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RESEARCH ARTICLE

STUDY OF CONTAMINATION BY METALLIC ELEMENTS IN COASTAL SEDIMENTS: CASE OF THE COTONOU CHANNEL

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Abstract

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Coastal aquatic ecosystems are environments increasingly affected by human activities due to urban discharges and their use as dumps. The objective of this study is to determine the profiles of metallic elements concentration (Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, and Pb) of Cotonou channel sediments and to evaluate their quality. For this, surface sediments (0-5cm) were sampled at 13 sites along the channel. Thus,Geoaccumulation Index (Igeo), Enrichment Factor (EF) and Sediment Pollution Index (SPI) were calculated to assess the chemical quality of these sediments. The metal contents of the sediments follow the following order of abundance: Fe >Al>Mn> Zn >Cr>Cu > Co> Ni >Pb> As> Cd. The "Igeo" geo-accumulation index and the Enrichment Factor "FE" reveal moderate polymetallic contamination by several elements. The results show Fe, Co, and Ni being the most concerning. As for the Sediment Pollution Index (SPI), it reports low, moderate and high pollution of sediments.

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Introduction:-

Estuary or coastal lagoon sediments constitute the ultimate reservoir of various materials from the continent. Many of these substances, heavy metals for example, come either as a result of natural processes or from human activities. In recent decades, the contribution of anthropogenic inputs to the enrichment of sediments has increased considerably. Many aquatic ecosystems, whose banks have been urbanized and industrialized, are characterized by sediments rich in metallic elements. A significant fraction of heavy metals present in aquatic environments is associated, in a reversible manner, with surface sediments (Srarfi et al, 2010). The stock of trace metals can reach such large proportions that a sudden desorption would be of great danger (Kikouama O., et al, 2009). It is therefore essential to study the dynamics of these elements in surface sediments to understand their future in all aquatic systems. From an ecological and socio-economic point of view, high concentrations of metallic micropollutants in the sediments through sorption and desorption phenomena can have harmful consequences on the fauna and flora of the lagoon and on oyster farming about embryogenesis of oysters (larval stages or calcification of the shells).

The Cotonou Channel, a body of water that connects Nokoué Lake to Atlantic Ocean by crossing the city of Cotonou is not spared from metal pollution. It experiences significant urban and industrial activities which are not without negative effects on the quality of the water and sediments of the channel (Badahoui et al, 2009). There are many polluting sources, the main ones being (i) the discharge of all kinds of wastewater from the city of Cotonou and put directly into the channel by users of the Dantokpa International Market, (ii) urban development (Hotel and

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artisanal centeranou), (iii) uncontrolled household waste dumps, and (iv) river transport activities. Currently the entire ecosystem is affected. Thus the objectives of this study are: i) to determine the concentration of heavy metals and their spatial distribution in the surface sediments of the Cotonou channel, ii) to assess the quality of the sediments and its link with the urbanization of the channel and iii) to predict the potential toxicity of the sediments.

Materials And Methods:-

Sampling

The surface sediments were sampled in March 2018 at the level of the surface layers (0-5cm) using a schipeck grab then brought to the surface on board the boat where they were collected, packaged and sealed in bags of polyethylene. Samples were then transported cold in coolers to the laboratory where they were kept in the freezer and freeze-dried before being subjected to the various s chemical analysis (Salvarredy, 2005).

Table 1 and Figure 1 presents a brief description of the sampling sites selected for the study.

Analytical techniques

Method of determining the water content of sediments

The water content corresponds to the hydric state of the sediment. The wet sediment is weighed in triplicate with a precision balance (2-10g) and dried under a laminar flow hood for 5 days. It is then placed in a desiccator for 24 hours, then weighed again. The water content of the sediments is determined by weight difference according to the following formula:

$$W\,(\%) = \frac{\text{weig ht of wet sediment} - \text{weig ht of dried sediment}}{\text{weig ht of wet sediment}} \text{ x } 100$$

Particle size analysis

Particle size analysis of a sediment consists of determining the proportion of the various classes of particle size. The gravimetric sieve method was used. After the sediment has dried, a mass of 100g is removed and then placed on a 63µm mesh sieve. The whole is sieved manually in the absence of a mechanical agitator. Subsequently, the contents of the sieve and the sieve are weighed to determine the sample fraction greater than 63 µm and that less than 63 µm.

