Full Length Research Paper

Microbial pollution of the Mezam river system and its health impact in Bamenda (North-West Cameroon)

TITA Margaret Awah¹*, MAGHA Alice¹ and KAMGANG KABEYENE Véronique Beyala²

¹Higher Teacher Training College, University of Bamenda, P. O. Box 39, Bambili, Cameroon.
²Higher Teacher Training College, University of Yaounde I, P. O. Box 47, Yaounde, Cameroon.

Accepted 20 September, 2013

A two-year study was carried out from June 2009 to May 2011 to investigate the microbial quality of the Mezam river system in Bamenda and its health impact, given the prevalence of waterborne diseases among the population who use the river water for various purposes, notably domestic and agricultural activities. River, spring and tap water samples were collected monthly and analysed quantitatively for faecal bacteria indicators of pollution and qualitatively for specific pathogens. The study shows that most of the sites were heavily polluted with faecal bacteria (12 to 2822 cfu/100 ml) that consistently exceeded the WHO recommended range for potability. These bacteria often comprised the pathogens Salmonella and Shigella which seemed to be endemic. They all tended to be highest in the dry season and at the onset of the rainy season. The incidence of waterborne diseases showed a seasonal pattern similar to the seasonality of the causative agents in water samples. The most impaired segments were the Ayaba and Mughed tributaries which receive inputs from urban and domestic activities, as well as the Nkimefeu tributary which receives direct waste discharge from the dressing of carcasses at the town slaughter house. The population which is dependent on the river water are thus exposed to health risks which could be reduced by minimizing the discharge of both liquid and solid wastes into water channels.

Key words: Faecal bacteria, market gardening, pathogens, river pollution, wastewater.

INTRODUCTION

Surface water plays an important role in the transmission of pathogenic agents discharged through human and animal faeces. These agents may find their way into the water via domestic wastewater, surface runoff from agricultural land and pastures during rainfall, or by direct deposition of faecal matter with access to stream channels (Eyles et al., 2003; Collins et al., 2005). They can transfer to humans by various routes, like recreation, irrigation of fruits and vegetables and drinking water (Davies-Colley et al., 2004). An understanding of the nature and dynamics of the microbial community in such surface waters is a necessity, since the indiscriminate increase in pollution factors has made natural purification capacities insufficient. In particular, knowledge of the levels of microorganisms in water is important for indexing the health hazard associated with its use, adopting meaningful interventions and improving bacterial water quality (Entry and Farmer, 2001).

The Mezam river sub-basin in Bamenda, West Cameroon, harbours a growing urban community that relies on the Mezam river for household chores, irrigation of market gardens and as a source for public watersupply (Tita et al., 2012). It also serves as recreational swimming pool for small children from nearby homes and
schools. The increasing demand on this water resource and the resultant contamination from human activities generate a number of pollution problems thus increasing the risk of outbreaks from waterborne diseases. Katte et al. (2003) and Kuitcha et al. (2010) have illustrated that serious public health problems prevail in Dschang and Yaoundé (Cameroon), respectively, due to the biological pollution of wells, backwaters and rivers resulting from poor domestic and industrial waste management.

In fact, a number of studies have highlighted the great threat to public health in urban centres in many developing countries caused by microbial contamination and associated increase in waterborne enteric diseases (Ilorin, Nigeria: Kolawole et al., 2011; Abidjan, Ivory Coast: Coulibaly et al., 2004; Blantyre, Malawi: Palamuleni, 2001).

Hospital records from the Bamenda Health District show a high prevalence of waterborne diseases in Bamenda, and isolated cases of cholera occur from time to time. There is, however, a complete lack of scientific information on bacteriological water quality in this locality for appropriate intervention.

The main objective of this study was to evaluate the microbial status of the Mezam river system in Bamenda and its health impact on the population. Specifically, the study aimed to determine the types and levels of faecal bacteria and to identify the factors responsible for the degradation of the water resources. Such a study is important as it shall provide a framework for practical measures to guide water management in the sub-basin and, through this, mitigate and control the impact of pollution on the population.

