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Environmental Profile and Quality of bathing waters on the sandy coast of the Beach Area between Azuretti and Grand-Bassam (Côte d'Ivoire)

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Abstract

Waste discharges into the ocean area from human activities have increased in recent years. This will affect the quality of the coastal environment. The deterioration of this environment has effects on the attractiveness of beaches and the quality of bathing water. The southeastern part of Côte d'Ivoire, and more specifically the beach area between Azuretti and Grand-Bassam, is facing this reality. This work aims to understand the state of beach quality and bathing water in the atlantic Ocean along the coastline between Azuretti and Grand-Bassam. The method used consisted of measuring the physicochemical parameters of the water with a Hanna-type multiparameter, and taking water samples to determine BOD_5 and bacteriological parameters. Macro-waste was identified on the various foreshores. Sediment samples were collected to study their particle size. Five stations were visited. The variation in the values of the physicochemical parameters is between 9.05 and 9.4 for pH; 29.7 and 32.92 for salinity; 23.03 and 25.24 g/l for TDS; 30.04 and 30.52 °C for temperature; 46.08 and 50.47 ms/cm for conductivity and between 3 and 5 mg/l O_2 for BOD_5. *Escherichia coli* and Salmonella were not determined in ocean waters. Total coliforms and enterococci were identified with levels ranging from 6200 to 45000 CFU/100 ml and from 00 to 930 CFU/100 ml, respectively. The waters of stations 1; 4 and 5 would be unsuitable for all leisure activities and water sports. Plastics, plants, pieces of wood, and paper and cardboard are the most abundant macro-waste on the beach. The sediments at the various foreshore stations consist largely of medium-grained sand. Very fine sand is less abundant.

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Atlantic ocean, bathing waters, macro-waste, Grand-Bassam, Côte d'Ivoire.

Introduction

The coastline is the convergence point between land and sea. A highly vulnerable environment, it is constantly transforming due to the effects of nature and human activities (Tabar-Nouval, 2010). In Côte d'Ivoire, it provides economic wealth through several activities, including fishing, tourism, hotel services, and especially swimming. This trend is driven by a variety of physical environments and diverse forms of human settlement (Hauhouot, 2008). However, this development of coastal areas is often accompanied by various types of pollution that affect beaches and recreational waters. They can be a source of poisoning for swimmers (Festy *et al.,* 2003). In recent years, discharges of materials into the coastal environment have reached a rate of 31% (Mansour, 2003). These discharges into the ocean environment without any prior treatment of macro-waste harm its attractiveness. The Ivorian marine environment in general, and the beach area between Azuretti and Grand-

Bassam, is no exception. This project, in the southeastern part of Côte d'Ivoire, aims to understand the quality of the beach and bathing waters along the coastline covering Azuretti and Grand-Bassam. It successively focuses on the study of physicochemical water parameters, bacteria indicative of fecal pollution, macro-waste, and beach sediments.

Materials and Methods

Measurement of Hydrological Parameters and Water Sampling

Temperature, dissolved oxygen, and salinity were measured at a depth of 0.5 meters using a Hanna-type multi-parameter meter. Water sampling was carried out at five stations (Figure 1). The 1-liter bottles were immersed directly into the waters of the atlantic ocean at each station.

Sediment sampling

Sediments were sampled on the bank using a shovel. Sampling was carried out at the surface. Fifteen sand samples were collected from the mid-foreshore, lower foreshore, and upper foreshore at each water sampling station (Figure 1).

Identification of different types of waste

To accurately assess the spatial distribution of the different types of solid waste found on the beach, an information sheet was created (Table 1). This sheet presents solid waste, such as plants, fermentable waste, pieces of wood, metal, glass, textiles, plastics, cardboard, paper, and other macro-waste (pebbles, pieces of concrete, etc.).

Macro-waste was counted along a 100 meter stretch of beach at each station in the Lower Foreshore (BE), Mid-Foreshore (ME), and Upper Foreshore (HE).

Sediment Particle Size Analysis

The sampled sediments were freed of all debris. They were washed and oven-dried. Sieving was performed on a set of 12 sieves ranging in size from 63 micrometers to 2 millimeters.

Each sieve oversize was weighed using a precision electric balance. The data were used to divide the sands into five particle size classes (Folk and Ward, 1957):

- 2000 µm > Mz > 1000 µm : Very coarse sands;
- 1000 µm > Mz > 500 µm : Coarse sands;
- 500 µm > Mz > 250 µm : Medium sands;
- 250 µm > Mz > 125 µm : Fine sands;
- 125 µm > Mz > 63 µm : Very fine sand;
- Mz < 63 µm : Silts and clays.

