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Impact of Industries on Water Quality and Local Population Activities of Wetland's Areas of Littoral Region, Cameroon

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Summary: *The present work evaluates the impact of industrial pollutants on the physicochemical quality of Bonaberi and Akwa North mangrove swamps. To that effect, 18 random samples of water have been taken from upstream to downstream in the two said mangrove swamp. Immediately after this sampling, the samples were transported to the Laboratory of ichthyology and applied Hydrobiology and the Soil and Environment Sciences laboratory of the University of Dschang in order to determine their level of phosphate, magnesium, iron, potassium, ammonia, ammonium, total nitrogen, sulphate, sodium, calcium, nitrate, nitric.The temperature, the pH, the electrical conductivity and the dissolved oxygen were determined in situ. Moreover, survey were carried out with the riverside population in a random manner without any distinction of sex or age. The data obtained were submitted to the one factor variance analysis. The comparison of these two mangrove swamps were done using Student test. In general, the main results revealed that the different physicochemical characteristics of water are affected by the industrials discharges from the upstream to the downstream. However, excluding the iron (6.4mg/L and 5.4mg/L respectively in Akwa North and Bonaberi) and the phosphorus (24.84mg/L and 15.86mg/L in Akwa North and Bonaberi respectively) the average level of the different physicochemical parameters of the water remain conformed to the standards.The discharges emission in these mangrove swamps considerably affect human activities (70.15% expresses the scarcity of fish).*
Keywords: *wetlands, population, physico-chemical parameters, mangroves*

I. Introduction

Wetlands are ecosystems where water is the main factor controlling the environment and the associated plant and animal life (Ramsar, 1971). They are characterized by shallow water covering the land and include the mangrove halophytic forest of tropical coasts (Iltis, 1994; Ramsar, 1971). Classified among humid zones by the Food and Agricultural Organisation (FAO), wetlands are particular ecosystems with an impressive biodiversity feeding 55% of the world's population (FAO, 2003). The improvement of the water quality along industrial areas represents at the same time an environmental and an economic challenge (Kablan, 2013). The chemical industry in Cameroon is one of the driving and dynamic field of the whole socioeconomic set. This technological advancement is responsible for an increased pressure on the environment in general and on the wetlands in particular. Bonabéri alone, shelters around half of the industries of the economic capital of Cameroon, Douala (OSEED, 2005), which are sources of diverse pollutants contrarily to Akwa North which is almost devoid of industries but there we mentioned the presence of some household compare to Bonaberi. The objective of this work is to contribute to the lasting management of discharges from industries in the water along the wetland's areas of Akwa North and of Bonabéri through an identification of the water's qualities and their impacts on the local populations of these areas.

II. Material And Methods

2.1- Description of the study area

The two highest industrial areas (Bonaberi and Bassa) enlarge a surface of 342 ha. They are managed by the Mission of Equipment and Management of Industrial Zone, housing a wide number of industries operate in Douala, the economic capital and most populous town in Cameroon. Bonabéri alone, regroups 42 industrials enterprises, we also notice that there we have 55 manufacturing enterprises (Essombé, 2007). These industries work in diverse fields as metallic transformations, joinery, painting, polish and printing ink, water production and distribution, electricity, hydrocarbon, plastic manufacturing, paper, batteries, matchsticks. Bonabéri include almost 21% of the mentioned industries in Douala town. However, Akwa North is not mentioned among the industrial zones of Douala (Essombé, 2007), this zone is taking into consideration to our investigation because of her location. Then, it is the main reason is the focus of our choice.While, by the global position system, Akwa

North is on the downstairs of Bonabéri. Furthermore, Akwa North is the section of many household what is not observed in Bonabéri. The two studied areas (Akwa North and Bonabéri) are travelled by a complex of stream and river with several delta forming a two-way network with one identity of these humid areas. The two zones are mantled by the administrative departments of Nkam, Wouri and Sanaga-Maritime.

