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Assessment of Contamination Marine Sediments From Dakar Coast (Senegal) By Chlorine And Metallic Elements (Cu, Zn and Cr)

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ABSTRACT

Coastal marine ecosystems are increasingly affected by human activity due to urban and industrial discharges. The objective of this study is to assess the state of pollution in chlorine and metals (copper, zinc and chromium) of the marine sediments in the Dakar coast. The samples were taken, using a hand grab at depths of 5 cm, at the three sites studied (Ngor, Hann and Soumbedioune). Chlorine, copper, zinc and chromium were measured by photometric method. The results of the analyses showed that the sediments of Soumbedioune and Hann are more contaminated than those coming from Ngor area. The geo-accumulation index of metals showed contamination in the order Cu>Cr>Zn and the comparative study shows that the sediments of Soumbedioune are more loaded with chlorine 2 than those of Hann and Ngor areas. These results constitute basic data for environmentalists but also for those working in the protection of coastal areas and marine organisms.

Key words: contamination, chlorine, heavy metals, sediments, Dakar coast.

1. INTRODUCTION

The contamination of aquatic ecosystems by chlorine and metals (copper, zinc, chromium) remains a serious environmental problem of increasing concern **[1]**. This contamination of coastal ecosystems can be caused by the wastewater discharged into these areas. These releases cause the displacement of suspended matter, plant and animal debris. They travel and settle downstream of the canals to form a large mass of sediment, a source of pollution. Among the chemicals released into the environment, some such as metals accumulate in sediments **[2]**. Metal contamination can be caused by diffusion into sediments. Accelerated urbanization, industrialization and infrequent cleaning of canals are promoting the increase in residual sludge and sediments are formed downstream of the discharge points located along the coast of Dakar.

Coastal sediments are of diverse origins and are often reservoirs of many chemical pollutants, particularly metals. Metal contamination can cause harm to the aquatic ecosystem **[3, 4]**. Thus, it becomes important to study the impact of these pollutants in this matrix in order to avoid ecological disasters and to contribute to an effective and durable protection of these environments. The present study aims to assess the level of contamination of marine sediments on the Dakar coast by chlorine and heavy metals (copper, zinc and chromium).

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2. MATERIALS AND METHODS

2.1. Sampling points

Ngor, Hann and Soumbedioune areas were chosen for the activities taking place there (**Figure 1**).