Determination of chemical and microbiological parameters

The water samples were used to determine the biochemical oxygen demand (BOD) and bacteria levels in each sample. BOD was determined using the method prescribed by AFNOR (AFNOR, 2001). Microorganisms were identified and counted by filtering homogeneous aliquots of 100 to 250 ml through a 0.45 µm diameter membrane. Details of the analysis conditions are given in table 2.

Determination of bathing water quality

Water quality is determined by comparing the parameter levels obtained after laboratory analysis with reference values (Tables 3 and 4).

Results and Discussion

Variation of physicochemical water parameters

The pH ranges from 9.05 to 9.4. The average value is 9.29. Salinity values range from 29.7 to 32.92 g/l, with an average of 32.21 g/l. The highest TDS value is 25.24 g/l, while the lowest value is 23.03 g/l. The calculated average value is 24.74 g/l. The highest temperature is 30.52 °C and concerns station 2. The lowest temperature value is observed at station 1 (30.04 °C).

The study area has an average temperature of 30.3 °C. Stations 5 and 3 records the minimum (46.08 ms/cm) and maximum (50.47 ms/cm) conductivity values respectively. The average conductivity value is 49.48 ms/cm. In the Vridi area, the conductivity value is 52.7 ms/cm (Meless, 2018).

This value is lower than that of this work. The difference between these two values would be due to a dilution of the ocean waters between Azuretti and Grand-Bassam by the continental waters of the Comoé river. The BOD_5 levels are between 3 and 5 mg/l O_2, with an average value of 4 mg/l O_2 (Table 5). These values place the bathing waters studied in the very good suitability class for leisure.

Suitability of atlantic ocean waters for swimming

Total coliform levels range between 6,200 and 45,000 CFU/100 ml. Stations 5 and 2 recorded the highest and lowest total coliform levels, respectively. The average levels were 17,640 CFU/100 ml. Analysis of water samples from stations 1 and 3 did not reveal the presence of enterococci. They were more concentrated at station 5 (930 CFU/100 ml).

The average enterococci level was 378 CFU/100 ml. The presence of total coliforms and enterococci in ocean waters would indicate recent fecal contamination (Hayzoun *et al.,* 2014). *Escherichia coli* and Salmonella were not detected in the various water samples from the atlantic ocean (Table 6). The absence of these two types of bacteria is thought to be linked to the self-purification process of ocean waters (Hayzoun *et al.,* 2014). It can also be attributed to salinity, which is a stress factor faced by bacteria of fecal origin when they arrive in the marine environment (Hughes, 2003).

Stations ST1, ST4 and ST5 indicate fecal coliform levels above 10,000 CFU/100 ml. The waters of these stations are unsuitable for all leisure and water sports. Total coliform levels obtained at stations ST2 and ST3 are above 500 CFU/100 ml and below 10,000 CFU/100 ml. The water quality of these two stations is acceptable for recreation and water sports but requires increased monitoring. With Enterococcus levels below 100 CFU/100 ml, stations ST1 and ST3 have optimal water quality for recreation and water sports. However, stations ST2, ST4, and ST5 have water quality that is acceptable for recreation and water sports but requires increased monitoring.

Macro-waste characteristics

The beach waste between Azuretti and Grand-Bassam consists of several macro-waste types, the most significant of which are plastics, plants, pieces of wood, and paper and cardboard (Figure 2a). The high proportion of plastics on the Azuretti-Grand-Bassam coastline is due to the increase in their use for consumer products. Furthermore, Grand-Bassam beach is cited, among the marine areas of Côte d'Ivoire, as the most impacted by plastic waste (Koumi *et al.,* 2021). Plants are mainly observed in the lower foreshore. Textiles are largely observed in the mid-foreshore. Plastics are more prevalent in the upper foreshore. Fermentable waste, pieces of wood, metals, and glass are more abundant in the upper foreshore. The proportion of these macro-wastes decreases in most cases from the upper foreshore to the lower foreshore. Fermentable waste and plants are abundant at station ST5 compared to the other stations. The largest quantity of plastic waste was observed at station ST3 (Figure 2b and 2c).

Beach sand grain sizes

A specific trend in the different grain size classes is not evident from west to east (ST1 to ST5). This is explained by the westward transfer of sediments. This direction is contrary to the main drift, which is from west to east (Abe *et al.,* 2014). Stations ST1 and ST4 have a low proportion of very coarse sands (1000-2000 µm) and high proportions of medium sands (250-500 µm). Very fine sands (63-125 µm) are less abundant in the beach area between Azuretti and Grand-Bassam.