2.2- Sampling methods and physicochemical analysis

- **Data sampling**

Six (06) points of measurement have been taken into consideration among which 03 points in Akwa North and 03 in Bonabéri, taking into account a certain number of elements notably the representativeness of the wetland's area. Water samples from Bonabéri and Akwa North have been taken upstream, close downstream and far downstream of each wetland's areas. Noticed that upstream is the wetland section directly before the industries, the downstream is the wetland section at certain miles of the upstream and the far downstream is at the ending so far to upstream.The water samples were carry in a plastic flasks (500 ml to 1L) washed beforehand in the water of the site and transported at low temperature (4°C) in moveable cool boxes. The conservation of the samples of sewage has been done according to the guide of conservation and manipulation of samples of ISO 5667/3.

- **Population sampling**

According to the population sampling we used to make questionnaires, interviews, and fields observations. The investigations conducted on the bordering populations have been made randomly without distinction of local population's sex and age, and amount 85% of the entirely population was investigated to determine the perception of the inhabitants of the study sites. The interviews were made nearby the delegation of environment and nature protection of littoral region to know exactly if the industries are conform to the regulation and law about industrial wastes management and what does these law talks about. The field's observations helped us to have an idea on the qualities of wastes in the quarters for example solid wastes if it come from households, hospitals or industries.

- **Physicochemical analysis**

The physicochemical parameters were monitored included temperature, pH, colour, dissolved oxygen, ammonia-N, conductivity, phosphates, magnesium, alkalinity and sulphates. The temperature, pH, dissolved oxygen and water conductivity were measured in situ by an EUTECH brand pH-meter, a thermos-oxymeter and thermos-conductimeter respectively.For the determination of concentrations in minor and major elements, the acute toxicity tests were conducted according to Standard Methods (Rodier, 2009). Five test concentrations (dilutions) of water sample were used. Each water sample concentration was tested in duplicate and the experiments were repeated once to evaluate variability and the average values of toxic end-points.

- **Data analysis**

Data collected were submitted to one way ANOVA using the statistics software SPSS v16. To analyse data from the local population, the results are expressed at 100% of the total population.

III. Results And Discussion

3.1- Origin of pollutions in Akwa North and Bonabéri wetlands

Table 1 shows the Origin of pollutions in Akwa North and Bonabéri wetlands

Table 1: Activities generator of pollution and their impacts on Bonabéri and Akwa North wetlands

Activities	Pollutants	Impacts on wetlands
Marine transport	Domestic and hydrocarbons wastes	- Accumulation of lead and others metals. -Increase on the level of mortality in the fauna and flora, ecological disorder or toxically species appearance.
Cement production Paint production Soap production	Acids, mercury, lead, copper, phosphates, organics substances	Lead and mercury accumulation and others heavy metals and decrease of productivity
Plastics production	Basic monomers	Accumulation of non-biodegradables minerals
House activities	Human wastes and organics matter	Eutrophisation and oxygen diminution, destruction of young trees
Buildings	Solids wastes and buildings	- Soil erosion -Habitat and vegetation loss

Water pollutants in general and in Bonabéri and Akwa North mangroves swamps are recognized to have several origins. The table 1 shows different activities generating marine wastes and their impacts on mangroves swamps. Numerous industries are responsible for water pollution of Bonaberi and Akwa North wetlands. These industries carried different activities wish determine their effluent (agroindustry, cement industries, metallurgy, chemicals and tanker).The installation of these industries not far from the aquatic areas carry away a huge number of pollutants in water (Ngongang, 2012). Domestic wastes, hydrocarbons, acids, heavy metals like lead, mercury, copper, chloride, phosphates, organic matters; solids wastes; sediments were traced. These hence on heavy metals accumulation (lead), the increase of the fauna and flora level of mortality, ecological disorder, toxically species appearance, water turbidity and sedimentation, Oxygen Biological Demand enhance, non-biodegradable minerals accumulation, habitat loss (Ngongang, 2012).

