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Evaluation of Solid Wastes, Physico-Chemical Parameters and Tidal Variations in the Mangrove Ecosystem of Wouri Estuary: The Case of "Village" and "Bois des Singes".

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Abstract-The paper presents the results of an evaluation of solid wastes, physico-chemical parameters and tidal variations in the mangrove ecosystem of Wouri estuary in the localities of "Village" and "Bois des Singes" in Douala. The methodology consisted of a survey, direct observation and a waste composition study. Interviews were conducted to determine the prevailing ecological and human health problems, their causes and impacts. Water samples collected during high and low tides from four sites designated as (S1, S2, S3, S4) in both case study areas, analyzed and tested in the laboratory for physico-chemical parameters such as temperature, turbidity, total dissolved solids, suspended solids, pH, salinity, conductivity, biological oxygen demand, dissolved oxygen, nitrates and phosphates. Waste composition analysis reveals that the mangroves of "Village" were heavily contaminated with plastic waste packaging's (51, 3%), followed by plastic bottles (40, 3%) while "Bois des Singes", was contaminated with plastic bottles (22, 6%), and domestic waste (22, 6%). The average readings of some physico-chemical parameters during the low and high tides for S1-S4 for "Village" and "Bois des Singes" were either within the normal range with no significant difference $p>0.05$ or with a significant difference ($p<0.5$). Typhoid and malaria were the most prevalent diseases while contamination from fecal coliform and streptococcus increased during high tides for both study areas.

Keywords*: Solid Waste, Waste Composition, Mangroves, Contamination, Tidal Variations*

I. INTRODUCTION

In mangrove ecosystem nutrients are considered as the most important parameters that influence growth, reproduction and metabolic activities of biotic components. The distribution of nutrients is mainly based on season, tidal conditions and fresh water influx from land [1]. The mangrove vegetation of western Africa is closely associated to the offshore coastal ecosystem. Frequently influenced and disturbed by seasonal freshwater and diurnal tidal flooding and contamination from solid wastes, with features of an immature ecosystem, namely low species diversity and high productivity. The excess organic production is exploited by many marine species especially fishes and crustaceans that enter the mangrove environment as juveniles and return to the sea as adults for reproductive purposes [2].

In Cameroon mangrove vegetation is mostly limited to estuaries with seasonally high rainfall and river flow which has led to extensive mudflat development. Throughout these areas, *R. racemosa* is the pioneer species, colonizing recently deposited alluvial soils up to the level of daily tidal flooding and the mangrove vegetation forming tall gallery forests along the Wouri Estuary of Douala) attaining a height of 40m and 1m trunk diameter [3] [4] [5]. Notwithstanding, [6], noted that, the *Nypha spp* is also distributed throughout the mangroves of the Wouri estuary in Douala [6].

A. *Ecological importance of mangroves*

Mangroves are known to play a critical role in the protection of coastal areas (shoreline and seashore protection, stabilization of coastal and shoreline substrate) against natural disasters such as floods. They also protect the aquatic and marine biodiversity reservoirs, spawning grounds and fisheries reproduction areas, regulation of climate with high capture and storage of carbon dioxide. For example, they store more carbon dioxide than rainforests in Central Africa adjacent to the mangroves [7].

B. *Main threats to Mangroves*

The development of large urban centres with significant industrialization poses a number of threats to the mangrove vegetation. Thus, around Abidjan, Côte d'Ivoire, industrial pollution has adversely affected the coastal lagoons and their associated mangroves [8] [9]. In Cameroon, the effects from Douala port extension, urban expansion, sand extraction and industrial pollution have caused damage to the mangroves of the Wouri estuary [5]. This condition is made worse by human activity through the construction of illegal settlements along the Wouri estuary and in particular in the localities of "Village" and "Bois des Singes"

The aim of this study was to make an evaluation of solid wastes, physico-chemical parameters and tidal variations in the mangrove ecosystem of Wouri estuary in the localities of "Village" and "Bois des Singes" in Douala. This will enable us have an in-depth knowledge of the functioning of mangrove ecology, the prevailing problems, the causes, the impacts and make recommendations based on data collected in the field for the conservation and sustainable management of mangrove estuaries in Cameroon.