The proportions of very fine and medium sands evolve as follows: HE > ME > BE. The proportion of medium sands dominates that of the other grain size classes at all stations. For coarse (500-1000 µm) and very coarse sands, the evolution gradient is: BE > ME > HE. The evolution gradient of the proportions of fine sands (125-250 µm) is: ME > HE > BE (Figure 3). These different gradients depend on the current speed and wave height (Toure *et al.,* 2023). Silt and clays (< 63 µm) are absent on Azuretti and Grand-Bassam beaches. This could be explained by the permanent agitation of the beach by breaking waves. Indeed, fine particles are deposited in a calm environment favorable to their decantation (N'Zi *et al.,* 2018).

Table.1 Sheet for determining the different types of macro-waste

Types of macro-waste	N° station :			N° station :			N° station :		
	HE	ME	BE	HE	ME	BE	HE	ME	BE
Wood									
Metals									
Glass									
Textiles									
Plants									
Fermentables									
Plastics									
Cardboard and paper									
Others									

Table.2 Microorganism analysis Conditions

Analyses	Method	Test sample	Environments used	Incubation temperature
Total coliforms	Membrane filtration	100 ml	ECC Agar	37°C
Escherichia coli				44°C
Intestinal enterococci				37°C
Salmonella		250 ml		37°C

Table.3 Water suitability class according to BOD_5 (SEQ-Eau, 2003)

	BOD_5 levels (mg/l O_2)				
	3	**6**	**10**	**25**	**>25**
Interpretations	Very good aptitude class for leisure activities	Aptitude class good for leisure	Average leisure suitability class	Poor class for leisure	Poor aptitude class for leisure

Table.4 Water quality according to bacteria content (SEQ-Eau, 2003)

Microbiological parameters	Interprétations		
	Optimal quality water for leisure and water sports	Water quality acceptable for recreation and water sports but requires increased monitoring	Water unsuitable for all leisure activities and water sports
Total coliforms (UFC/100 ml)	500	10000	> 1000
Enterococci (UFC/100 ml)	100	> 100	> 100
Escherichia coli (UFC/100 ml)	100	2000	> 2000

Table.5 Physicochemical parameters of atlantic ocean waters

Physicochemical parameters	Stations					Average	Standard deviation
	ST1	ST2	ST3	ST4	ST5		
pH	9,05	9,29	9,33	9,38	9,4	9,29	0,14
Temperature (°C)	30,04	30,52	30,44	30,37	30,42	30,36	0,19
Conductivity (ms/cm)	50,33	50,13	50,47	50,38	46,08	49,48	1,90
TDS (mg/l)	25,16	25,07	25,24	25,19	23,03	24,74	0,96
Salinity ($^0/_{00}$)	32,92	32,67	32,9	32,85	29,7	32,21	1,41
BOD_5 (mg/l O_2)	5	5	4	3	3	4,00	1

Table.6 Microbiological parameters of water samples collected

Stations	Bacteria			
	Total coliforms (UFC/100 ml)	**Escherichia coli** (UFC/100 ml)	**Enterococci** (UFC/100 ml)	**Salmonella (UFC/250 ml)**
ST1	16800	00	00	**00**
ST2	6200	00	530	**00**
ST3	7400	00	00	**00**
ST4	12800	00	490	**00**
ST5	45000	00	930	**00**
Average	17640	00	378	**00**