**MATERIALS AND METHODS**

**Study area**

The study area is the Mezam river sub-basin in Bamenda (North West Cameroon), situated between latitudes 5°43' and 7°10' N and longitudes 9°35' and 11°12' E. The Mezam River is a second order perennial stream fed by several small streams and springs which take their rise from the Bamenda Escarpment. Water samples were collected for bacteriological analyses at six sites (SPR, MNA, MAY, MMU, MNK and MNG) in the Mezam river system (Figure 1). Details of the sites are given in Table 1.
Table 1. Location and characteristics of sampling sites in the Mezam river system in Bamenda.

<table>
<thead>
<tr>
<th>Site No</th>
<th>Code</th>
<th>Location</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SPR</td>
<td>Spring situated at the foots of the escarpment and constitutes reference point.</td>
<td>Presence of a few farm and grazing lands.</td>
</tr>
<tr>
<td>2</td>
<td>MNA</td>
<td>Naaka stream, western boundary of Bamenda town.</td>
<td>Rural tributary for the most part. Water drains in from the Mbatu plain, an intensive agricultural area in the basin.</td>
</tr>
<tr>
<td>3</td>
<td>MAY</td>
<td>Ayaba tributary</td>
<td>Urban tributary. Drains through thickly populated commercial centre and residential area.</td>
</tr>
<tr>
<td>4</td>
<td>MMU</td>
<td>Mugheb tributary</td>
<td>Urban tributary. Drains waste from the Nkwen market and its neighbourhood.</td>
</tr>
<tr>
<td>5</td>
<td>MNK</td>
<td>Nkimefeu tributary, northern boundary of Bamenda town.</td>
<td>Receives waste successively from fish farms, carwash, market gardens, soap factory and town slaughter house.</td>
</tr>
<tr>
<td>6</td>
<td>MNG</td>
<td>Mezam river at Ngomgham Situated at the outlet of the Mezam River from Bamenda.</td>
<td>Drains the Municipal open waste discharge at Mile 8.</td>
</tr>
<tr>
<td>7</td>
<td>MTW</td>
<td>Tapwater</td>
<td>Treated water from Mezam River distributed to population.</td>
</tr>
</tbody>
</table>

Water sampling

Sampling was carried out monthly from June 2009 to May 2011 for bacteriological analyses. On each sampling occasion, 1-l samples of water were collected from a well-mixed, flowing section of the river using sterile glass bottles and transported in an ice bucket to the Centre Pasteur Laboratory in Yaoundé, where they were analysed quantitatively for bacteria indicators of faecal contamination within 24 h. Every other month, qualitative analyses for specific indicators and pathogens were also carried out. During these occasions, tap water (MTW) was simultaneously sampled for both quantitative analysis of faecal bacteria and qualitative determination of pathogens.

Quantitative analysis of bacteria indicators of pollution

Heterotrophic bacteria and *Clostridium* were quantified by incorporation in plate count agar and beef liver agar, respectively, and incubated at 37°C for 24 h. Total coliforms, faecal coliforms, faecal streptococci and *Pseudomonas* were enumerated using the membrane filter technique (APHA, 1998). After filtration, the membrane was placed over lactose agar and cultured for 24 h at 37°C (total coliforms) or 44°C (faecal coliforms). To estimate faecal streptococci, the membranes were cultured over Slanetz medium for 48 h at 37°C. *Pseudomonas* was estimated on Cetrimide agar for 24 to 48 h at 37°C. The results are expressed in colony forming units (cfu) per 100 ml.

Qualitative analysis of specific indicators and pathogens

*Escherichia coli* were identified by inoculating characteristic total coliform colonies in MacConkey broth. Growth characteristics together with reaction to indole methyl red confirmed the presence of *E. coli* (Marchal et al., 1991). Meanwhile, Enterococci were detected by incubating faecal streptococci colonies on Enterococci specific agar and confirmed by negative catalase test. The pathogens *Salmonella*, *Shigella* and *Vibrio* were identified on Hectoan agar after enrichment on Rappaport (APHA, 1998), and presumptive colonies were confirmed biochemically (search for galactosidase, urease and indole oxidase, respectively) (Marchal et al., 1991).