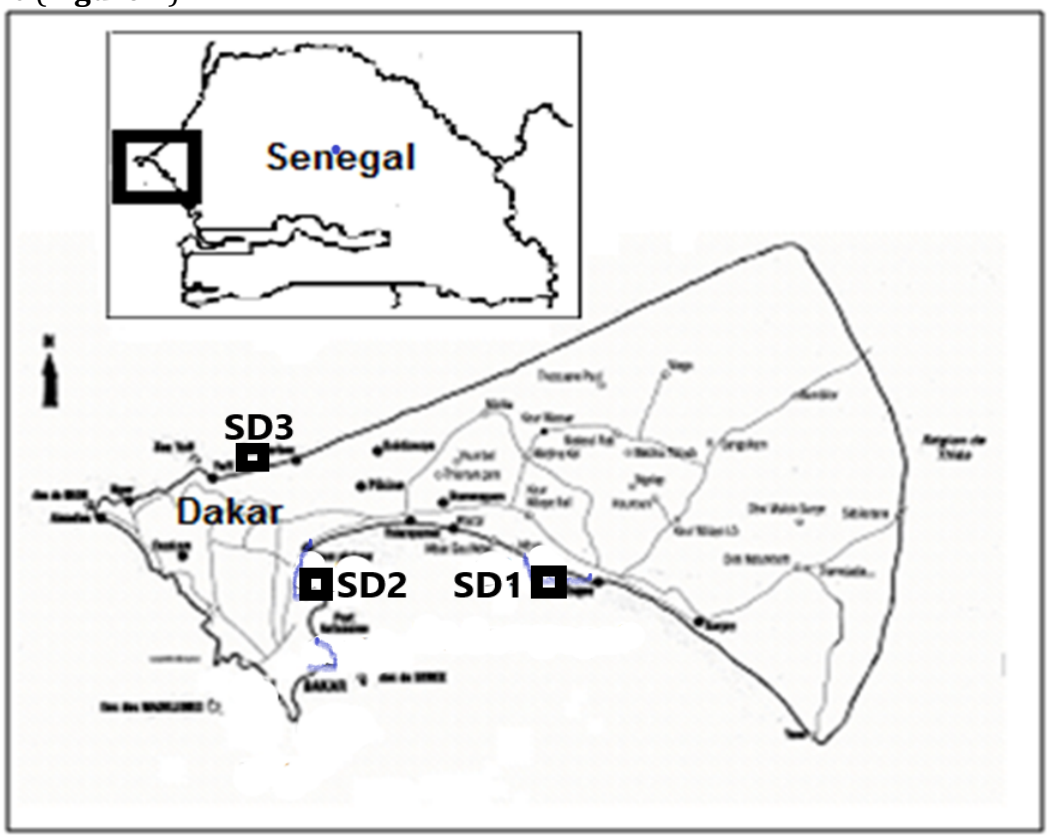


Figure 1. Map of location of sediment sampling areas.

The bay of Hann (SD1) is home to fishing activities, textile factories, processing of fishery products and receives wastewater from the East Canal. Soumbedioune beach (SD2) is a place where fish products are unloaded and receives wastewater from the West channel (open channel IV) which crosses a good part of the municipalities of Dakar. The site of Ngor (SD3) is a beach which receives many visitors. It houses an open-air canal transformed into a landfill, which crosses the entire district.

2.2. Sediment sampling and processing

Sampling of surface sediments was carried out using a small Van Veen type grab at depths of 5 cm, using reference methods for studies of marine pollution **[5]**. The sediments collected were stored in polyethylene bottles and then placed in the dark in coolers at 4 °C **[6]**.

In the laboratory, the sediments were placed in a freezer (-20 °C). After drying in an oven (40 °C) for 3 hours, the sample was pre-screened for 2 mm in order to remove the pieces of shells, branches and leaves before being sieved **[7, 8]**. Sediments smaller than 63 µm were kept in plastic bottles, with a plastic tape around the closure device to protect them from humidity, then stored in a cabinet in the dark and cool (20 °C) for analysis **[9-11]**.

2.3. Sample preparation

For each sample, a quantity of dry and homogenized sediment of 0.20g is placed in Teflon tubes and mineralized with 4 mL of concentrated nitric acid **[12]**. Heating is carried out at 80 °C in the oven for one hour. After cooling to ambient air, the solution obtained is quantitatively transferred to a 25 ml volumetric flask and the mixture is made up with ultra-pure water up to the mark. The solution thus obtained is used for reading with a PF-11 round cell photometer.

2.4. Analysis of samples by Photometry

The blank consists of the sample to be analysed without the standard solutions. For each analysis, a 5 mL sample is taken, to which the reagents are added. It is very important to respect the order and the time prescribed in the analysis protocol to obtain a homogeneous solution.

2.5. Principle of the analysis

The Visocolor, Visocolor Eco or Nanocolor mode is chosen, as indicated in the protocol, as is the filter number depending on the element to be dosed. These numbers are between 1 and 6, and each corresponds to a wavelength. The concentration zero serves as a reference for each measurement. It must be settled before each determination. First, place the tube containing the blank in the measuring well and press the button "zero". The photometer displays zero and then indicates that the sample is ready for analysis. Then place the prepared sample in the measuring well and press the M key to directly obtain its concentration in mg/L. The relationship below allows to express the content of chlorine and metallic elements in mg/ Kg.

C= [(A ×V) ÷ m] × F, where **C** represents the concentration of the substance in mg/kg in the sample; **A**, that of the metal to be dosed in mg/L; **V**, the volume of the solution in mL; **m**, the sample size in g and **F**, the dilution factor.

