Tidal effect on the dispersion of fecal pollution indicator bacteria and associated health risks along the Kribi beaches (Southern Atlantic coast, Cameroon)

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Abstract

Assessment of fecal contamination indicator bacteria concentrations on beaches are important for health risk prevention and management. This study assessed temporal changes in bacterial abundances as a function of tidal cycles and seasons along the Kribi beaches, Cameroon. Overall, samples taken during low and high tides during the different seasons of the year showed that the waters of Kribi beaches are exposed to fecal contamination due to the presence of different concentrations of fecal coliforms (5-35 CFU/100 ml), total coliforms (100-600 CFU/100 ml), *Escherichia coli* (0-15 CFU/100 ml), *Streptococcus feacalis* (50-700 CFU/100 ml), *Pseudomonas aeruginosa* (300-7200 CFU/100 ml), *Vibrio cholerea* (5-250 CFU/100 ml), *Vibrio parahemoliticus* (0-115 CFU/100 ml), and Aerobic Mesophilic Heterotrophic Bacteria (99-875 CFU/100 ml). Regardless of bacterial strain and sampling site, cell abundances were significant at low tides and during rainy seasons. At each sampling station (Mpalla, Ngoyè and Mboamanga), depending on the seasons and tidal cycles, significant correlations were recorded between the abundances of some bacterial strains and some environmental variables ($P < 0.05$). The presence and high abundance of these potentially pathogenic bacterial strains in the waters of Kribi beaches constitute a real public health threat for swimmers. The limitation of this microbiological pollution requires the implementation of an efficient collection and treatment plan for solid and liquid waste (sanitary wastewater) in the city of Kribi.

Keywords: fecal pollution; health risks; Kribi beaches; tidal cycles; solid and liquid waste management

Introduction

Microbial pollution of coastal recreation areas is a serious ecological and public health problem (Xue et al., 2022; Manini et al., 2022). Runoff, from urban, domestic, and industrial wastes, can support intense microplankton growth and proliferation of pathogenic microorganisms (Basili et al., 2021). To prevent swimming-related infectious diseases, it is therefore recommended that beach water quality be monitored by quantifying total and fecal coliforms and enterococci (Kongprajug et al., 2021; Makkaew et al., 2021). Epidemiological studies of different aquatic environments have shown a relationship between coliform quantification and the frequency of infectious disease (Martínez et al., 2007; WHO, 2021).

Fecal contamination is one of many forms of contamination that can affect water ecosystems (Manezeu Tonleu et al., 2021). The presence of pathogenic microorganisms in fecal matter such as viruses, bacteria, and parasitic protists makes consumption or contact with contaminated water risky for human health. Fecal contamination has an economic impact, as it can affect the development of recreational and tourist activities (Martínez et al., 2007). Many potential sources of fecal contamination can affect water quality. Human sources are mainly from discharges through sanitary sewers, treated or not, discharged into waterways. Animal sources include livestock operations and manure spreading. Heavy rainfall can then cause runoff to streams and migration to groundwater (Saingam et al., 2020). Animal contamination can also come from wildlife and urban wildlife, such as that caused by raccoons. In developing countries, waterborne outbreaks attributed to fecal contamination are very common (Ashbolt, 2004). They are partly explained by two important factors; a lack of appropriate infrastructure and drinking water purification treatment as well as a lack of infrastructure for sanitary wastewater treatment and disposal (Yahya et al., 2017; Edge et al., 2021).

Swimming in water of poor microbiological quality thus poses health risks and can lead to several infections, mainly gastroenteritis, more or less severe depending on the germs involved, ear infections and dermatitis (Manezeu Tonleu et al., 2021). In rare cases, contaminated water can also lead to more serious infectious diseases such as typhoid, cholera, etc. (Nimnoi and Pongsilp, 2020). Some elements of the environment can also act as a "vector" of contamination from water to humans, notably shellfish, which are particularly sensitive to pollution due to their physiology. Indeed, they are microphagous filter-feeding organisms, which feed on assimilable particles from the surrounding environment, phytoplankton and bacteria and concentrate them in their digestive system (Yahya et al., 2017; Edge et al., 2021).