3.2- Water quality of wetlands of Bonaberi and Akwa North

The water quality of Bonaberi's and Akwa North's wetland is measured in two parts: the first is measured in situ and the second is measured in the laboratory.

3.2.1- Parameters measured in situ

Table 2 shows the parameters measured in situ

Table 2: Parameters measured in situ in the Akwa North and Bonabéri Wetlands

	Parameters	**pH**	**OD**	**T (°C)**	**Conductivity (µS/Cm)**	**Colour**
Wetlands	**Bonabéri**	6.98±0.13	2.36±1.41	21.27±0.04	0.5±0.00	black
	Akwa North	6.92±0.80	3.15±0.60	21.29±0.05	0.5±0.00	inebriate
	Standard value	6.5-8.5	18	24	$\leq 2700\times10^6$	

- **Temperature**

The in situ measure of temperature in mangroves swamps water gave value not off 30°C (table 2), values in conformity with Cameroonian standard (Jora, 2011; Rodier, 2009) related to surface water with are in the range of 21, 27 to 23°C. The studies conducted by Kahoul *et al*. (2013) at Agadir in Morocco gave the similar results of temperatures, which fluctuate between 17, 98°C and 21, 5°C.

- **pH and conductivity**

The electric conductivity and pH of Bonaberi and Akwa north mangroves swamps are in standard (table 2). As the matter of fact, the local reglementation required for these parameters in case of surface water the following values: 5.5 to 8.5 for the pH and ≤2700ms/cm for electric conductivity (Jorra, 2011). These results are similar to the studies conducted by Mbomba *et al*., 2007; Kahoul *et al*, (2013) in Morocco in sea water of Agadir where they find the pH value between 6.8 and 8,3.

- **Disolved oxygen**

According to the dissolved oxygen, which is 3,15mg/L at Akwa North and 2,36 mg/L at Bonabéri (table 2), all these value are less than the standard authorized which is 8mg/L for the temperature between 20 and 25°C (Jora, 2011 ; Rodier, 2009).

3.2.2-Parameters measured in the laboratory

Table 3 shows the Parameters measured in the laboratory

Table 3: Variations of chemical parameters of water at each sampling in the wetlands of Bonabéri and Akwa North

Wetlands	**Akwa North**			**Bonabéri**		
Parameters **(mg/L)**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**
Nt	9,80±0,98[a]	7,7±2,2[a]	16,8±6,92[a]	21±00[a]	37,1±9,89[a]	22,75±21,28[a]
Ca	0,07±0,14[a]	0,06±0,04[a]	0,10±0,01[a]	0,11±00[a]	0,13±0,14[a]	0,14±0,14[a]
Mg	0,24±0,28[a]	0,22±0,18[a]	0,41±0,24[a]	0,47±0[a]	0,55±0,16[a]	0,81±0,04[a]
K	74,49±6,95[b]	48,32±3,24[a]	66,58±14,67[b]	84,41±00[a]	94,58±0,0[b]	107,6±3,74[b]
Na	59±4,94[b]	48,5±0,80[a]	60,75±2,4[b]	56±00[b]	57,25±2,47[b]	78,25±2,47[a]
P	41,9±56,5[a]	17,98±1,28[a]	14,65±4,28[a]	11,02±00[a]	15,56±4,7[a]	16,7±2,1[a]
PO_4	2,37±3,1[a]	0,15±00[a]	0,25±0,14[a]	0,19±0,13[a]	0,44±0,28[a]	0,21±0,03[a]
NH_4	0,025±0,03[a]	0,26±0,01[b]	0,08±0,007[b]	1,07±0,8[a]	0,74±0,84[a]	1,34±0,53[a]
NO_2	0,05±0,014[a]	0,025±0,007[b]	0,06±0,0[b]	0,04±00[a]	0,04±0,0[a]	0,06±00[a]
NO_3	2,5±0,7[a]	2±00[a]	2,5±0,05[a]	5±4,24[a]	1,5±0,70[a]	3,5±0,70[a]
Fe	1,96±1,46[a]	7,2±5,9[a]	1,03±2,95[a]	7,16±00[a]	6,64±2,2[a]	1,44±0,73[b]
$S0_4$	199,2±7[a]	288,8±105,9[a]	246,9±30,2[a]	284,7±00[a]	308,5±24,39[a]	246,85±23,3[a]