Total concentration of metals (Al, Fe, Mn, Co, Pb, Cd, Cu, Zn, Cr, and As) in the sediment

The metallic elements of the sediments were analyzed using ICP-OES (Optical Emission Spectrometry Coupled with Inductive Plasma) (device: Thermo Scientific, ICAP 6000 Series) andICP-MS (Mass Spectrometry Coupled with an Inductive Plasma (device: Thermo Scientific, ICAPQ Varian 820-MS) after total mineralization of the sedimentary fraction ≤ 63 µm. This is carried out according to the protocol proposed by Ouddane(2004)and modified by Billon(2001). Approximately 200 mg of sediment were introduced into a Teflon reactor and 5 mL of hydrofluoric acid 40%, 5 mL of hydrochloric acid 37% and 2.5 mL of nitric acid 69% were added. Mineralization is carried out in the microwave (CEM Corporation, Mars 5 x-près) at 180°C for 25 minutes and the hydrofluoric acid is neutralized by adding 4% boric acid. At the end of the neutralization, the supernatant was poured into a Teflon flask tube of 50 mL which was supplemented with ultra-pure water to the volume then analyzed.

Sediment quality assessment

Three indices were calculated to assess the metallic contamination of the Cotonou Channel sediments: the Geo-accumulation Index, the Enrichment Factor (EF) and the Sediment Pollution Index (SPI).

a) Geoaccumulation index (Igeo)

This is a criterion for determining the level of metal pollution introduced by Müller (1981). It is based on comparing the concentration of a metal in the sediment studied with that from the regional geological background according to the following formula:

$$\text{Igeo} = \frac{\log \frac{[\text{Me}]\ \text{sed}}{1{,}5 \times [\text{Me}]\ \text{Background}}}{\log 2}$$

[Me] sed: mass concentration of the element Metal in the sample;
[Me] Background: mass concentration of the Metal element in the geochemical background;

Müller (1981) defined a scale of values with six classes depending on the intensity of the pollution. This scale stipulates that: Igeo< 0 (class 0): without contamination; 0~1 (Class 1) with no to slight contamination; 1~2 (class

2): moderate contamination; 2~3 (class 3): moderate to heavy contamination; 3~4 (class 4): heavy contamination; 4~5 (class 5): High to extreme contamination and Igeo> 5 (class 6) indicates extreme contamination.

b) Enrichment Factor

It was determined to understand whether heavy metals are present in high concentration compared to their concentrations in the earth's crust as a result of anthropogenic pollution. It isexpressed by the following formula:

$$EF = \frac{[Me/X]sed}{[Me/X]Background}$$

Me sed: mass concentration of the element Metal in the sample;
X sed: content of the reference element in the sample;
Me Background: mass concentration of the Metal element in the geochemical background;
X Background: content of the reference element in the geochemical background.
The reference element comes exclusively from the natural terrigenous source. It is often selected from Al, Li, Sc, Zr, Ti and Th or sometimes Fe or Mn.

The background or geochemical background of the metal indicates the concentration of metal in the sediments where there is no anthropogenic input (Memet and Bülent., 2012). Due to the unavailability of the geochemical background in the estuarine system of the channel, we considered the sample from site 13 (Enagnon) as representative of the geochemical background for the sediments studied, given its location far from the major industrial and urban anthropogenic effects..

According to Sakan et al (2009) and Han et al (2006), EF<1.5 indicates that the sediment is not contaminated, 1.5 <FE <10 the contamination is moderate and FE > 10 indicates that the contamination is very significant.

There is no predefined rule for the choice of the reference element except that it must be locally mainly representative of terrigenous sources (Billon 2001). For this work, we have chosen to normalize the concentrations of heavy metals measured in relation to aluminium, a major constituent of clay minerals and which proves to be a good tracer of the fine fraction. Moreover, this element is found in high concentrations in all sediments so that artificial enrichment linked to an anthropogenic contribution is unlikely and that, given that it is a refractory element, its massive diffusion towards the interstitial water or supernatant does not occur significantly (Boughriet et al, 2007).

c) Sediment Pollution Index

The Sediment Pollution Index (SPI) is the linear sum of the EFs of all the metals present in the sediment, in which the relative toxicity of each metal is taken into account by assigning it a weighting factor (Nadem, 2015). Thus, as weighting factors, a weight of 1 is assigned to Cr and Zn, 2 to Cu and Ni, 5 to Pb and 300 to Cd (Rubio et al, 2000; Singh et al, 2002). The calculation of the IPS is done by the following formula:

$$IPS = \sum(FE_m * W_m) / \sum W_m$$

- FEm is the Enrichment factor of each metal;
- Wm is the toxicity weight or weighting factor of the metal;

According to Singh et al. (2002), the IPS classifies sediments into five classes of pollution level, namely:

- natural sediment: 0<IPS <2;
- slightly polluted sediment: 2<IPS<5;
- sediment moderately: 5 <IPS <10;
- heavily polluted sediment: 10 <IPS <20;
- dangerous sediment: IPS >20.

Results and Discussion:-

Levels of metals in sediments

In lagoon, estuarine or lacustrine ecosystems, heavy metals can be mixed with sediments from where they are likely to be released to the overlying water column (Ouddane et al, 2004) where their loads can become more and higher. In fact, sediments are micropolluant traps, which give an indication of the historical pollution of water bodies (Nadem et al, 2015).