Figure.1 Water and sediment sampling stations

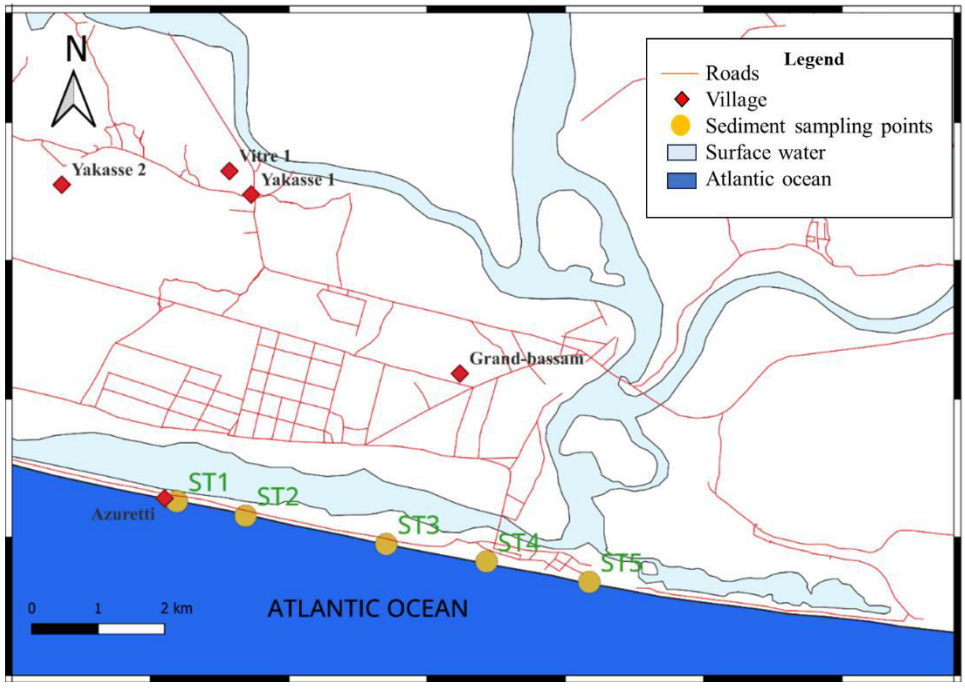


Figure.2 Nature of the discharges on the beach between Azuretti and Grand-Bassam

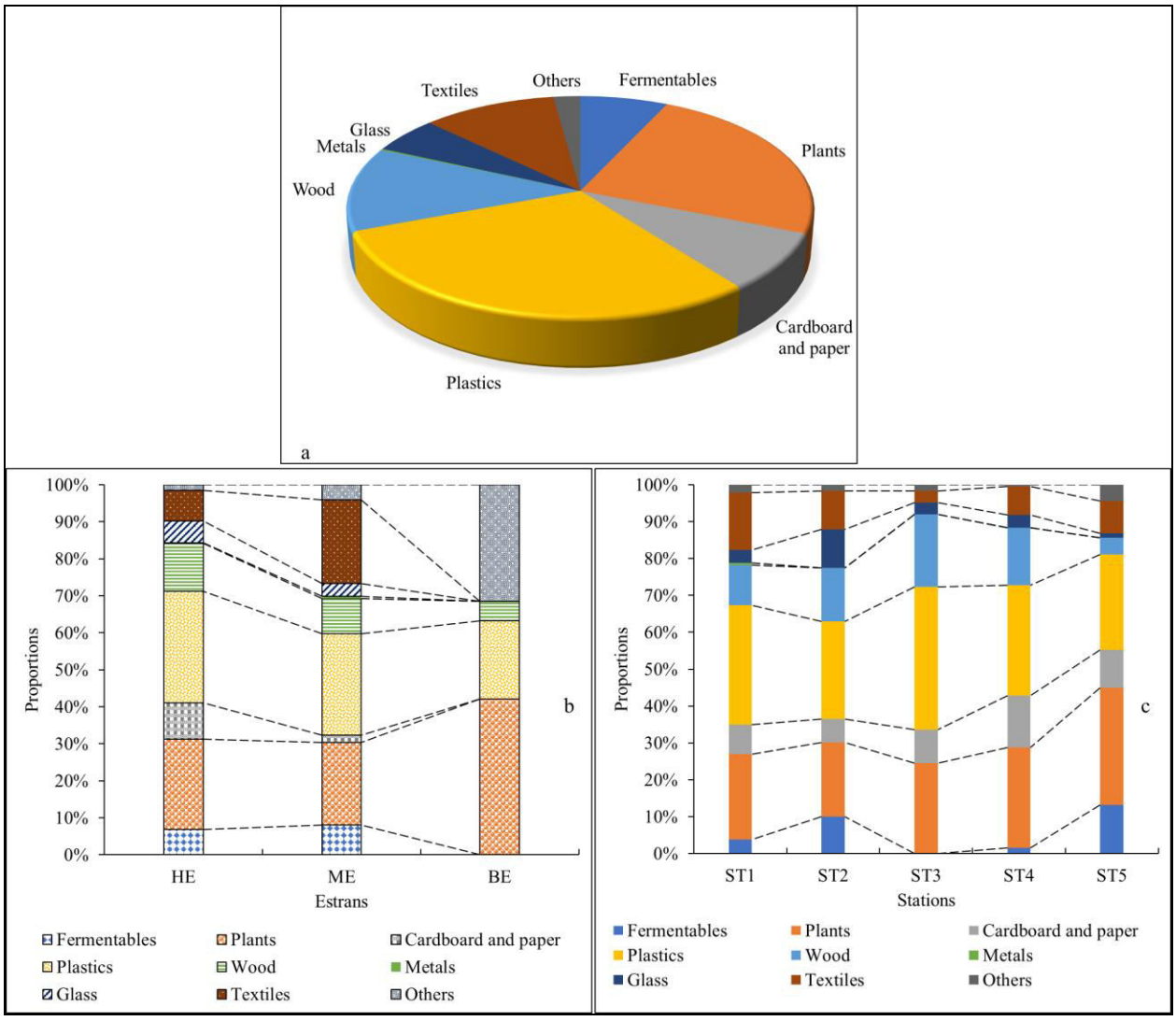
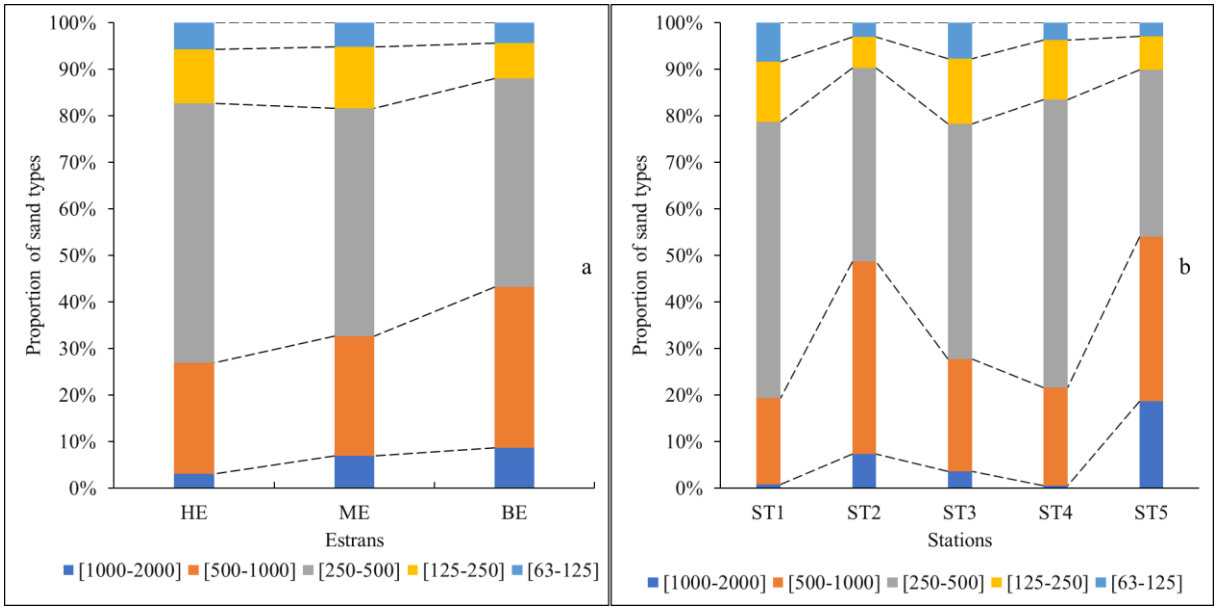