3. RESULTS AND DISCUSSION

Analysis of the fine fraction of the sediments collected between June and September 2018, reveals the presence of varying concentrations of chlorine, copper, zinc and chromium at the different study sites. **Table 1** shows the minimum, maximum and average contents (mg/Kg) of dry weight, obtained for a series of four measurements and their standard deviation.

Table 1. Minimum, maximum and average levels of chlorine 2 and metal elements found in the sediments studied.

Content of elements	Hann (SD1)		Soumbedioune (SD2)		Ngor (SD3)	
	Min-Max	Mean ± DS	Min-Max	Mean ± DS	Min-Max	Mean ± DS
Cu (mg/Kg)	0.2-87.5	75 ± 2.5	50-112.5	90.6 ± 4.7	0.1-87.5	70.8 ± 3.6
Zn (mg/Kg)	0.1-37.5	37.5 ± 1.2	62.5-150	109.4 ± 6.2	37.5-75	68.8 ± 0.3
Cr (mg/Kg)	16.2-86.3	37.2 ± 2.8	36.3-55	45.4 ± 2.6	23.8-125	64.4 ± 2.8
Cl_2 (mg/Kg)	12.5-250	103.1 ± 4.8	100-237.5	181.3 ± 6.7	0.1-100	75 ± 3.3

Analysis of **Table 1** shows that the chlorine and metal contents vary from one site to another. The chlorine contents, of the fine sediment fraction (< 63µm) from the Dakar coast, range between 0.1 and 237.5 mg/Kg. With regard to metals, the zinc contents vary between 0.1 and 150 mg/Kg while those of chromium and copper vary between 16.2-125 and 0.1-112.5 mg/Kg, respectively. However, some levels exceed the minimum effect threshold (28 mg/Kg) and the toxic effect threshold (86 mg/Kg) established by Canadian legislation (**Table 2**).

Table 2. Canadian Standards for the Biological Effects of Metals in Benthic Organisms: Screening Level Concentration Approach (SLCA) **[13]**.

Metallic elements	Minimal effet (mg/kg)	Effet threshold (mg/kg)
Copper	28	86
Chrome IV	55	100
Zinc	150	540

Figure 2 shows the chlorine and metal contents for the three sites studied on the Dakar coast (Hann, Soumbedioune and Ngor). The analysis results show that the content of chlorine is higher than that of metals such as copper, zinc and chromium. Thus, the Soumbedioune's range registers on average the highest chlorine content 2 with 181.3 mg/Kg and the Ngor's range has the lowest value (75 mg/Kg). These high chlorine contents can be attributed to its massive abundance in the earth's crust and atmospheric fallout **[14]**. The presence of this element, in large quantities, can constitute a danger for living beings. Thus, under a very long exposure time, chlorine can affect the immune system, the blood, the heart and the respiratory system of animals.

For metals, copper has the highest contents (70.8; 75 and 90.6 mg/Kg) followed by zinc (37.5; 68.8 and 109.4 mg/Kg) and chromium records the lowest contents (37.2; 45.4; 64.4 mg/Kg). The high copper contents may indicate contamination of the geochemical background in comparison with the content of the earth's crust (approximately 70 mg/Kg) and that contained in the continental crust (14 mg/Kg) **[11, 15]**. The average copper contents found are higher than the Threshold Effect

Concentration (TEC) (31.6 mg/Kg) for freshwater sediments **[16]**. However, they are lower than the concentration found by Cheikh Diop et al in 2012 (9.978 mg/Kg) **[17]** and that found by Kikouama et al in 2013 (24.840 mg/Kg) **[11]**.

Chromium has the lowest levels with average values between 37.2 and 64.4 mg/Kg. The chromium contents recorded at Ngor are higher than the values found by Cheikh Diop et al in 2012 (27.972 mg/Kg) **[17]**. However, the chromium contents obtained in Soumbedioune and Hann are lower than the value found by Kikouama et al in 2013 (51.4 mg/Kg) and the threshold value with minimal effect (55 mg/Kg) **[11]**.