In sub-Saharan Africa in general and Cameroon in particular, data on microbiological standards of beach waters are scarce (Leme Banock et al., 2014), yet these environments constitute high contamination sites given their high frequency of use at all seasons of the year. Moreover, very few studies have been conducted on the impact of beach water quality on the health of the population. There is almost no data on the classification of Cameroonian beach water in relation to the standards of the World Health Organization. There is a problem of permanent fecal contamination and public health on Cameroonian beaches in general and those of Kribi in particular. The main objective of this study was to evaluate the influence of tides and seasons on the dissemination of enteric bacteria and its associated health risks along the Kribi beaches, in the Southern Region of Cameroon. Specifically, it was necessary to perform qualitative and quantitative analyses of some indicator bacteria of fecal contamination on three beaches of Kribi (Mpalla, Ngoyè and Mboamanga), during high and low tides and at different seasons of the year: Long Dry Season (LDS), Short Rainy Season (SRS), Short Dry Season (SDS) and Long Rainy Season (LRS). In this study, the hypothesis

that the spread of enteric bacteria along the Kribi beaches is influenced by the tidal cycle and the seasons will be tested.

1. Materials and methods

1.1. Study area

The study was conducted in 2021 year on three most frequented beaches of the city of Kribi, in the Ocean Division, Cameroon southern Atlantic coast (Figure 1). This area is subject to a Guinean-type equatorial climate, characterized by four seasons: LDS from December to February, SRS from March to May, SDS from June to July and LRS from August to November (Olivry 1986; Dzana 2011; Mama et al. 2018). Four sampling campaigns were conducted: January (LDS), April (SRS), July (SDS) and October (LRS) respectively. At the level of each beach, one sampling station was surveyed based on it accessibility and frequentation. Station 1 is located at Mpalla beach (3°00'29"N - 0009°56'54.5"E) and characterized by a gray sandy substrate. Station 2 is situated at Ngoyè (2°57'26.6"N - 0009°54'36.9"E), at 4 km from Mpalla, and characterized by a black sandy substrate. Located at 9 km from Ngoyè, station 3 on Mboamanga beach (02°56'22.4"N - 0009°54'12.3"), is characterized by the sandy clay gray substrate.

1.2. Measurement of abiotic parameters

Physicochemical parameters were analyzed according to Rodier et al. (2009) and APHA (2017) standard methods. At each campaign and each sampling station, eight physico-chemical parameters were measured *in situ*, in triplicate during each tide period (low and high tide), using a hand-held multiparameter (HANNA/HI9829). These variables include pH (CU), Salinity (PSU), Temperature (°C), Dissolved Oxygen (mg/l), Suspended Solids (mg/l), Turbudity (NTU), Total Dissolved Solids (mg/l) and Electrical Conductivity (mS/cm). Additional, water depth and current velocity were also measured during low and high tides.

1.3. Bacteriological analysis

At each station, water samples were collected at high and low tide, in 1000 ml sterile polyethylene bottles, bacteriological analyses were focused on the isolation and enumeration of eight strains. The bacteria were isolated by surface plating in 90-mm diameter petri dishes containing Endo culture media for fecal coliforms, total coliforms and *Echerichia coli*, Bile Esculin Azide (BEA) for Streptococcus feacalis, Cetrimide agar for *Pseudomonas aeruginosa*, TCBS agar for *Vibrio* spp and Plate Count Agar (PCA) for mesophilic aerobic heterotrophic bacteria. The number of colony forming units (CFU) is expressed in CFU/100 ml of water according to the formula (Ajeagah et al., 2010):

$$Ab = (Nc/Vw) \times 100$$

Ab = abundance (CFU/100 ml), Nc = number of colonies counted on the petri dish, Vw = volume of water analyzed (ml).

1.4. Data analysis

The SPSS software version 16.0 allowed us to perform correlation tests. P values were used to assess the significance of the correlation between abiotic and biotic parameters. The safety threshold was 5% ($P < 0.05$).

2. Results

2.1. Abiotic variables

At the different surveyed site, the minimum water depth (0.30 m) was recorded at low tide during the SDS at Mpalla and the LDS at Mboamanga. As for the depth (2.07 m), was recorded at high tide at Ngoyè, during the LRS (Table I). The maximum tidal range (1.62 m) was obtained during the LRS at Ngoyè. On the other hand, the minimum tidal range (1.03 m), was obtained during the LDS at Mboamanga. Overall, at the different sampling points, the

current velocity was higher at low tide than at high tide, during all seasons of the year (LDR, SRS, SDR and LRS). The lowest current was recorded during SDS at high tide, on Ngoyè beach with a value of 0.90 m/s (Table I).

