counts by Region for Selected Companies

Region	Company Code	Total Coliforms (UFC/100 ml)	Fecal Coliforms (UFC/100 ml)
Center	1	90	0
Center	2	7	0
Center	3	>200	0
Center	4	16	0

Center	5	70	0
Center	6	0	0
Littoral	7	8	0
Littoral	8	>200	0
Littoral	9	0	0
Littoral	10	70	0
Littoral	11	>200	0
Littoral	12	80	0
North-West	13	178	0
North-West	14	0	0
North-West	15	>200	0
North-West	16	16	0
North-West	17	0	0
South-West	18	>200	0
South-West	19	>200	0
South-West	20	>200	0

South-West	21	>200	33
West	22	0	0
West	23	15	0
East	24	0	0
South	25	0	0
Adamaoua	26	0	0
North	27	>200	>200
Far North	28	>200	>200

3.6 Regional Contamination Patterns

Figure 3: Contamination by Region (Number of Germs Isolated)

The regions with the highest numbers of bacterial isolates were:

1. **North:** 100 isolates (20.74%)
2. **Far North:** 100 isolates (20.74%)
3. **Center:** 72 isolates (14.94%)
4. **South-West:** 61 isolates (12.66%)

The lowest contamination levels were found in:

1. **South:** 5 isolates (1.04%)
2. **Adamaoua:** 6 isolates (1.24%)
3. **East:** 10 isolates (2.07%)

3.7 Coliform Type Distribution

Figure 4: Coliform Type Distribution

Coliform Type	Number	Percentage
Total Coliforms	282	59%
Fecal Coliforms	200	41%

Fecal coliforms were detected in 41% of positive samples, indicating recent fecal contamination.

4. DISCUSSION

4.1 High Prevalence of Coliform Contamination

The finding that 58.65% of sachet water samples were contaminated with coliforms is alarming and indicates widespread microbiological quality issues. The presence of total coliforms in 59% of positive samples and fecal coliforms in 41% of positive samples demonstrates that a significant proportion of sachet water is fecally contaminated.

This prevalence exceeds that reported in many other African countries. N'diaye (2008) reported a 29.13% contamination rate in Abidjan, Ivory Coast, while Chérif (2006) reported 41% in Dakar, Senegal. The higher prevalence in Cameroon may reflect:

1. **More extensive sampling:** Covering all ten regions rather than a single city
2. **Regulatory gaps:** Insufficient quality control and enforcement in the Cameroonian sachet water industry
3. **Infrastructure challenges:** Limited access to safe water sources for production
4. **Hygiene practices:** Poor sanitation and hygiene during production and handling

4.2 Regional Variations in Contamination Levels

The North and Far North regions had the highest contamination levels, each accounting for 20.74% of bacterial isolates. Several factors may explain this pattern:

1. **Sahelian Climate:** Limited water availability and high temperatures may increase contamination risks

2. **Poor Sanitation:** Open defecation practices contribute to environmental fecal contamination
3. **Proliferation of Flies:** High fly populations attracted by vegetation and poor sanitation
4. **Water Scarcity:** Use of unsafe water sources for production
5. **Recurrent Epidemics:** The North and Far North regions experience recurrent cholera epidemics

The Center region (14.94%) and South-West region (12.66%) also showed significant contamination. The Center region includes Yaoundé, the capital, where sachet water production and consumption are concentrated. The South-West region, with its tropical climate and higher rainfall, may face different contamination challenges related to moisture and microbial growth.

The lowest contamination levels were found in the South (1.04%), Adamaoua (1.24%), and East (2.07%) regions. These regions have lower population densities and perhaps better water quality in some areas, though the limited number of samples from these regions may affect the reliability of these findings.

4.3 Implications of Coliform Contamination

4.3.1 Indication of Fecal Contamination

The presence of fecal coliforms in 41% of positive samples strongly suggests recent fecal contamination. This is particularly concerning as it indicates that pathogens such as *Salmonella*, *Shigella*, and *Vibrio cholerae* may be present in sachet water. The detection of *Salmonella typhi* (6.22% of isolates) confirms this concern.