Figure.3 Granulometry of the sands on the beach between Azuretti and Grand-Bassam



Conclusion

The objective of this study was to determine the quality of the beach and bathing waters of the Atlantic Ocean along the coast between Azuretti and Grand-Bassam. The average values of the measured physicochemical parameters were 9.29 for pH, 30.36 °C for temperature, 49.48 mS/cm, 24.74 mg/l, 32.21 0/00 for salinity, and 4 mg/lO2. Total coliforms and Enterococci were determined with an average of 17,640 CFU/100 ml and 378 CFU/100 ml, respectively. *Escherichia coli* and Salmonella were not observed in the ocean waters.

Only stations 1, 4, and 5 showed waters unsuitable for all leisure activities and water sports. The observed macro-waste is dominated by plastics, plants, pieces of wood and paper and cardboard. 55.56% of macro-waste (plastics, paper and cardboard, pieces of wood, metals and glass) is found mainly in the upper foreshore, 22.22% (fermentables and textiles) in the mid-foreshore and 22.22% (plants, others) in the lower foreshore.

The transfer of sediments from West to East and towards the West does not allow a particular evolution of the size of the sand grains going from station 1 to station 5. Stations 1 and 4 have a high proportion of medium sands. Very fine sands are less abundant. Silts and clays are absent due to the agitation of the area. Coarse and very coarse sands have a higher proportion in the lower foreshore. The proportion of medium sands is higher compared to other fractions on all foreshores.

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