During the SRS, whether at high or low tide, the waters of the surveyed beaches were strongly basic with a maximum pH value of 8.81 CU recorded at Mboamanga. The lowest pH value (6.89 CU) was recorded at Mboamanga during high tide, during the LDS (Figure 2A). Salinity values were slightly higher at low tide than at high tide. Overall, salinity values showed a decreasing trend from the dry seasons (LDS, SDS) to the rainy seasons (SRS, LRS). The minimum salinity (31.01 PSU) was recorded during the LRS, at high tide at Ngoyè and the maximum value (35.77 PSU) during the LDS, at low tide at Mboamanga (Figure 2B).

During high tide, water temperature ranged from 26.16°C during LRS at Ngoyè to 31.75°C during LDS at Mboamanga. At low tide, the water temperature ranged from 27.29 °C at LRS at Ngoyè to 32.44 °C at LDS at Mpalla (Figure 2C). At all stations, the warmest water was recorded at low tide, specifically during dry periods (LDS, SDS). Regardless of the tidal cycle, Kribi beach waters were significantly more oxygenated during the rainy seasons (LRS, SRS) than during the dry seasons (LDS, SDS). The minimum value (2.99 mg/l) was recorded at Ngoyè at low tide during the SDS. On the other hand, the maximum value (5.12 mg/l) was obtained at high tide at Mpalla during the LRS (Figure 2D).

The waters of the Kribi beaches contain high amounts of suspended solids. However, these values were more significant at high tide than at low tide. The maximum value (131 mg/l) was obtained at Mboamanga at high tide and during the SRS (Figure 2E). The high amount of suspended solids contained in the waters of the Kribi beaches would justify its high turbidity. Indeed, regardless of the tidal cycle, maximum turbidity values were recorded during the rainy seasons (SRS, LRS) at all surveyed sites (Figure 2F). Total Dissolved Solids evolved

from 412 mg/l (in LDS) to 716 mg/l (in LRS) during high tide and from 375 mg/l (in LDS) to 636 mg/l (in LRS) during low tide (Figure 2G). Indeed, across all three beaches surveyed, the waters of Mpalla were lower in inorganic salts and some small amounts of dissolved organic matter. Regardless of the tidal cycle, electrical conductivity values varied very little from one season to the next. However, it was noted that the waters of the Kribi beaches were less loaded with ions, mineral salts and dissolved trace elements during the dry seasons (LDS, SDS) than during the rainy seasons (SRS, LRS) (Figure 2H).

2.2. Bacterial distribution and abundance

Bacteriological analyses have revealed an abundant diversity of bacterial strains in the waters of Kribi beaches: faecal coliforms, total coliforms, *Escherichia coli*, *Streptococcus feacalis*, *Pseudomonas aeruginosa*, *Vibrio cholerea*, *Vibrio parahemoliticus*, and Aerobic Mesophilic Heterotrophic Bacteria. These bacteria are found exclusively in human and animal feces and are potentially pathogenic when their load exceeds a certain threshold in the environment. Their pathogenicity is either specific (they cause specific pathologies) or opportunistic (they are only expressed on weakened individuals). It should be noted that the presence of *Vibrio cholerea* and *V. parahemoliticus* on the water of the Kibi beaches indicates a high health risk.

Overall, the high concentrations of bacteria found in this study were recorded during low tides and mainly during the rainy seasons (SRS, LRS) (Figures 3A-H). Fecal coliforms were the least abundant strains (5-35 CFU/100 ml); in contrast to *Pseudomonas aeruginosa* whose maximum concentrations reached 2700 CFU/100 ml during low tide at Mpalla during the SRS.

Different groups of bacteria are used as indicators of fecal contamination in different countries and jurisdictions. Total and fecal coliforms have been the main indicators of fecal contamination for a long time, but nowadays *Escherichia coli* and intestinal enterococci are

recognized as more appropriate and proposed to replace coliforms in some microbiological water quality standards. However, it is important to understand the potential and limitations of these different indicators in tropical bathing waters, particularly those of the Kribi beaches.