The averages bearing the same letters on the same line are not significatively different (P>0,05). P= probability, Sig= significativity, NS= non significant, *= significa

Whatever the wetlands, the level of total nitrogen, calcium, magnesium, phosphate and nitrate for the different points of sampling are not significatively different (P>0,05 ; table 3) and remain less than the authorised norm which is 30mg/L for the nitrogen, 20mg/L for the calcium, 1370mg/L for the magnesium, 3mg/L for the phosphate and 20mg/L for the nitrate respectively (Rodier, 2009). The level of potassium in the close downstream in the wetlands of Akwa North are comparable (P<0,05 ; table 3) in upstream and far downstream of the wetland. While these levels differ significatively in far downstream of Bonabéri compared to the upstream and the close downstream. These values remain less than the authorised norm which is 1500mg/L (Jorra, 2011). The low significant value observed in Bonaberi can be explained by the fact that the system still have a strong capacity of self-purification by the potassium.

The level of sodium in the close downstream of the wetland of Akwa North is comparable (P<0,05 ; table 3) from the upstream to the far downstream of the wetland, meanwhile the upstream of the Bonabéri's wetland presents some significant differences from the close downstream to the far downstream of the wetland.

The levels of ammonium are not significatively different (P>0,05 ; table 3) in the wetlands of Bonabéri but remain greater than the authorised norm which is 0,5mg/L (Rodier, 2009); meanwhile in the upstream of the Akwa North wetland it is significatly different (P<0,05 ; table 3) from the close downstream and the far downstream and remain less than the norms. Ammonia-N being the final major product of the protein catabolism excreted by aquatic animals (Monkiedje *et al.*, 2004), its significantly low excretion could be ascribed to the decrease of the density of organisms in these wastes. The levels of nitrites are not significatively different in the Bonabéri wetlands (P>0,05 ; table 3) whereas in the Akwa North upstream they are significatively different from the close downstream to the far downstream (P<0,05 ; table 3).

The levels (table 3) of iron in Akwa North wetland are not significatively different (P>0,05) compared to Bonaberi's wetlands where the upstream is significatively different from the close downstream to the far downstream (P<0,05 ; table 3). These levels in the two wetlands remain greater than the authorised norm which is 0,12mg/L (Rodier, 2009). These approximately high values can be explained by the fact that the power of self-purification has been overcome by this parameter and the proximity of Bonaberi's wetlands not far from the industries. The levels (table 3) in sulphates do not present any significant difference in the two wetlands (P>0,05). But they remain greater than the authorised norm which is 150mg/L (Rodier, 2009; Jorra, 2011). The general variation of some physico-chemical parameters of the water of the wetlands of Bonaberi of Akwa North are presented in table 4.

Table 4: Variation of some physico-chemical parameters of the water of the wetlands of Bonaberi of Akwa North

Variables (mg/L)	**Wetlands**		**P**	**Sig**
	Akwa North	Bonabéri		
N_t	11,43±4,76[a]	25,67±10,28[a]	0,09	NS
NH_3	0,0006±0,0003[a]	0,006±0,003[b]	0,04	*
NH_4	0,18±0,12[a]	1,36±0,38[b]	0,007	*
NO_3	0,19±0,07[a]	0,21±0,05[a]	0,89	NS
NO_2	7,7±0,95[a]	11,5±7,56[a]	0,43	NS
P	24,84±14,85[a]	15,86±0,79[a]	0,35	NS
PO_4	0,32±0,41[a]	0,12±0,049[a]	0,45	NS
Ca	0,078±0,24[a]	0,12±0,20[a]	0,06	NS
Mg	0,29±0,11[a]	0,62±0,17[a]	0,05	NS
K	67,59±16,9[a]	93,88±14,11[a]	0,107	NS
SO_4	245±44,85[a]	276±29,74[a]	0,36	NS
Fe	6,4±4,21[a]	5,4±3,5[a]	0,75	NS

The averages bearing the same letters on the same line are not significantly different (P>0,05). P= probability, Sig= significance, NS= non significant, *= significant.