Waterborne diseases

Data on waterborne diseases were obtained from the Mezam Health District Service and through structured interviews involving 500 households randomly selected from all the quarters in the city of Bamenda. Respondents were required to furnish information on their sources of water for domestic chores and the occurrence of waterborne diseases in their respective families.

Statistical analysis

The Duncan test was used to evaluate significant differences among sampling sites and the probability for significance set at p ≤ 0.01. All calculations (mean, standard deviation and t-tests) were performed using Microsoft EXCEL statistical package for win XP-2002 and SPSS version 10.1 statistical calculation program (SPSS Inc., Chicaco IL).

RESULTS

Distribution of faecal indicator bacteria in the Mezam river system

The microbial survey carried out on water samples from the Mezam river system showed that apart from tap water, all the sites sampled contained all the indicator bacteria analysed, and each exceeded the WHO (2001) recommended limits for potable water (Table 2). They were dominated by coliforms and *Clostridium* spores. Further analysis of the coliforms revealed the presence of faecal coliforms in all the samples. Faecal streptococci were also numerous while *Pseudomonas* sp was generally the least represented.

Statistical analysis indicated that faecal indicator bacteria counts were significantly different among sites (p ≤ 0.01). The highest mean coliform counts (>1600 cfu/100 ml) were recorded downstream at MNG and MNK, as well as MAY and MMU located on the urban tributaries (Table 2). Faecal coliforms and streptococci were also most prolific at these urban sites, whereas upstream at MNA, bacteria counts were less than 100 cfu/100 ml. *Pseudomonas* and *Clostridium* also presented a similar trend. All the indicators were much
fewer but nonetheless present in spring water (SPR) at the river source. In tap water (MTW), total coliform, faecal coliform and faecal streptococcus counts were within the recommended limit for drinking water (<1 cfu/100 ml) but heterotrophic bacteria, Pseudomonas and Clostridium spores exceeded their respective limits.

### Temporal variations in faecal indicator bacteria in the Mezam river system

The faecal bacteria exhibited great temporal variations at all the sites: high counts were recorded during periods of low and rising water levels (February to May), corresponding to the dry season and the onset of the rainy season, respectively (Figure 2). The counts were much lower in periods of high and falling water levels (August to November). Clostridium levels were particularly high and more or less constant (1000 to 1200 cfu/100 ml) but increased two to four fold between February and April. On its part, Pseudomonas, which was almost absent during high discharges, registered a sharp increase between January and March.

### Occurrence of specific indicators and pathogens in the Mezam river system

E. coli and Enterococci were present in all the water samples analysed except tap water. The pathogens Salmonella and Shigella were detected at various sites and at different times. Salmonella was more frequently (63.3%) detected than Shigella, and Vibrio sp. was detected only once at MNK (7.69%) (Table 3). None of the pathogens was identified in tap water. Analysis of the isolation frequency of Salmonella showed that more than 65% of the Salmonella-positive samples were recorded between January and May which corresponds to the dry season and the onset of rains, respectively (Figure 3).

### Incidence of waterborne diseases in Bamenda

Household interviews conducted in Bamenda town showed that in most households, the inhabitants repeatedly suffer from various waterborne diseases, and records from the Bamenda Health District Service indicated that between 2008 and 2010, 29695 patients consulted for diarrhoeal diseases, while 8544 were diagnosed for dysentery and 9166 for typhoid fever (Figure 4). Many people more suffered from diarrhoea between December and May while dysentery and typhoid infections were more common from March to June. Meanwhile, less than 20% of the respondents use tap water for drinking while more than 60% use either spring, well and/or river water for domestic activities that include cooking, washing, bathing and even drinking (data not shown). River water is also extensively used for the irrigation of market vegetables.