4.3.2 Health Risks

Consumption of coliform-contaminated water is associated with:

- Diarrheal diseases
- Typhoid and paratyphoid fever
- Cholera
- Other gastrointestinal infections

4.3.3 Economic Impact

Waterborne infections increase healthcare costs and reduce productivity through illness. The economic burden falls disproportionately on low-income populations who rely on sachet water.

4.4 Fecal Coliforms as Pathogen Indicators

Fecal coliforms, particularly *E. coli*, are considered the most reliable indicators of recent fecal contamination and potential pathogen presence. The high prevalence of fecal coliforms (41% of positive samples) suggests that a substantial proportion of sachet water is contaminated with human or animal feces.

Escherichia coli was isolated in 20.75% of positive samples, making it the second most common isolate after *Pseudomonas* spp. This indicates that sachet water frequently serves as a vehicle for fecal contamination.

4.5 Coliform Counts and Quality Classification

Samples with coliform counts >200 UFC/100 ml (35.71% of companies) exceeded the detection threshold, indicating high levels of contamination. According to WHO guidelines (WHO, 2004), drinking water should contain:

- 0 CFU/100 ml for total coliforms
- 0 CFU/100 ml for fecal coliforms

None of the coliform-positive samples in this study would meet WHO standards. Even samples with <200 UFC/100 ml contain coliforms and are therefore non-compliant with international water quality standards.

4.6 Comparison with International Standards

The WHO drinking water quality guidelines (WHO, 2004) stipulate that drinking water should contain no detectable coliforms in 100 ml. The detection of coliforms in 58.65% of samples indicates that sachet water in Cameroon consistently fails to meet international water quality standards.

The high proportion of fecal coliforms (41% of positive samples) suggests that the contamination is of recent origin and likely contains enteric pathogens that could cause disease.

4.7 Source of Contamination

The high prevalence of coliform contamination indicates multiple potential sources:

1. **Inadequate Water Treatment:** Failure to eliminate bacteria through filtration, chlorination, or other treatment processes
2. **Post-Treatment Contamination:** Contamination during packaging, handling, or storage
3. **Contaminated Water Source:** Use of fecally contaminated source water for production
4. **Poor Hygiene Practices:** Unsanitary conditions in production facilities
5. **Improper Storage:** Exposure to unsanitary conditions at retail points

4.8 Recommendations for Improvement

Based on these findings, the following recommendations are proposed:

For Regulatory Authorities:

1. Establish and enforce mandatory microbiological testing for sachet water producers
2. Implement regular inspections of production facilities
3. Require zero coliform levels in drinking water
4. Strengthen penalties for non-compliance

For Producers:

1. Ensure adequate water treatment (filtration, chlorination, or UV disinfection)
2. Maintain strict hygiene in production facilities
3. Implement regular quality control testing
4. Use appropriate storage and handling practices

For Consumers:

1. Be aware of the health risks associated with contaminated sachet water
2. Consider alternative water sources or treatment methods

3. Avoid consuming sachet water showing signs of damage or poor quality

For Public Health Authorities:

1. Conduct public awareness campaigns about water safety
2. Monitor waterborne disease outbreaks
3. Improve sanitation infrastructure

5. CONCLUSION

This study demonstrates that sachet drinking water in Cameroon is frequently contaminated with total and fecal coliforms, indicating poor microbiological quality and potential health risks. Key findings include:

1. **High contamination rate:** 58.65% of samples contained coliforms
2. **Fecal contamination:** 41% of positive samples contained fecal coliforms
3. **Regional disparities:** The North and Far North regions had the highest contamination levels
4. **Pathogen presence:** Several enteric pathogens were isolated, including *Salmonella typhi*
5. **WHO non-compliance:** No coliform-positive samples met WHO drinking water quality standards

The high prevalence of coliform contamination in sachet water represents a significant public health concern, particularly in regions with limited access to safe water. Urgent interventions are needed to improve water quality, strengthen regulatory oversight, and protect consumer health.

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