Through the study of table 2 and figures 2 to 13 from the data of our study, which show the spatial distributions of metals (Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, and Pb) in the superficial sediments of the Cotonouchannel.It is noted that the metal levels follow the decreasing order of abundance below: Iron (5053-3319 mg.kg-1), Aluminum (4770-1638 mg.kg -1), Manganese (76.38- 27.98 mg.kg-1), Zinc (33.32- 18.01 mg.kg-1), Chromium (20.80- 4.58 mg.kg-1), Copper (11.13- 1.70 mg.kg-1), Cobalt (9.40-1.79 mg.kg-1), Nickel (4.15- 2.24 mg.kg-1), Lead (3.59-1.19mg.kg-1), Arsenic (1.5- 0.6 mg.kg-1), Cadmium (0.39- 0.03 mg.kg-1).

Metals such as manganese, zinc, chromium, nickel, cobalt, copper, arsenic, cadmium and lead are those with the lowest concentrations (C<100 mg.kg-1) in sediments while aluminum and iron are at very high concentrations on all the sites. We also note that the sites of Dédokpo contain particularly high levels of cobalt and copper (9.40 mg.kg-1 and 11.17 mg.kg-1 respectively). This could be linked to household waste and the market gardening, painting and dyeing activities carried out in the vicinity of these sites. Previous studies carried out in Benin (Adjagodo et al, 2016) or in other countries (ECCC/Canada, 2016) on the fluxes of pollutants linked to anthropogenic activities in aquatic ecosystems around the world, have identified paintings, car coatings and artisanal dyeing workshops, as well as animal waste used in the manufacture of organic fertilizers and certain phytosanitary products, as being the sources of significant metal pollution in these environments.

Other sites of heavy metallic pollution of the sediments in the Cotonou channel are around Gbogbanou, Missèbo, Hôtel du Lac and Hindé; these areas are marked by the installation of uncontrolled dumping sites for household waste and outlets for sewage pipes coming from homes in the city of Cotonou.

By studying the metals concentration levels in relation to the location of the samples, we notice that the metals studied have higher concentrations in the sediments with high fine sand contents (between 50 and 60%) such as sediments from the Gbogbanou, Hôtel du Lac and SofladoDantotokpa sites. Granulometry is undoubtedly the important natural factor likely to influence the concentrations of metals in a sediment. The smaller the size of the grains that make up a sediment, the greater its ability to fix the metals present in the environment. Many authors have shown the existing relationships between the content of metallic elements and the grain size of the sediment (Yacoub et al (2009) in the lagoon of Fresco in Côte d'Ivoire, Coulibaly et al (2009) in the estuarine bays of Abidjan in Ivory Coast).

Indeed, according to Mondé et al (2011), metallic elements are mostly found in household waste and the leaching of this waste is a main source of heavy metals in aquatic environments. This also justifies the presence of a high concentration of metals on these sites which are landfill sites for household waste.

Evaluation of the chemical quality of sediments

In order to evaluate the chemical quality of the aquatic ecosystem from the metallic pollution of the sediments, three indices were calculated and used, namely: the Geo-accumulation Index, the Enrichment Factor (EF) and the Sediment Pollution Index (SPI).these parameters made it possible to assess the quality of the sediments of the Cotonou channel.

a) Geo-accumulation index

Table 2 presents the results of this geoaccumulation index for the trace metals analyzed in the sediments.

Analysis of Table 2 reveals that metals such as chromium, manganese, copper, zinc, arsenic, cadmium and lead present contamination levels ranging from nil (Igeo<0) to slight (0 <Igeo< 1) on most of the sampling sites, with the exception of the following sampling sites:

- Gbogbanou, moderately contaminated by chromium but marked by a strong presence of cadmium;
- Missèbo, moderately polluted by cadmium; and
- Dédokpo, moderately polluted by copper.

On the other hand, a moderate presence of iron, cobalt and nickel characterizes the sediments on all the sites (1<Igéo< 2), except site 5 (that of dyeing and painting activities) where a high rate of cobalt contamination is observed (Igéo> 3).

Thus, the calculation of geo-accumulation indices (Igeo), reveals that the content of heavy metals iron, cobalt and nickel on all sites exceeds the geochemical background of the study area. Also, the distribution of metallic elements in superficial sediments depends on the sources of pollution which can be natural or anthropogenic.

b) Enrichment factor

As noted above, the enrichment factor (EF) provides insight into whether heavy metals are present in high concentrations when compare to concentrations in the earth's crust as a result of anthropogenic pollution. The EF values calculated and presented in Table 3 show that metallic elements such as Cr, Mn, Cu, Zn, As, Cd and Pb have indices between 0 and 1.5 on all sites, except those below :

- Gbogbanou for chromium and cadmium;
- Missèbo for zinc and cadmium;
- Dédokpo for chromium, copper, zinc and cadmium;
- Hindé for copper, zinc and cadmium,
- and the Dantokpa wharf for copper and cadmium.