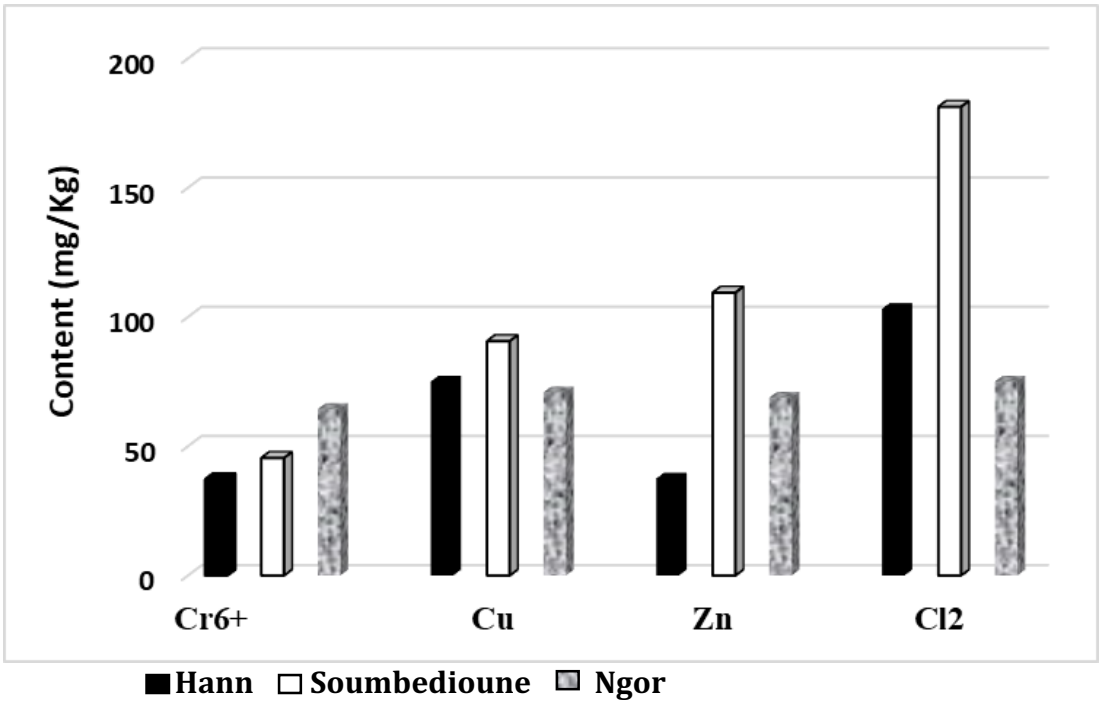


Figure 2. Levels of chlorine and metals in sediment from three areas of Dakar coast.
The copper and chromium contents found are higher than the threshold effect producing concentrations (SEC) for marine sediments (19 mg/Kg and 52 mg/Kg, respectively) **[3]**. The contents of the metals found are greater than those of the reference values.

The sampling points for these sediments are discharge sites for the various channels, the anthropogenic source of which can have a strong influence on the sediment overload. Indeed, this wastewater, often loaded with organic matter, the preferred carriers of metals, can justify this pollution **[18]**. These levels can contaminate or alter the cellular functioning of benthic organisms which are often in contact with sediments. Thus, the probability of observing harmful effects on benthic organisms increases with the concentration of metallic elements. As the fixation of metals is not final, the redistribution of these metals in surface waters also disturbs the aquatic ecosystem.

To better assess the contamination of sediments, the geo-accumulation index (Igeo) of metals is calculated. The calculation was made according to the following formula:

Igeo= $\log_2(\frac{Cn}{1,5Bgx})$ where **Cn** represents the concentration measured for an element and **Bgx**, the geochemical background for an element n. The results obtained are collated in Table 3.

Table 3. Index of geoaccumulation (Igeo) of metals in sediment from the three sites.