2.3 Correlation between abiotic and biotic variables

On all the beaches surveyed, significant correlations were found between certain abiotic and biotic parameters, exclusively at low tide and during the rainy seasons (SRS, LRS). Thus, at Mpalla, a positive and significant correlation was observed, during SRS, between *Streptococcus feacalis* and turbidity (r = 0.713, P = 0.045). At Ngoyè, significant positive correlations were observed during the SRS between *Vibrio parahemoliticus* and dissolved oxygen (r = 0.628, P = 0.041); between Aerobic Mesophilic Heterotrophic Bacteria and suspended solids during the SRS (r = 0.638, P = 0.033). At Mboamanga, Total coliforms and *Escherichia coli* were positively correlated during SRS with temperature (r = 0.811, P = 0.045 and r = 0.732, P = 0.038).

Comparison of the mean abundances of *Pseudomonas aeruginosa* at low tide, according to the two main seasons (LDS+SDS and SRS+LRS) showed a significant difference at Ngoyè (P = 0.048). At Mboamanga, under the same conditions, there was also a significant difference between the means of Fecal coliform abundances (P = 0.044). On all the sites surveyed, these comparison tests revealed no significant difference at high tide. Seasonal variations, tidal cycles and environmental variables seem to have an influence on the dynamics of microorganisms along the Kribi beaches.

3. Discussion

Although swimming is recreational activity that allows relaxation and physical exercise that is beneficial to health, it thus present certain health risks, which are related to the swimming activities, but especially to the physicochemical and microbiological quality of the water

(Basili et al., 2021). This study revealed several strains of potentially pathogenic enteric bacteria in the waters of Kribi beaches, whose abundance varied from one season to another and according to tidal cycles.

Indeed, microbiological pollution is one of the major problems facing coastal and marine environments today (Dang and Lovell, 2016; Basili et al., 2021). This term refers to the presence in these ecosystems of microbial germs, such as bacteria, viruses or parasites, some of which may be pathogenic to humans or animals (Nimnoi and Pongsilp, 2020). While marine and coastal ecosystems are the natural environment for some microorganisms, most of the germs implicated in the microbiological contamination of the waters of Kribi beaches are of human origin (Rodríguez et al., 2021). These are mainly enteric bacteria, i.e. from the intestines of humans or warm-blooded animals and brought into the environment via their excreta: discharges of treated and untreated sewage on land, ships, ballast water, livestock effluents (animal feces), stormwater discharges, rainfall runoff and other diffuse sources (Assako Assako et al., 2010; Manini et al., 2022).

Several causes would explain the arrival of fecal bacteria along the Kribi beaches. Human contamination is mainly linked to a total absence of wastewater treatment systems in this city. Indeed, the city of Kribi has no real wastewater and faecal sludge treatment system (Assako Assako et al., 2010). The treatment plants are non-existent. Naturally, any absence or defect in the collective sanitation system can lead to the discharge of raw water into the aquatic environment, resulting in the introduction of microbial germs into the natural environment (Basili et al., 2021; Rodríguez et al., 2021). Other activities on the Kribian coast could lead to the input of enteric bacteria into the environment, in particular: recreational activities, especially when the boats are inhabited and do not have a wastewater collection system. Fecal pollution due to these activities is mainly located at marinas and fishing camps. Recreational

activities, including swimming, restaurants (contamination related to these activities is however "secondary" and their impact on coastal uses seems very low) (Weiskerger et al., 2019; WHO, 2021).

Contamination of animal origin is essentially linked to agricultural activities in the watershed of the Nyong and Kienké rivers, which flow through the city of Kribi before emptying into the sea. These contaminants would come from the leaching of grazed surfaces and the movement of livestock, which during rainy episodes, drain the contaminants present in the soil towards these rivers that flow into the sea. Rainfall would therefore be one of the main factors in the dispersal of these enteric bacteria (Di Biase & Hanssen, 2021; Manini et al., 2022). These contaminations could also be due to industries, especially agri-food industries, if their effluents are not properly treated, or to wildlife, especially poultry (Yahya et al., 2017; Edge et al., 2021). Indeed, the lack of a collection and treatment system for solid and liquid waste in the city of Kribi is conducive to the deposition of sediment, which would promote the development of microorganisms that will be evacuated to the beaches during rainy episodes. This would explain the high abundance of bacterial strains found along the Kribi beaches during the rainy seasons (SRS, LRS).