Thus, according to the classification of Zang and Lui (2000), the metallic elements such as Cr, Mn, Cu, Zn, As, Cd and Pb come from indigenous materials or natural processes that take place on the sites of the Hôtel du Lac, Direction des Pêches, Teinturerie, Kpankpan, Hlacomè, Ladji, and SofladoDantokpa, while the metallic contamination observed in the sediments of Gbogbanou, Missèbo, Dédokpo, Hindé and EmbacardèreDantokpa would have a more anthropogenic source. Because, we note that these latter sites are located not far from the deposits of household or similar waste as well as near the outlets of runoff collectors leaching the urban soils of the city of Cotonou.

Considering also the metallic elements, namely Fe, Co, and Ni, we observe EF values greater than 1.5 on all the sites with a very strong rise in this factor on the Teintureriedyeing site for cobalt and which is of 11.55. This observation seems to indicate a strong contribution of anthropogenic activities in the metal pollution of the channel, linked in particular to discharges by runoff of urban effluents and to the discharge of solid waste of all kinds into this aquatic ecosystem (Nadem et al, 2015). These enrichment factor (EF) values noted in the sediment samples are in agreement with the geoaccumulation index data (Igeo).

c) Sediment Pollution Index (SPI)

Table 3 presents the values of the sediment pollution index (SPI) calculated for each site. Examination of the data from said table allows the following observations to be made.The sites of Gbogbanou and Missèbo have the highest value of the IPS while that of the Direction des Pêches is characterized by the lowest value. According to the classification of Singh et al (2002) the sediments of sites such as Hôtel du Lac, Direction des Pêches, Teinturerie, Kpankpan, Hlacomè, Ladji and SofladoDantokpa would be affected by light metallic contamination ($0 < SPI < 2$), when those of the Hindé and Dantokpa Pier sites have a low level of pollution ($2 < SPI < 5$), accompanied by the sites of Gbogbanou, Missèbo and Dédokpo, moderately polluted and sometimes tending towards a level of heavy metal contamination ($5 < SPI < 10$). Thus, by considering the toxic effect of each metal and by accumulating the toxicities of the metals by site, it is possible to establish the sequential pollution between the sites in descending order as follows: Gbogbanou>Missèbo>Dédokpo>Hindé>Dantokpa Pier >Teinturerie>Ladji>Kpankpan>Hôtel du Lac >SofladoDantokpa>Hlacomè>Direction des Pêches>Enagnon.

This result seems to confirm the observations made on the sites along the banks and which are characterized by the presence of numerous piles of solid waste filth and outlets of sewage and runoff gutters, especially on the west bank of the Cotonou channel.

Correlation matrix

In order to compare metals and verify the similarity of their source in the sediments of the Cotonou channel, a correlation matrix was carried out. According to the Pearson correlation coefficients presented in Table 4, a positive and significant correlation exists between the metallic elements such as Cr, As, Cd and Pb and testifies to their common source of contamination (lithological source). The strongest correlations of Al/Mn, Fe/Ni, Cr/Ni, Ni/As and As/Pb suggest that the elements Al, Fe, Mn, Ni, Cr and As would present a uniform distribution in the sediments.

List of tables

Table 1:- Location and description of sampling sites on the Cotonou channel.

	Sites names	Description of potential pollution sources	Geographical coordinates	
			X	Y
S1	Gbogbanou	Solid waste drumps	04° 37'692''N	07°03'970''E
S2	Missèbo		04°37'817''N	07°03'664''E
S3	Hotel du lac	Hotel Water waste	04°38'471''N	07°02'979''E
S4	D pêche		04°38'234''N	07°03'256''E
S5	Dédokpo	Domestic water waste	04°37'963''N	07°03'865''E
S6	Kpankpan peintre	Wastewater from pain and dye	04°37'884''N	07°04'293''E
S7	Teintuerie		04°37'837''N	07°04'593''E
S8	HLacomè	Waste drumps (obsolete electrical appliances)	04°37'775''N	07°05'990''E
S9	Ladji	Déposit of trained essences	04°37'487''N	07°05'785''E
S10	Hindé	Wastewater from the city of Cotonou (collectors)	04°37'521''N	07°04'948''E
S11	Soflado		04°37'576''N	07°04'857''E
S12	Embacardère	Motorized boat station	04°37'604''N	07°04'456''E
S13	Enagnon	No anthropogenic contribution	04°38'617''N	07°02'479''E

Figure 1:- Location of sampling sites.

Table 2:- Geo-accumulation index of metals Fe, Mn, Cr, Co, Ni, Cu, Zn, As, Cd and Pb in the sediments of the Cotonou channel.