II. MATERIAL AND METHODS

The study was carried out in the localities of "Village" and "Bois des Singes", in the Wouri estuary of Douasla between April and October 2015. The methodology consisted of a survey including direct observation and a waste composition study by measuring the weights of each waste fraction with an electronic balance and the average percentage compositions using descriptive statistics. Interviews were conducted to determine the prevailing ecological and health problems in the case study areas, their causes and impacts. Contamination from fecal coliform and streptococcus was investigated by collecting water samples in 1000ml, fine categorized screw-capped sterile plastic bottles and put in a handy cooler box having ice boxes to maintain the 4^{o}C temperature before getting to the Laboratory as recommended by [10] [11]. Analysis of the collected samples was carried out in the Hydrobiology, Environment and Bacteriology Laboratories of the Faculty of

Science, University of Yaounde 1, taking into consideration quality control procedure for water quality analysis as recommended by[10].

III. RESULTS AND DISCUSSION

A. Composition of solid waste

The results of the waste composition study reveals that the mangroves of "Village" were heavily contaminated with plastic waste packaging (51, 3%), followed by plastic bottles (40, 3%), (Figure 1). The mangroves of "Bois des Singes", were mostly contaminated with plastic bottles (22, 6%) and domestic waste (22, 6%), (Figure 2). The results of this study is in line with a recent study [12] in a typical rural community with domestic wastes and plastic bottles as predominant waste fractions. The predominance of plastic waste packaging and bottles in the study areas can be explained by the interplay of the low and the high tides at the Wouri estuary as well as the high rainfall recorded during the study period of July, August and September considered the raining season of Cameroon.

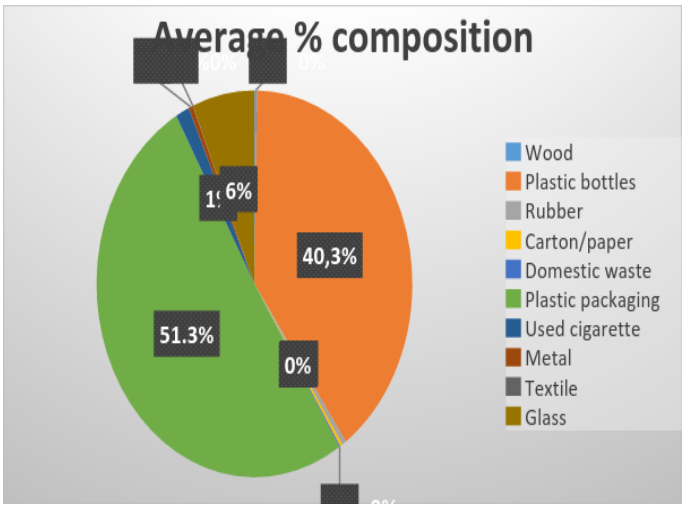

Figure 1: Average waste composition in "Village"

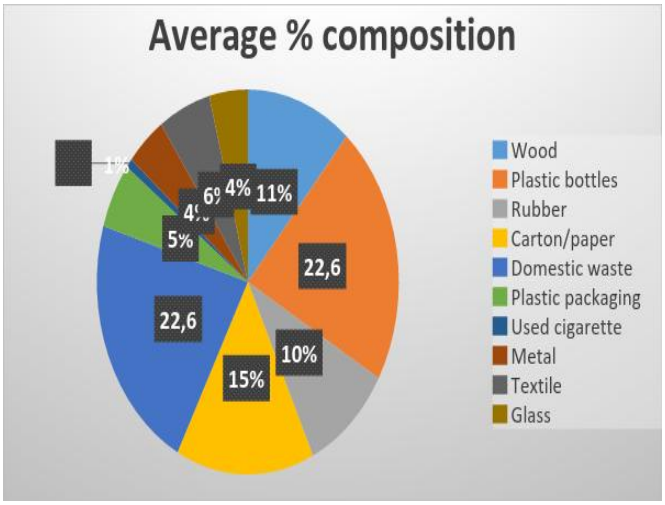

Figure 2: Average waste composition in "Bois des Singes"

B. Disease prevalence in the study areas

The results also revealed the prevalence of typhoid (259), cases followed by Malaria (202) in "Village" (Figure 3) and for "Bois des Singes" (Figure 4), with malaria (251) and typhoid (212) cases registered in the local health center during the study period. Interview results indicates that the frequency of occurrence of the aforementioned diseases was higher during the high tides for both case study areas.