In the city of Kribi, wastewater disposal is generally done individually. Household wastewater is discharged into the environment. Apart from a few homes that have modern cesspits (about 15%), most people pour their wastewater into the yard or into poorly equipped traditional latrines in the open. The flatness of the terrain and the presence of multiple geomorphological depressions mean that domestic wastewater discharged into nature, obviously without any treatment, creates numerous stagnation points where a host of pathogenic germs, parasites and infectious disease vectors develop and are washed ashore during SRS and LRS (Assako Assako et al., 2010). In the case of hotels, which are generally located on the coast, their

septic tanks are emptied by private drainage companies. These waste are generally transported and dumped, without any prior treatment, upstream of the Nyong and Kienké rivers, which flow into the sea.

Ballast water is considered one of the most worrisome vectors of species introduce worldwide (Bradie et al., 2022). Since the deep sea port of Kribi became operational, several hundred taxa would be contained in the ballast water of ships that dock there. These are mainly planktonic microorganisms, but also pathogenic parasites, including enteric bacteria.

When microorganisms, favored by rainfall, are drained onto the coastal zone, their abundance and diffusion rate would depend on tidal range, physicochemical variables, and hydrodynamics, among other things (Di Biase and Hanssen, 2021). Tides generate and influence ocean currents (Madani et al., 2020). In turn, these currents directly and indirectly affect the movement of aquatic fauna (seedlings, fish) and the dispersion of microbes. Like the tide, winds, underwater topography, climatic conditions, and prey behavior influence the dispersal of microorganisms (Ferrarin et al., 2021, Kraus et al., 2022). Influenced in turn by tidal cycles and seasons, physico-chemical variables would have an impact on the survival and abundance of bacteria along the Kribi beaches. Indeed, the dilution that occurs immediately after the discharge is favored by the mixing of waters: currents, turbulence and tidal action. It is estimated that 90-99% of sewage bacteria are destroyed after 48 hours of suspension in seawater and that their numbers decrease with distance much faster than would be expected from simple dilution (Kraus et al., 2022). Direct or indirect sedimentation determines the momentary disappearance of bacteria. This disappearance may be temporary, as there may be resuspension of sediment and bacteria. This process is very effective in calm waters, but is reduced by the turbulence of beach waters. Some studies have shown that fecal coliforms in seawater are very sensitive to sunlight (Chedad and Assobhei, 2007). This can be

explained by the bactericidal effect of the UV fraction of solar radiation on the cell, inducing damage by release of peroxide ions that act on the cell making it permeable to inorganic salts, which then varies its osmotic pressure. This would explain the low bacterial abundance recorded on the Kribi beaches during the dry seasons (SDS, LDS). Generally, low temperatures favor the survival of bacteria in the marine environment by limiting their energetic expenditure by decreasing the metabolic activities of bacteria (Chedad and Assobhei, 2007). This explains the high concentration of bacteria observed during LRS and SRS. High turbidity of the water would limit the penetration of UV rays into the water and also contribute to reduce the efficiency of UV rays towards bacterial cells. This turbidity is due to terrigenous inputs on one hand and the other hand to resuspension by waves and current to resuspension by waves and currents, as well as the contribution of organic particles. Work has shown that the survival of fecal coliforms was influenced by the pH of the incubation medium. Indeed, basic pH levels would result in a significant decrease in fecal coliform survival (Chedad and Assobhei, 2007). Salinity is also a very important stress factor that fecal pollution bacteria undergo when they arrive in the marine environment (Hughes, 2003), where the bacteria must re-establish the osmotic equilibrium between the external environment and its cytoplasm. This re-establishment involves complex mechanisms that involve increasing the concentration of certain solutes (osmo-regulators) in the bacteria. Thus, strong variations in salinity from one environment to another tend to prevent the habituation of allochthonous bacteria to their new environment, which would lead to a decrease in their numbers. Authors have also pointed out that the presence of organic particles allows microorganisms to fight more effectively against salt stress (Pommepuy et al., 1991).