In general, except for the ammonia and the ammonium which levels are comparable (P<0.05; table 4) in the two wetlands, the others are not. However, these values are lower than the standards. Indeed for a surface of water the admitted values are 10mg/L for the ammonia and 0,1mg/L for the ammonium (Rodier, 2009). The significant difference of levels of ammonia and ammonium between the wetlands of Bonabéri and Akwa North may be due to the plant substance found in water, but also the organic or human substances. As a matter of fact, the downstream of the pollution centers is characterised by the concentrations in ammoniacal nitrogen (ammonia and ammonium) in the order of 0.5 mg/L to 1mg/L (Rodier, 2009). Ammonia-N being the final major product of the protein catabolism excreted by aquatic animals, its significantly low excretion could be ascribed to the decrease of the density of organisms in these microorganisms (Monkiédjé *et al*., 2004). These results are similar to the works done by Priso *et a*l, (2014) in Kribi, Cameroon where he found the different levels of ammonium in those four sampled points. In actual practice, the total nitrogen is an indicator of pollution of the system and its control helps to follow the evolution of the contaminations. In our case, the intensity of the variations of the total nitrogen, during the study remains low (table 4). The values are 11.43 in Akwa-North and

25.67 mg /l in Bonabéri, and remain lower the standards which is 30 mg/l (Hajji *et al.*, 2013).The levels of phosphorus do not present any significant difference between the wetlands (P>0.05; table 4). However, the levels are 15 times greater than the authorised norm in Bonabéri and 24 times higher in Akwa North which is 1mg/L (Rodier, 2009). In fact, the phosphorus is an indicator of eutrophication which acts as a sign of the increase of plant substance in waters (IBGE, 2005), this could explain the presence of total nitrogen close to the authorised norm which is of 30 mg/l (Davis, 1975a). These data are not sufficient to determine which of these wetlands is more polluted.

The table 4 shows equally that the levels of phosphate, nitrate, and sulphate in the mangrove swamps are not significantly different (P>0.05). These values are respectively 0.32mg/L; 0.19mg/L; 2.45mg/L in Akwa North and of 0.12mg/L; 0.21mg/L and 2.76mg/L in Bonabéri. They remain lower than the authorised norms which are 3mg/l for the phosphate, 20mg/l for the nitrate, and 150mg/l for the sulphate (IBGE, 2005). The results are in line with those found by Kahoul *et al*., 2013.The average values of calcium, magnesium and potassium obtained in Akwa North and Bonaberi are not significantly different (P<0.05; table 4) between the wetlands (respectively, 0.078 mg/l; 0.29 mg/l and 67.59mg/l in Akwa North and 0.12 mg/l; 0.62 mg/l and 93.88 mg/l in Bonabéri). Indeed, these values remain lower than the authorised norm which is 20 mg/l for the calcium, 1350 mg/l for the magnesium and 1500 mg/l for the potassium (Rodier, 2009).