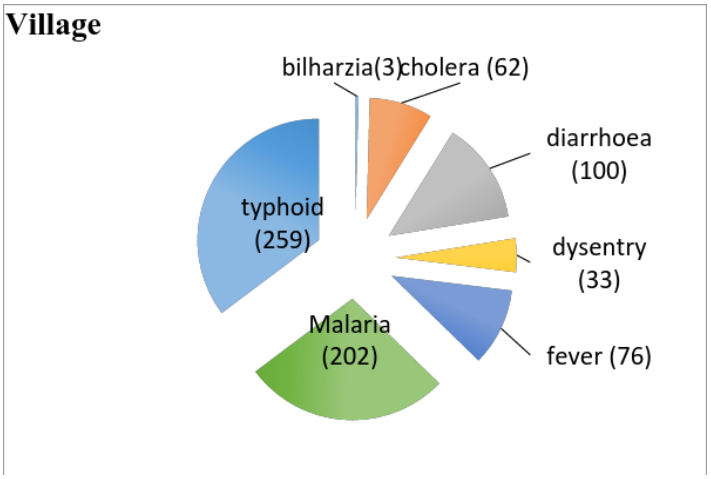

Figure 3: Frequency of disease cases recorded in "Village"

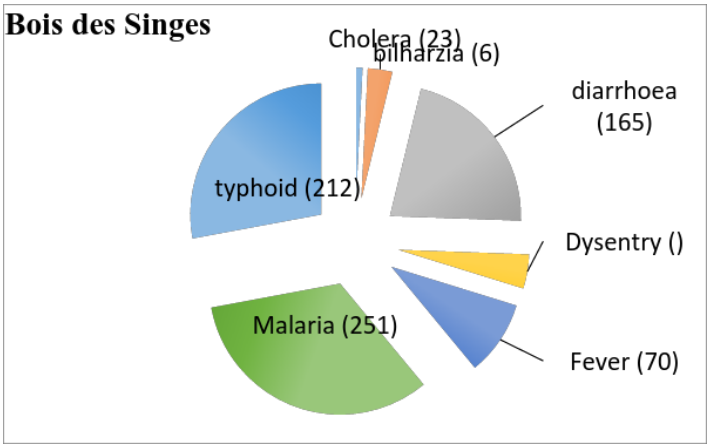

Figure 4: Frequency of disease cases recorded in"Bois des Singes"

Contamination from fecal coliform and fecal streptococcus increased during high tides for both study areas (Table 1). The results falls short of WHO standards which stipulates zero coliform or streptococcus in drinking water [13].

Table 1: Average readings of fecal coliform and fecal streptococcus (CFU/100ml)

Biological parameters for **"Village"**				Biological parameters for **"Bois des Singes"**				Site No.
Fecal streptococcus Average reading(CFU/100ml)		**Fecal coliform** Average Reading (CFU/100ml)		**Fecal streptococcus** Average reading(CFU/100ml)		**Fecal coliform** Average reading (CFU/100ml)		
High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	
408.000	-	22.000	11.000	67.000	184.000	41.000	9.000	S1
270.000	57.000	56.000	91.000	206.000	45.000	94.000	47.000	S2
261.000	82.000	19.000	13.000	207.000	40.000	68.000	35.000	S3
419.000	20.000	-	45.000	210.000	68.000	26.000	12.000	S4

C. Surface water analysis during the low and high tides

Results from the analysis of the surface water for physico-chemical parameters during low and high tides are shown below in Tables 2&3.

1. Physical parameters

The average temperature readings during the low and high tides for S1-S4 for "Village" and "Bois des Singes" were within the normal range (26^0C -28.5^0C) (Table 2). Slight fluctuations in the temperatures of S1-S4 may be due to the influence of environmental temperature which is in line with [14].

Site S3 for both "Village" and "Bois des Singes" were more turbid during low and high tides (Table 2) with less visibility. According to [15] higher levels of turbidity are associated with disease causing bacteria.

The average value for Total Dissolved Solids (TDS) showed an increase as the tide rises and decreases as the tide retreats. The very high values of the range 82 – 475 mg/100ml (Table 2). is within the EPA and WHO recommended 500 ml/L.

The results show higher values during high tides for suspended solids in all the four sites in "Village" when compared to "Bois des Singes" (Table 2).