Enteric bacteria introduced into the marine environment can affect swimming water quality and cause health impacts, which can lead to the closure of affected beaches if contamination is significant and persistent (Bonadonna et al., 2019; Manezeu Tonleu et al., 2021). Enteric

diseases are among the most common infections in the world and affect the poorest and most disadvantaged communities (WHO, 2006). They are transmitted by strains present in human excreta, which contaminate soils where sanitation conditions are inadequate. Swimming in water of poor microbiological quality thus presents health risks and can lead to infections, mainly gastroenteritis, more or less severe depending on the germs involved, ear infections and dermatitis (WHO, 2006; Bonadonna et al., 2019; Manezeu Tonleu et al., 2021). In rare cases, contaminated water can also lead to more serious infectious diseases such as typhoid, cholera, etc (WHO, 1994). On the Kribi beaches, bathers would be more exposed during low tides (less dilution) and during the rainy seasons (leaching and drainage of wastewater to the coastal zone).

Conclusion

The main objective of this study was to evaluate the influence of tidal cycles and seasons on the dispersion of enteric bacteria in the waters of Kribi beaches. It was found that the waters of the beaches surveyed concentrated large quantities of bacteria indicative of fecal contamination. These bacterial strains, potentially pathogenic, originating mainly from untreated solid and liquid waste from the city of Kribi, were significantly more abundant during low tides and the rainy season. Despite the many benefits of swimming in the waters of Kribi beaches, it is not without risks to human health. Indeed, it is possible to develop infections such as enteric diseases. More serious complications such as hemolytic uremic syndrome can sometimes occur. Monitoring of fecal contamination indicators on Kribi beaches would provide useful information on changes in water quality that may occur and provide a measure for public health decision making. However, water quality monitoring results should not be the sole measure of whether an area is suitable for recreational activities. Routine monitoring for *Escherichia coli* or enterococci should be an integral part of a

preventive risk management approach to protect the health of recreational water users. It should be noted that today, the level of microbiological standards for swimming waters is generally established on the basis of epidemiological studies conducted only in temperate regions and whose results are probably not directly transposable to tropical regions; it seems important today to launch specific epidemiological studies in tropical regions to ensure the relevance of microbiological quality standards. Better management of the health risk associated with the water on the Kribi beaches requires the continuation of epidemiological studies in order to better understand the relationship between the presence of indicators and the occurrence of diseases, but also requires further study of the ecology indicator and pathogenic germs in the natural aquatic environment.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit authorship contribution statement

Paul Alain Nana ; **Rodrigue Ebonji Seth** ; **Noël Arlette Ndjuissi Tamko** ; **Victorin Rodrigue Onambélé Ossomba ; Claire Stéphane Metsopkeng**: Conceptualization, Methodology, Writing – original draft. **Geneviève Bricheux** ; **Moïse Nola** ; **Télesphore Sime-Ngando**: Supervision, review and editing.

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Figure 1 : Location map showing sampling points

Figure 2 : Physico-chemical variables according to tidal cycles and seasons. **A** : pH (CU), **B** : Salinity (PSU), **C** : Temperature (°C), **D** : Dissolved Oxygen (mg/l), **E** : Suspended Solids (mg/l), **F** : Turbidity (NTU), **G** : Total Dissolved Solids (mg/l), **H** : Electrical Conductivity (mS/cm)

Figure 3 : Bacterial abundances according to tidal cycles and seasons. **A** : Coliformes fécaux, **B** : Coliformes totaux, **C** : *Escherichia coli*, **D** : *Streptococcus feacalis*, **E** : *Pseudomonas aeruginosa*, **F** : *Vibrio cholerea*, **G** : *Vibrio parahemoliticus*, **H** : Mesophilic Aerobic Heterotrophic Bacteria

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Table I : Some hydrodynamic characteristics of the surveyed sites