Igeo	Hann	Soumbedioune	Ngor	Moyenne
Zinc	0.049	0.72	0.42	0.396
Copper	1.305	1.052	1.27	1.209
Chrome	0.29	0.42	0.63	0.447

In the absence of an environmental standard, the metal contamination index was used to compare the enrichment of a locality with regional values. Table 3 shows that the geo-accumulation index of copper is higher than that of chromium and zinc. According to the Muller scale (1981), sediments are valued from unpolluted to slightly polluted (0≤Igeo <1) in chromium and zinc. These sediments are slightly polluted to moderately polluted in copper (1≤Igeo <2) **[19]**. The comparative study shows that the Soumbedioune sediments are more loaded with chlorine 2 than the Hann and Ngor sediments (**Figure 3**).

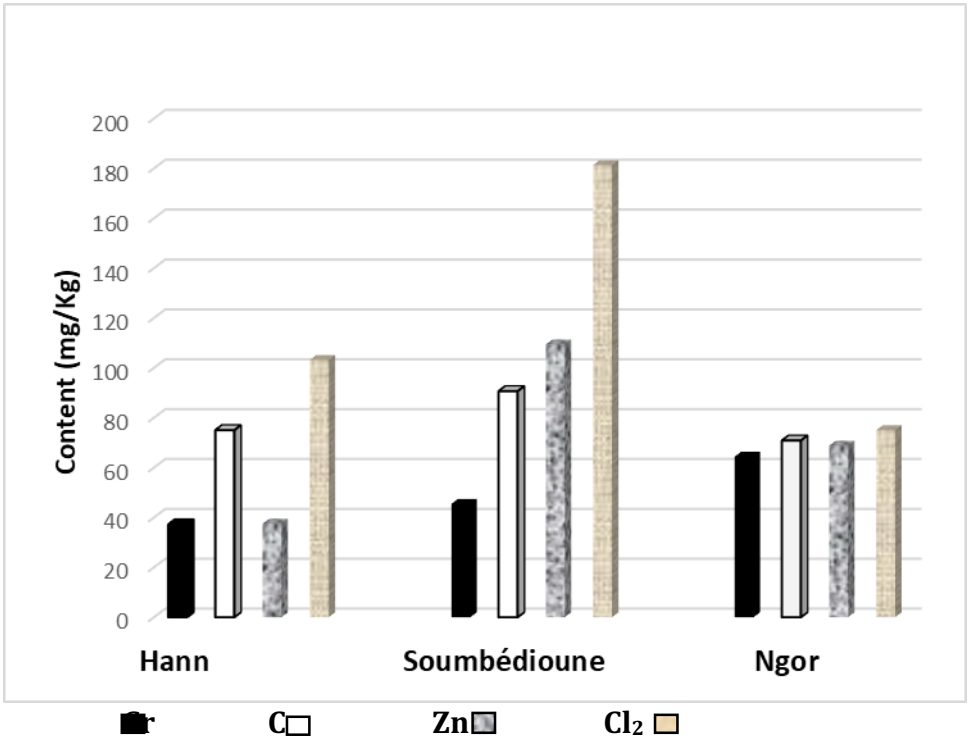


Figure 3. Comparative study of sediments from three studied areas of the Dakar coast

4. CONCLUSION

In this work, we evaluated the contamination of sediments from the beaches of Hann, Soumbedioune and Ngor located at the coast of Dakar by the determination of chlorine and metals such as copper, zinc and chromium. The analyses were carried out by photometry.

The measurement results show the presence of chlorine and metals (copper, zinc and chromium). Thus, the content of chlorine is higher than that of metals such as copper, zinc and chromium. The sediments of Soumbedioune and Hann are more contaminated than the sediments of Ngor.

To estimate sediment pollution and make comparisons, the metal geo-accumulation index was calculated. The results show that the sediments are more contaminated with copper than the other metals (zinc and chromium).

The comparative study shows that the Soumbedioune sediments are more loaded with chlorine 2 than the Hann and Ngor sediments.

The level of contamination of chlorine and heavy metal sediments in the coastal area of Dakar highlights the urgency of reducing the discharge of pollutants into these environments, which could avoid certain public health problems and the scarcity of fishery resources.

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