### DISCUSSION

Total coliforms and heterotrophic bacteria are used to evaluate the hygienic status of water and any presence of the coliform group in water indicates contact with sewage (Markosova and Jezek, 1994). Faecal coliforms such as E. coli are prevalent in the digestive tracts of warm-blooded animals and it is believed that there is a correlation between their presence and pathogenic organisms since they have very similar survival characteristics to those of the well-known pathogenic members of the family, Salmonella and Shigella (Van Kessel et al., 2004). They thus serve as indicators for these pathogens and associated animal wastes that enter a water body, and their presence is definite evidence of faecal contamination and the potential risk of zoonotic pathogens (Entry and Farmer, 2001). Faecal streptococci, particularly Enterococcus spp, and Clostridium spores also show faecal contamination, the former indicating recent contamination as they do not multiply in the environment, and the latter representing more ancient contamination (Payment and Franco, 1993).

### Spatial distribution of faecal indicator bacteria in the Mezam river system

The distribution of faecal bacteria in the Mezam river...
Figure 2. Temporal variations in faecal bacteria levels in water samples from the Mezam river system in Bamenda: (■) faecal coliform, (●) faecal streptococci, (◆) Pseudomonas spp, (○) Clostridium spores) with respect to river discharge (▲(n = 12)).

system seemed to reflect input from the surrounding land. The lowest counts were measured in SPR, whereas the highest concentrations were obtained at MAY, MMU, MNK and MNG. Bacteria levels at MNA were low to moderate depending on the type of bacteria and the season. MNA is situated downstream of a flood plain where riparian vegetation provides a significant buffer zone such that inputs from human wastes and grazing stock are likely to be reduced (Eyles et al., 2003). Besides, the river gradient is low in this section and this, together with the in-stream vegetation that is almost unique to the segment, may favour the settling of faecal
Table 3. % positive samples for pathogens identified in water samples from the Mezam river system in Bamenda (n = 12).

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Sites in the Mezam river system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MRS</td>
</tr>
<tr>
<td>Salmonella sp.</td>
<td>7.69</td>
</tr>
<tr>
<td>Shigella sp.</td>
<td>0</td>
</tr>
<tr>
<td>Vibrio cholerae</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 3. Temporal distribution of *Salmonella*-positive samples (●) in the Mezam river system in Bamenda with respect to river discharge (▲(n = 12)).

MAY and MMU are urban sites and receive numerous direct sewage inputs from residential areas along the watercourses as there is no central treatment system for Bamenda town (> 350,000 inhabitants). In fact, many homes do not have latrines and the stream simply serves this purpose. Just upstream from the MMU sampling point, pipes can be seen discharging from some homes, while huge quantities of garbage are deposited either near the river or directly into the river channel. MNK is situated downstream from the town slaughter house whose wastes are discharged directly into the river channel. Furthermore, a number of small animal farms are found in the back yards of many homes, while the presence of a carwash and soap factories attracts a concentration of people for whom sewage facilities are generally not available. Finally, MNG located at about 7 km downstream from MMU, receives not only the bacteria loaded water from the latter, but also input from the urban tributaries, as well as that from the Municipal open waste discharge that extends into the river channel.

Temporal variations in faecal indicator bacteria in the Mezam river system

Faecal contamination of the river was generally higher...
during low and rising water levels and tended to reduce under high and falling discharge rates, corresponding to the dry season/onset of rains and rainy season/end of rains, respectively. In the dry season, water levels are much reduced and bank vegetations cleared for the cultivation of market vegetables using river water for irrigation. This makes the streams more accessible to both humans and animals. This may increase faecal bacteria levels in the water column through direct deposition of faecal matter and re-suspension from sediments, compounded by minimum dilution due to low river flow (Castillo et al., 2004). It is also possible that as the water velocity reduces in the dry season, faecal bacteria accumulate and settle as a result of greater contact between water and sediment which enables significant sediment-water exchange (Mitsch and Gosselink, 2000). Moreover, a lot of faecal matter and associated wastes accumulate on land due to the lack of rainfall. The first rains wash them into surface water and the upsurge in bacteria counts at this time could thus be a combination of contributions from such land stores and those re-suspended from sediments.

On the other hand, regular rainfall flushes faecal matter from land as they are deposited, and with the increased volume of water in river channels, there is maximum dilution resulting in lower counts (Castillo et al., 2004). However, storm events typically resulted in elevated bacteria counts, whether during low or high discharge regime. Storm events are characterised by turbulent rolling waves that result in channel mixing and entrainment of particles in the wave front (Wilkinson et al., 2006).