	Mpalla				Ngoyè				Mboamanga			
	LDS	**SRS**	**SDS**	**LRS**	**LDS**	**SRS**	**SDS**	**LRS**	**LDS**	**SRS**	**SDS**	**LRS**
Water depth at low tide (m)	0.37	0.43	0.30	0.47	0.35	0.41	0.40	0.45	0.30	0.39	0.31	0.48
Water depth at high tide (m)	1.45	1.97	1.80	2.02	1.56	1.99	1.85	2.07	1.33	1.69	1.60	2.01
Marnage (m)	1.08	1.54	1.50	1.55	1.21	1.58	1.45	1.62	1.03	1.30	1.30	1.53
Wave current speed at low tide (m/s)	2.10	2.02	2.02	1.88	2.05	1.89	1.99	1.87	2.11	2.10	2.09	1.88
Wave current speed at high tide (m/s)	1.31	1.23	1.21	1.11	1.41	1.01	0.90	1.12	0.99	1.14	1.35	1.02

Figure

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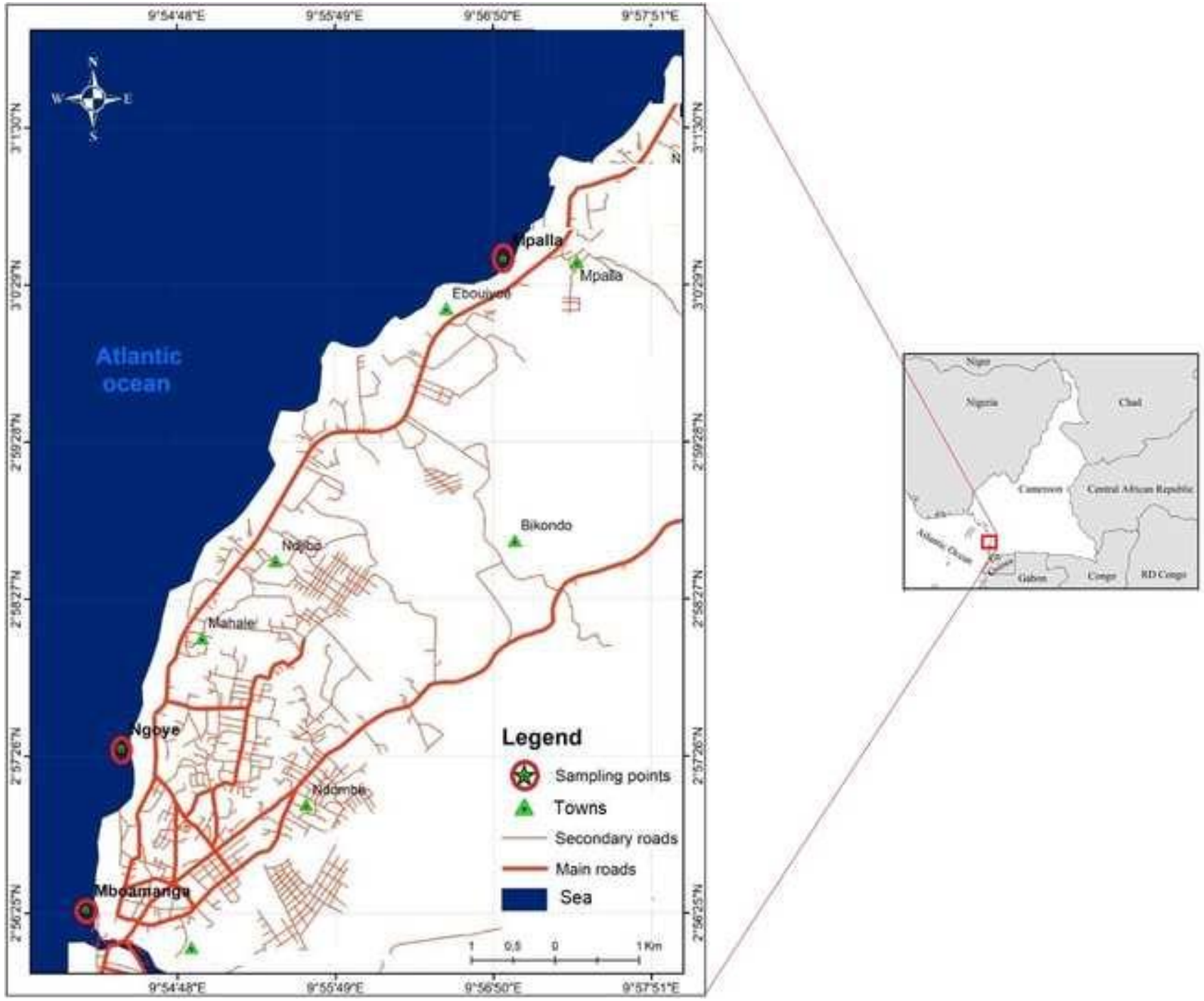