Métals Sites	Fe	Mn	Cr	Co	Ni	Cu	Zn	Cd	As	Pb
Gbogbanou	1,90	0,46	1,96	1,24	2,16	0,95	0,55	3,70	1,1	0,6
Missèbo	1,19	-0,15	0,46	1,66	1,01	0,47	0,73	2,74	0,20	-0,11
Hotel du Lac	1,67	0,99	0,72	1,85	1,66	0,54	-0,34	0,74	0,28	-0,05
Direction des Pêches	1,42	0,98	0,50	1,58	1,37	0,28	-0,30	0	0,13	-0,39
Teinturerie	1,41	0,82	0,77	3,97	1,90	0,41	-0,34	1	0,62	0,06
Kpankpan	1,35	0,17	0,66	1,81	1,47	0,63	-0,10	0,41	0,46	0,36
Dédokpo	1,33	0,19	0,89	1,08	1,22	2,40	0,74	2,32	0,20	-0,31
Hlacomè	1,46	0,96	0,32	1,45	1,28	0,14	0,13	0	0,21	-0,38
Ladji	1,12	0,13	-0,22	1,57	1,15	-0,30	-0,36	0	-0,32	-1
Hindé	1,72	-0,46	-0,11	1,65	1,19	0,84	0,76	1	-0,16	-0,13
Sofladoto Dantokpa	1,49	0,98	0,51	1,71	1,35	0,33	-0,13	0	0,23	-0,25
Embarcadère Dantokpa	1,2	-0,42	0,02	1,34	1,30	0,30	-0,12	0,41	0	-0,55
Enagnon	-0,58	-0,58	-0,58	-0,58	-0,58	-0,58	-0,58	-0,58	-0,58	-0,58

Table 3:- Enrichment Factor and Sediment Pollution Index of metals in the sediments of the Cotonou Channel.

Métaux Sites	Fe	Mn	Cr	Co	Ni	Cu	Zn	Cd	As	Pb	IPS
Gbogbanou	2,03	0,75	2,12	1,29	2,43	1,05	0,79	7,07	1,08	0,82	6,96
Missèbo	2,41	0,76	1,45	3,35	2,13	1,47	1,75	7,05	1,21	0,97	6,85
Hôtel du Lac	1,75	1,1	0,91	1,99	1,75	0,80	0,44	0,92	0,67	0,53	0,92
Direction des Pêches	1,75	1,29	0,93	1,95	1,69	0,79	0,53	0,65	0,71	0,5	0,65
Teinturerie	1,95	1,3	1,26	11,55	2,76	0,98	0,58	1,47	1,13	0,77	1,46
Kpankpan	2,13	0,94	1,31	2,93	2,32	1,30	0,78	1,11	1,15	1,07	1,11
Dédokpo	2,62	1,19	1,93	2,21	2,43	5,54	1,75	5,23	1,2	0,84	5,12
Hlacomè	1,80	1,28	0,82	1,79	1,58	0,72	0,71	0,65	0,76	0,53	0,66
Ladji	2,92	1,47	1,15	3,99	3	1,09	1,05	1,35	1,07	0,67	1,35
Hindé	5,21	1,17	1,49	5,07	3,68	2,88	2,73	3,22	1,44	1,47	3,19
Sofladoto Dantokpa	1,72	1,2	0,87	2	1,57	0,77	0,54	0,61	0,72	0,51	0,67
Embarcadère Dantokpa	3,44	1,12	1,51	3,80	3,28	1,85	1,38	2	1,5	1,02	2
Enagnon	1	1	1	1	1	1	1	1	1	1	1

Table 4 : Correlation matrix between metals Al, Fe, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, and Pb in sediments

	Al	Fe	Cr	Mn	Co	Ni	Cu	Zn	As	Cd	Pb
Al	1										
Fe	0,5556	1									
Cr	0,5993	0,6591	1								
Mn	**0,8517**	0,2478	0,1676	1							
Co	0,1052	-0,0612	0,0053	0,2576	1						
Ni	0,6711	**0,6845**	**0,8419**	0,3702	0,4217	1					
Cu	-0,1405	0,0437	0,2628	-0,2092	-0,1666	-0,0362	1				
Zn	-0,3177	0,2593	0,2538	-0,5465	-0,3213	-0,1234	0,5791	1			
As	0,6522	0,5787	**0,9181**	0,2666	0,2946	**0,9051**	0,0895	0,0815	1		

Cd	0,2385	0,4899	**0,8618**	-0,2134	-0,1505	0,5539	0,3188	0,6046	0,7072	1	
Pb	0,4841	0,6559	**0,7973**	0,0355	0,1524	0,7666	0,0868	0,2467	**0,8825**	0,6476	1