The results obtained for the levels of iron in the waters have not shown any significant difference (P>0.05; table 4) between the two wetlands, though the average value is higher in Akwa North than in the wetlands of Bonabéri (6.4mg/L and 5.4mg/L, Table 4). These values are however above the authorised norm which is 0.12mg/L (IBGE, 2005); this reveals a metallic pollution of the two mangrove swamps. Metallic pollution observed in the wetlands could indeed be explained by the corrosion of canals or the usage of iron salt for the coagulation-flocculation treatment (Rodier, 2009). Besides, we notice that the level of iron is higher in Akwa North (6.4mg/L) than in Bonabéri (5.4mg/L) compared to the authorised norm which is 0.12 mg/l (Jorra, 2011). This could explain the presence of the slope observed with the GPS coordinates on the site. The discharged pollutants in the wetlands of Bonabéri are washed out towards the Akwa North wetland which is a place of accumulation very rich in minerals. This observation is the same concerning the levels of phosphorus: 24.84 mg/L in Akwa-North and 15.86 mg/l in Bonabéri (table 4); and remain largely higher than the authorised norm which is 1mg/l (Rodier, 2009).

3.3-Impact of pollutants on the means of existence of the riverside residents

3.3.1-Main activities in Akwa North and Bonaberi's wetlands

The activities which are been practices in this village are fishing which occupied 40.30% of the population been interview, followed by steaming fish with 25.31% (figure1). Activities such as trade, breeding and extraction of sand are the less practices in this village with the respective percentages of 4.48%, 2.99% and 1.49% (figure1). These results are the same with those of Ajonina (2004) in the mangrove of Cameroon; Feka *et al*., (2009) in Ivory coast; and of Njifonjou *et al*.,(2005) in the mangrove of the estuary of Wouri in Cameroon . As a matter of fact, in the context of malnutrition represent one fundamental activities and in the same time as alimentary complement and as a possible way of numerating in Cameroon in general and in the region of littoral in particular by sales of fish. The city of Douala is the principal center for consumption of aquatic product in Cameroon (Desse, 2003). The inhabitant without distinction of sex that are in between 11 and 15 year in the village are the most efficient (figure 2) about 21% of the population appears in the categories of resident carried out fishing and 13% steam of fish. Meanwhile the habitant which are more than 26 year in the zone do not practice any activities 11% (figure 2). This weak activities register in this final cut will be to the fact that they are in the majority of septuagenarian devoid of highly physical force. According to Ajonina *et al*., (2005) fishing is an activity which required much physical effort and which might explain the highly register activities which have passed 11 to 15 year in the zone of study and it is between 18 to 40 year in this categories of resident.

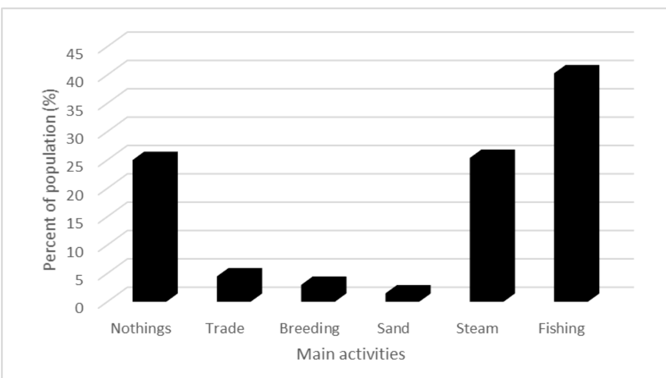

Figure 1: Main activities of local populations of Bonaberi and Akwa North wetlands

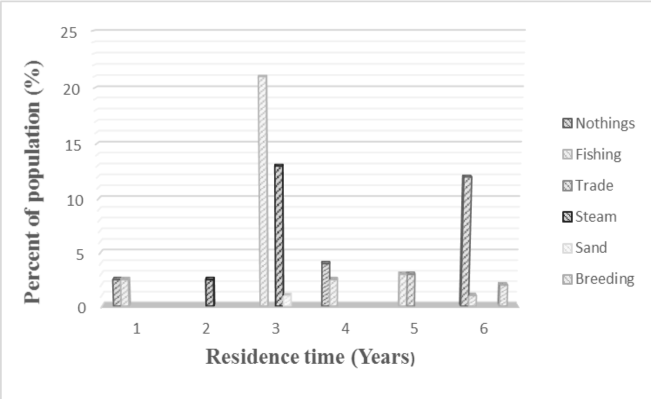

Figure 2: The relation between the residence time of wetlands's population and the main activities