Figure

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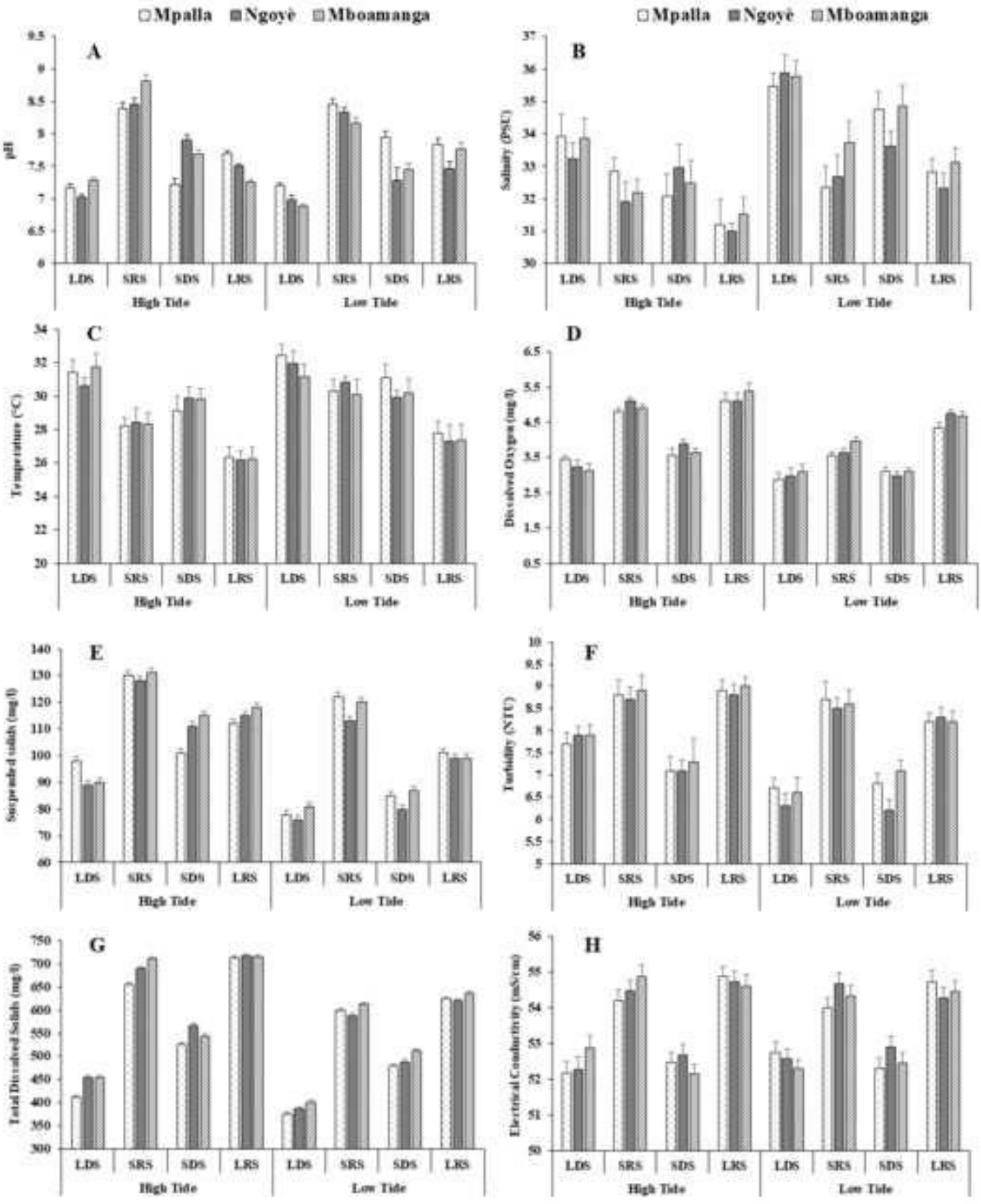

Figure

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