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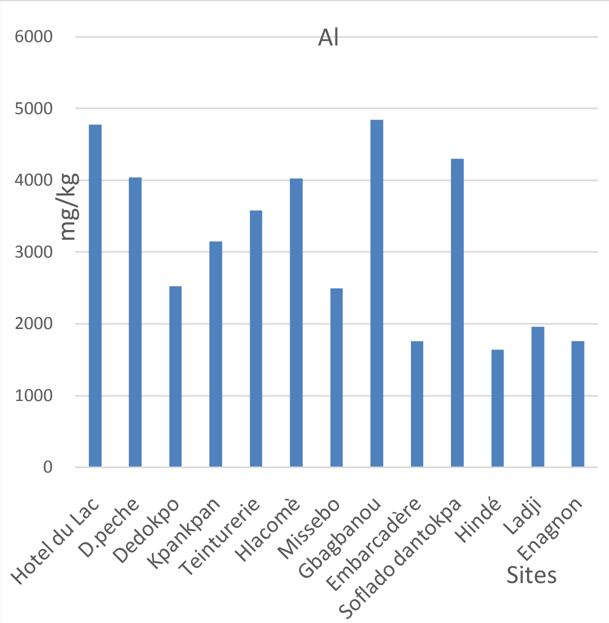

Figure 2: spatial distribution of aluminium

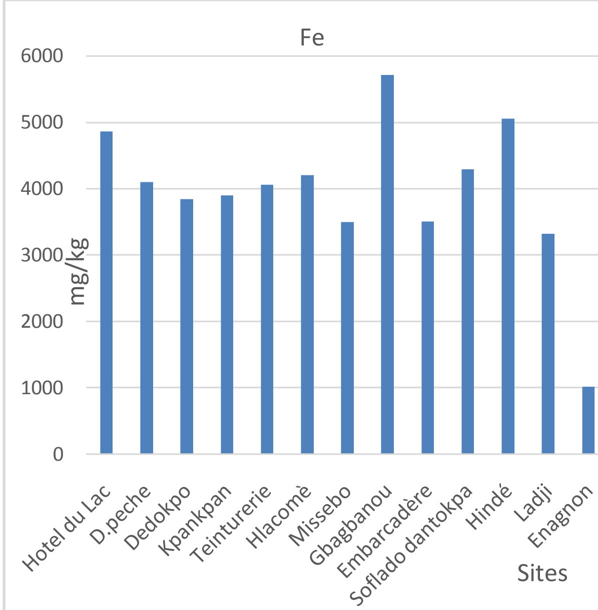

Figure 3: spatial distribution of Fer

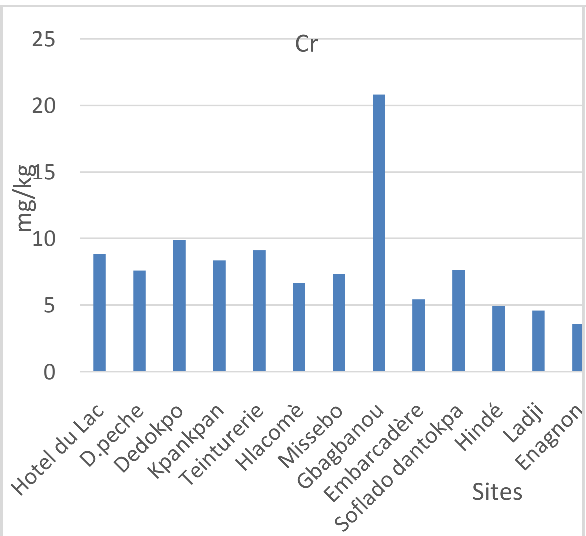

Figure 4: Spatial distribution of Chromium

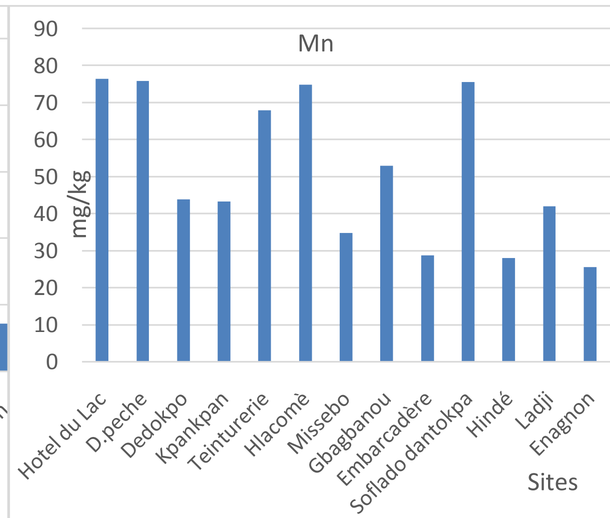

Figure 5: Spatial distribution of Manganese

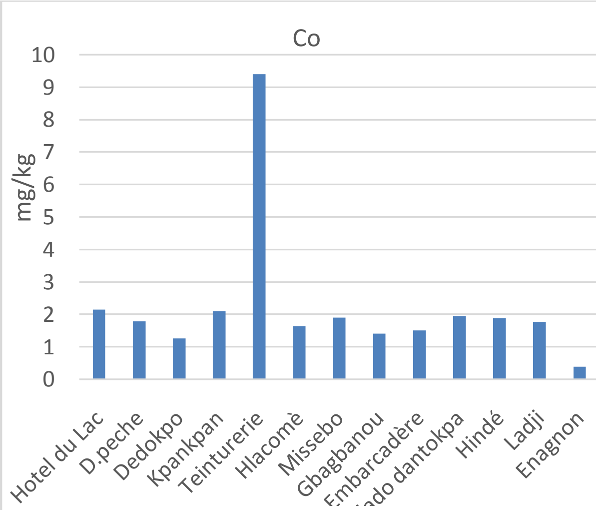

Figure 6: Spatial distribution of Cobalt

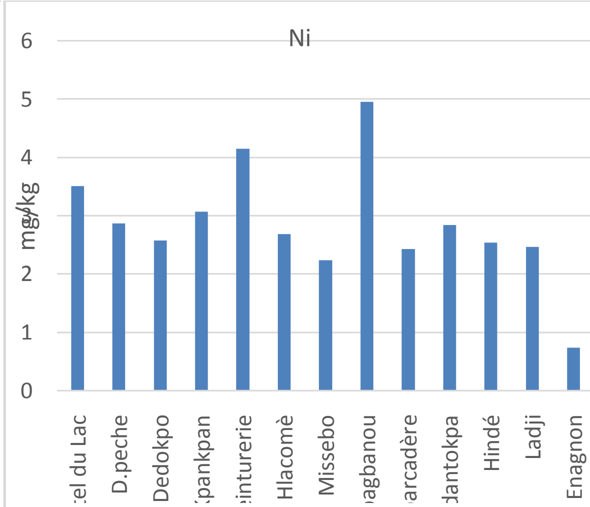

Figure 7: Spatial distribution of Nickel

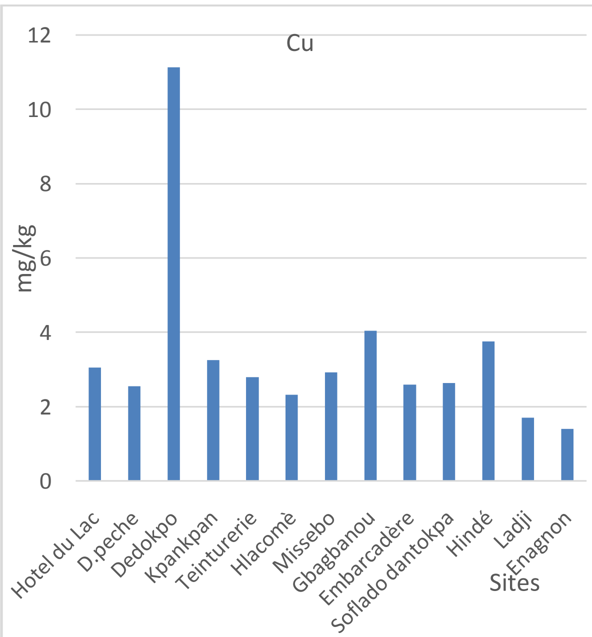

Figure 8 : Spatial distribution of Copper