Besides, the large volumes of water generated may lead to ingress of the stream water into encroaching garbage and waste dumps, as well as the overflow of poorly maintained septic tanks. Faecal bacteria levels are therefore greatly increased by re-suspension from the streambed and allochthonous inputs from runoff and dissolution of actively decomposing waste matter from far afield. As the rainy season dwindles to an end, there is reduced input from land stores through runoff and, with decreasing flow, settling out of sediment particles with associated bacteria is enhanced. The sediments thus gradually switch from being in-channel sources of faecal bacteria to serving as sinks. Consequently, the water column bacteria counts remain low during this phase of the hydrograph.

**Implications for public health**

Freshwater quality criteria for domestic supply require that faecal bacteria levels should not exceed a geometric mean value of 100 cfu/100 ml while the drinking water criterion is <1 cfu/100 ml (WHO, 2001). Many segments of the Mezam river system are thus highly polluted and either unacceptable for public water supply, or require fairly expensive treatment before use. The presence of *Clostridium* spores in tap water suggests that highly persistent micro-organisms like protozoan cysts may
have survived during treatment, while high counts of heterotrophic bacteria are indicative of the availability of nutrients in the water, which may result in aesthetic problems or in the presence of opportunistic pathogens (Payment et al., 2003). Indeed, heterotrophic bacteria are used to assess the suitability of water for use in the manufacture of food and drink products, where high counts may lead to spoilage. This is of particular concern in the present study area where local homemade beverages such as “foléré”, “ginger”, “Alaska”, “kossam” and corn beer are very common. On the other hand, the presence of *Pseudomonas* spp. in high concentrations should be of great concern today with the increasing number of HIV/AIDS patients as it causes opportunistic infections in debilitated patients (Baron and Hollander, 1993).

The pathogens *Salmonella*, *Shigella* and, to a much lesser extent, *Vibrio* were identified at the studied sites. A few significant correlations (p ≤ 0.01) existed between the presence of *Salmonella* and the levels of some of the faecal indicator bacteria but generally, no direct relationship could be established between the presence of pathogens and levels of faecal indicators. However, it is worth noting that the pathogens were more frequently detected at the urban sites that were also quite remarkable for their chronically elevated levels of faecal bacteria.

The prevalence of waterborne diseases in Bamenda is similar to the situation described by Djuikom et al. (2006) and Katte et al. (2003) in some urban and precarious quarters of Yaoundé and Dschang, respectively. Diarrhoeal diseases are waterborne and common in communities where living standards are low, and wastewater and excreta disposal facilities inadequate. Typhoid is caused by *Salmonella* spp. and bacillary dysentery by *Shigella dysenteriae*. *Salmonella* was shown in this study to be the most prevalent and endemic of the three classic bacterial agents of intestinal infections investigated. The incidence of the diseases seemed to follow a seasonal pattern that was almost reflected in the seasonality of the agents in water samples. Although the Bamenda Health District lacks the technical facilities to identify many diarrhoea agents and their serogroups, there seems to be strong circumstantial evidence that the enteric diseases in general and typhoid fever in particular, could be transmitted, at least in part, through the use of contaminated water from the Mezam river system.

**Conclusion**

The high levels and variety of faecal bacteria recorded in this study as well as the presence of pathogens in both river and spring waters clearly show that the Mezam River in Bamenda receives faecal contaminants on a continual basis. The urban tributaries are highly impacted by commercial and domestic activities but the Nkimefe tributary is the most impacted due to direct waste discharge from the dressing of carcasses at the town slaughter house. The implications of these findings are that people who are dependent on the river water for domestic or agricultural uses may be exposed to public health risks. The evidence of the data and processes discussed indicate that the risk could be reduced by minimising the discharge of both liquid and solid wastes into water channels. This may be achieved by encouraging the establishment of thick and perennial bank vegetations to limit direct access to the river channel, accompanied by the provision of waste collection and disposal facilities by the Municipality. This should be reinforced with the periodic inspection of homes to ensure the effective and proper installation of latrines and individual sewage evacuation systems.

**REFERENCES**