Table 2: Average readings during low and high tides for physical parameters at "Bois des Singes" and "Village"

Physical parameters **"Village"**								Physical parameters **"Bois des Singes"**								Site No.
Suspended solids (mg/l)		Total dissolved solids (mg/l)		Turbidity (NTU)		Temp (^{o}C)		Suspended solids(mg/l)		Total dissolved solids (mg/l)		Turbidity (NTU)		Temp (^{o}C)		
High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	
30	10	481	420	59	41	27	28.5	15	60	82	474	36	35	26	27	S1
50	10	480	410	48	27	28	28.5	10	55	350	475	22	25	26	26.5	S2
40	5.0	12	483	47	43	26	26.5	55	15	322	359	47	67	27.5	27	S3
40	10	09	473	38	35	27.5	28.0	60	20	370	422	49	35	27	26.5	S4

2. Chemical parameters

The pH varied from 7.2 to 7.3 during the low and high tides for all the four sites in "Village" and "Bois des Singes" (Table 3). Usually fluctuations in pH values during low and high tides is attributed to factors like removal of CO_2 in photosynthesis, through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity, temperature and decomposition of organic matter [16] [17] [1].

Salinity was higher during the high tide and lower during the low tides (Table 3). Salinity at low tides can cause large changes in the water content [18] thus influencing the pH and conductivity level.

The conductivity values varied from 405 to 940 ds/m (Table 3). According to [19], conductivity is an important parameter to assess the water quality. Any change in the concentration of sulphates and chlorides are reflected in corresponding changes in the conductivity.

Dissolved oxygen was found with a range of 80.7.-86.3% (Table 3) which is far beyond acceptable standards and according to [20], is influenced by temperature and salinity. The increase in dissolved oxygen due to photosynthesis of algae during the day could increase the formation of nitrate in the water. An influx of wastewater or untreated human sewage from household and industrial area could also increase the concentration of nitrate [21].

Nitrates as well as phosphate concentration increased with low tides, but with no significant difference at the different sites for "Village" and "Bois des Singes" (Table 3). The high concentration of nitrate during low tide can also be attributed to the inhibition of nitrate reduction and stimulation of nitrification by the increase oxygen supply through benthic algae photosynthesis [18].

Table 3: Average readings during low and high tides for chemical parameters at "Bois des Singes" and "Village"

Chemical parameters **"Village"**														Site No.
Phosphates (mg/l)		Nitrates (mg/l)		Dissolved oxygen (%)		Biological oxygen demand (mg/l)		Conductivity (µS/cm)		Salinity (°/00)		pH		
High tides	Low tides	High tides	Low tides	High Tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	High tides	Low tides	
6.1	7.32	5.4	4.2	84.2	83	10	30	936	817	0.4	0.3	7.3	7.2	S1
6.7	6.2	4.1	4.2	86.3	84.2	10	50	938	789	0.4	0.4	7.3	7.3	S2
5.3	5.03	4.0	4.0	80.7	82	5.0	40	413	940	0.2	0.4	7.3	7.3	S3
7.4	7.01	4.3	4.9	81.6	83	10	40	405	920	0.2	0.4	7.3	7.2	S4

CONCLUSION

The results of this research study on solid wastes, physico-chemical parameters and tidal variations in the Mangrove Ecosystem of Wouri Estuary has interlinking economic, environmental and health implications. The economic aspects in the decline of mangroves due to man's activity is from the indiscriminate felling of mangroves for firewood and the construction of makeshift structures. The environmental, public and human health issues arises from the uncontrolled dumping of solid waste impacting heavily on the wellbeing of the locals in "Village" and "Bois des Singes" and beyond. It is on this basis that the study recommends the active participation of ecologists, oceanographers, environmentalists, health practitioners, policy makers, Non-Governmental Organizations (NGOs), Educational Establishments and the authorities of the Douala urban councils to work together to protect our mangrove ecosystems from declining. The Douala urban council working in collaboration with the Cameroon Wildlife Conservation Society/ Coastal Forests and Mangrove Conservation Programme and the Institute of Fisheries and Aquatic Sciences, University of Douala, at Yabassi had in many occasion undertook reforestation programmes for mangroves in the localities of "Village" and "Bois des Singes" but with very little success. It is on this basis that this research work recommends that for any future actions a combination of both reforestation and behavioural change programmes be taken onboard.

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