3.3.2- The local population's perception of industrial waste in Akwa North and Bonaberi wetlands

Since the implementation of industries around the mangrove of Bonaberi and Akwa North and for a while, 70.15% of the total population interview find infrequency of fish resources meanwhile 13.43% of these same local population raised the problem of flood and 1.49% of the population complaint of the rise of prices of aquatic resources (figure 4). The salty areas around the bay and the basin of sea are areas of reproduction of the maritime life which the majority of the population depends for their existence (Adam *et al.,* 2010). According to Akpofure *et al*., (2000) 60% of fishes in the golf of Guinean reproduce in the mangrove Forest of Niger Delta the oil spill have a harmful impact in aquatic resources (Akpofure *et al.,* 2000) according to Aworawo (2000) the population leaving in the Niger Delta experience the method incontestable any endemic poverty. Besides, the last author observed that the pollution tanker upon coastal who supplies the population over fish trained any stress of the poverty and that of malnutrition according to member of the community interview in function of time of residency (figure 3). Throughout this investigation in the Fields they have been a massive reduction of the fish catch by fishermen or around 80% of the total population interviewed have mentioned the problem of scarcity of fish (figure 4). We have equally noted that during the study, that location pollution doily oils certain fish were fleshy convert with oil they remain non eatable why others floating without life on the surface of water.

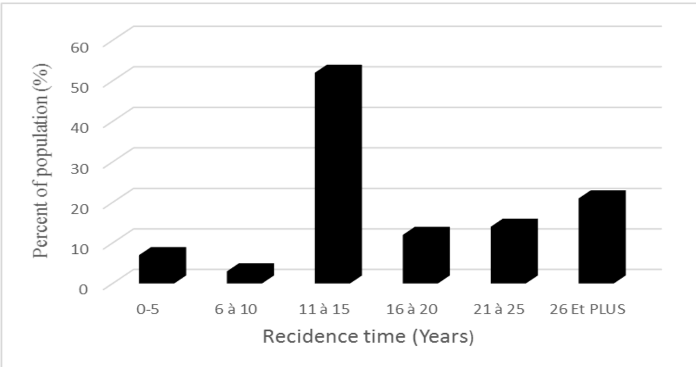

Figure 3: Relation between the residence time and the population main activities in Akwa North and Bonaberi wetlands

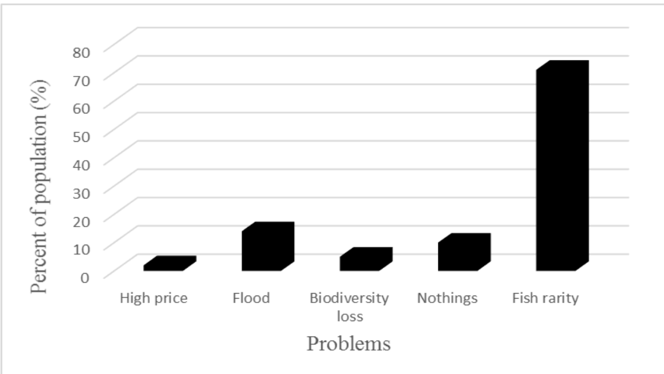

Figure 4: Problems due to industrials wastes in Akwa North and Bonaberi wetlands

IV. Conclusion

The follow up and the physico-chemical characterisation of the Akwa North and Bonabéri mangrove swamps show that they are a source of contamination to the aquatic environment. A pre-treatment of the wastes does not always end up in a total purification and sometimes leaves remains of pollution able to the change the structure and the functioning of the natural ecosystems. A control of the sources of pollution is thus necessary to put in place a system of physico-chemical and biological treatment before discharging in the environment. This control should also concern the receiving system and the long term impact of micro pollutants on the natural environment.

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