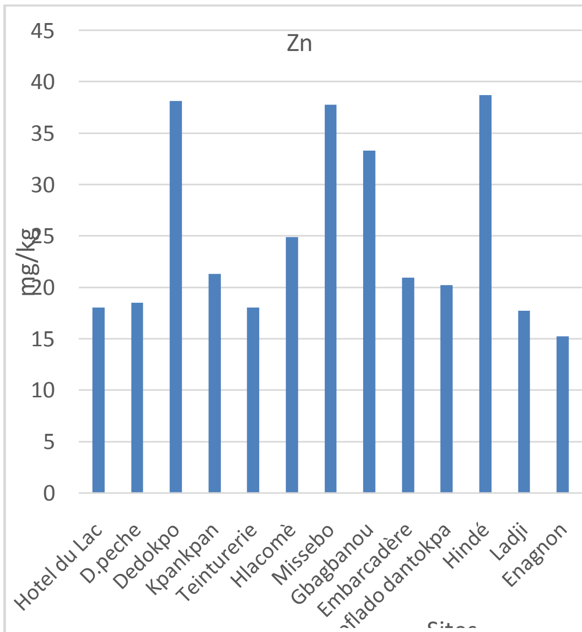

Figure 9: Spatial distribution of Zinc

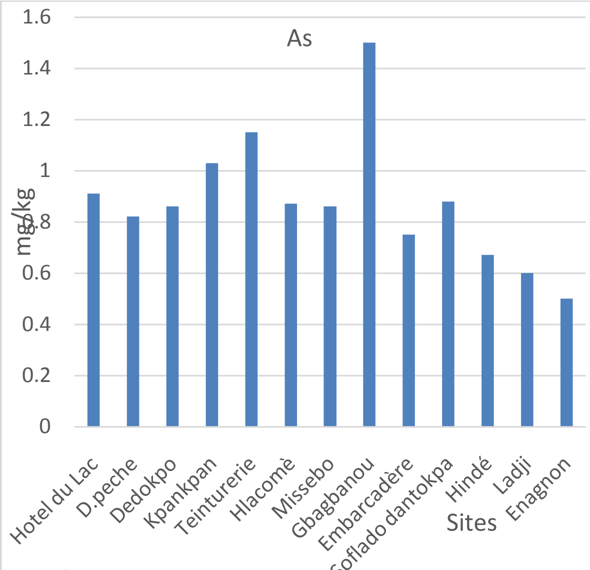

Figure 10 : Spatial distribution of Arsenic

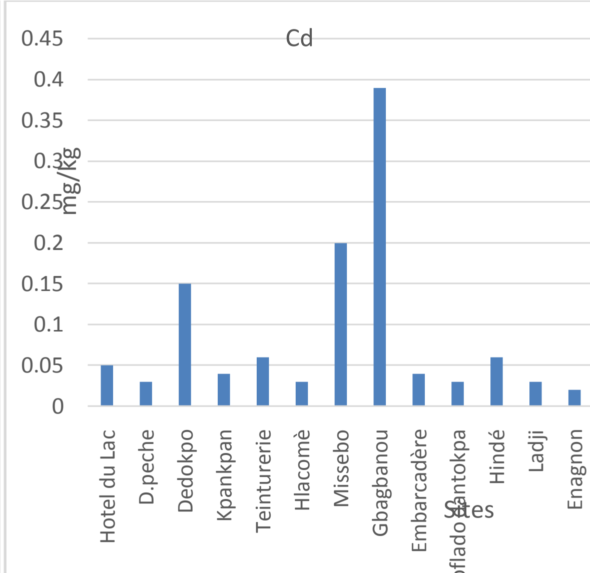

Figure 11 : Spatial distribution of Cadmium

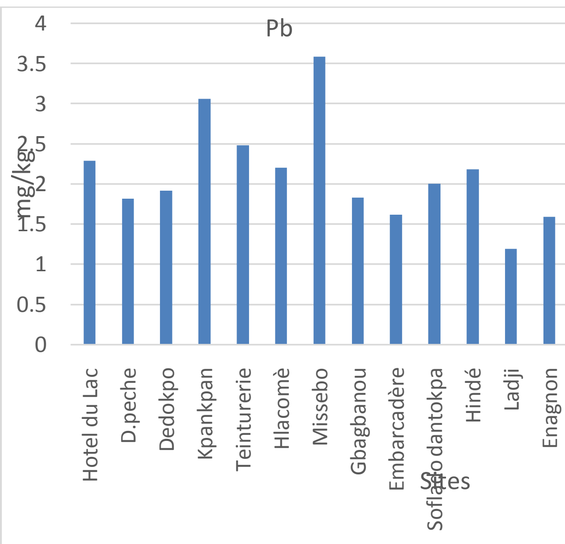

Figure 12: Spatial distribution of Lead

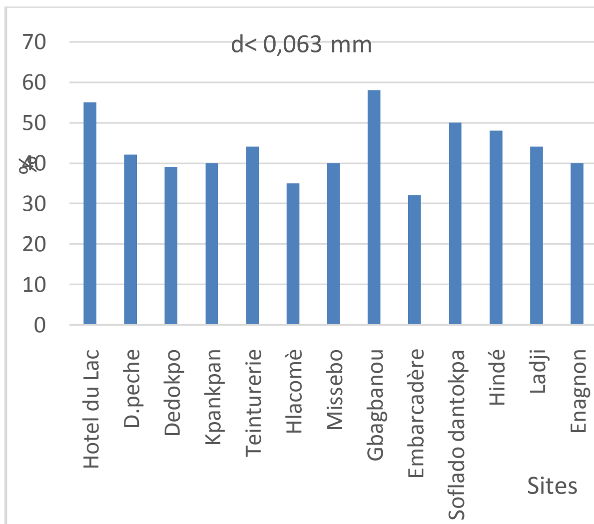

Figure 13: Mesure of fraction d< 0,063 mm

Conclusion:-

Sediment quality was assessed by calculating various indices.The metallic elements such as Cr, Mn, Cu, Zn, As, Cd and Pb would come from indigenous materials or from natural processes that take place on the sites of the Hôtel du Lac, the Direction des Pêches, Teinturerie, Kpankpan, Hlacomè, Ladji, and SofladoDantokpa, while the metallic contamination observed in the sediments of Gbogbanou, Missèbo, Dédokpo, Hindé and EmbacardèreDantokpa would have a more anthropogenic source. A moderate enrichment of the sediments in iron, cobalt, nickel was especially noted on all the sites. This study also made it possible to identify the Gbogbanou, Missèbo and Dédokpo sites as the most presenting a risk of potential dangerousness of the sediments. It is therefore necessary to draw up a sanitation plan for the banks of the Cotonou channel

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