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Impact of dredging on the physicochemical parameters of water in the estuary of Sebou river (Morocco)

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ABSTRACT

For ports, the dredging is an operation that allows the removal of debris, including the sand, clogging the navigation channels. For sands, because of the shortage of this product very used in the Buildings and Public Works, this activity is booming in Morocco. Furthermore, it is recognized that sediment dredging and their disposal at sea is a pathway of contamination of the marine environment.

The present work concerns the study of some physico-chemical parameters and concentrations of heavy metals from the waters of the estuary of a major river of Morocco, the Sebou, just after a first dredging operation.

The results showed that these waters are highly polluted. This pollution is manifested by an increase in the values of indicators of pollution (COD, BOD5, TSS, conductivity, ammonium, nitrate and ortho-phosphate). The values often exceed those found by other authors just before the installing of the Operating Company of sea, sand at the estuary especially those of Ed-Darouich realized in 2006.

These values often exceed the recommended standard thresholds by the draft Moroccan surface water quality. For the heavy metals, particularly chromium, copper and lead concentrations in surface water the values are low and do not pose a risk of contamination. So, the dredging must be done within a framework of integrated management, taking into account the ecological balance of the coastal zone as a whole.

KEYWORDS

Estuary;
Sebou river;
Dredging impact;
Physicochemistry;
Water;
Heavy metals;
Morocco.

INTRODUCTION

The maintenance dredging is repetitive operations that involve the removal of sediments that is accumulated in the channels and docks that interferes with the navigation. They are permanent in many estuaries in the open ports on Sea.

Until recently, the dredging practices consisted to be loaded the unwanted rubbles blocking the channels or limiting the depth of the basins and file these collected solids far enough from shore. The analysis of the quality of these deposited materials remained brief and limited to considerations of particle sizes on site. Environmental concerns were secondary.

Moreover, the role of the dredging in the physical construction and the ease of naval operations in estuaries is known. But, this role cannot be pursued without taking into account the constraints of preservation of coastal ecosystems. Indeed, it is acknowledged that dredging activities may have impacts on wildlife habitats, causing changes in the hydrological regime[1-3].

In fact, many authors, including Boutmin (1986)[3] and Guillaud et Romana (1984)[4] have reported that the dredging causes a suspending of the adsorbed sediment creating so a high turbidity in the biotop. Therefore, the concentration of chemical pollutants and metallic trace elements have become important in the water. By this way, this operation affects the marine biologic environment.

In Morocco, the estuary of Sebou is one of the important estuaries linking the Atlantic Ocean to one of the major rivers, the Sebou. The low relief of its environment has favored its extension to over 15 kilometers, and it is the only Moroccan estuary having a river port that receives a large number of small boats. However, this estuary has experienced many problems such as its filling with sediment from both fluvial and marine origin. Thus, since 2004, intensively and perm the dredging was used as a means for solving this problem. But, as has pointed Alzieu (2005)[5], it should make provisions which limit the impact of dredging on the ecosystems in particular, with regard to the disturbance of the behavior of certain physicochemical characteristics during the dredging period.

Thus, in this present work we evaluate the impact of the dredging operation on the behavior of many physicochemical parameters and many trace elements in the estuary of the Sebou River (Morocco). Note that the dredging tests have begun in the estuary by the DRAPOR Company in 1994.

MATERIAL AND METHODS

Studied site

The estuary of Sebou River is located on the Atlantic coast of Morocco (34 ° 10N, 6° 39W) at 10 km from the city of Kenitra. It is in the form of an arm of the ocean and it extends over a distance of 15 km, oriented roughly northwest from upstream to downstream[6]. It crosses the Gharb plain which is linked to the Prerif mountains that has a bedrock formed of a soft ground, marls and flyshes covered by the consolidated sandstones[7].

The studied estuary is a meandering where depths vary between 1 and 10 m. It is predominantly marine extending up to 15 km from the mouth. The uncorked of the estuary is channeled through two parallel piers crossing a sand bar (alluvial fan) (Figure 1). The site is characterized by a particular tidal dynamics which determines the parameters and the hydrology of the biotop. The current velocity varies from 0 to 0.82 m / s. The filling of the estuary occurs after 2 hours, while its drain ends after about 5 hours[8, 9]. Also, the estuary has a port complex consists of:

- A commercial port in Kenitra city (12 km from the mouth);
- A mineral port at Mehdia town (3, 5 km from the mouth);
- A fishing port in Mehdia town (3 km from the mouth).

Selection of study stations and methods for assessing physicochemical characteristics of the water

Our study was based on analysis of physicochemical water of the estuary. The samples were collected at five stations distributed along the estuary (Figure 1). The choice of these stations reflects the bibliographic data, including those of Zitan (2002)[10], Ezzaafrani (2004)[11], Tazouti (2004)[12] and Ed-Darwish (2006)[13]. The rate of flow of water, the ease of access and exposure of the station to a possible source of pollution were also taken into consideration.

The stations are designated as follows:

- S1: It's located 10 km upstream from the collector of industrial discharges of CMCP plant;

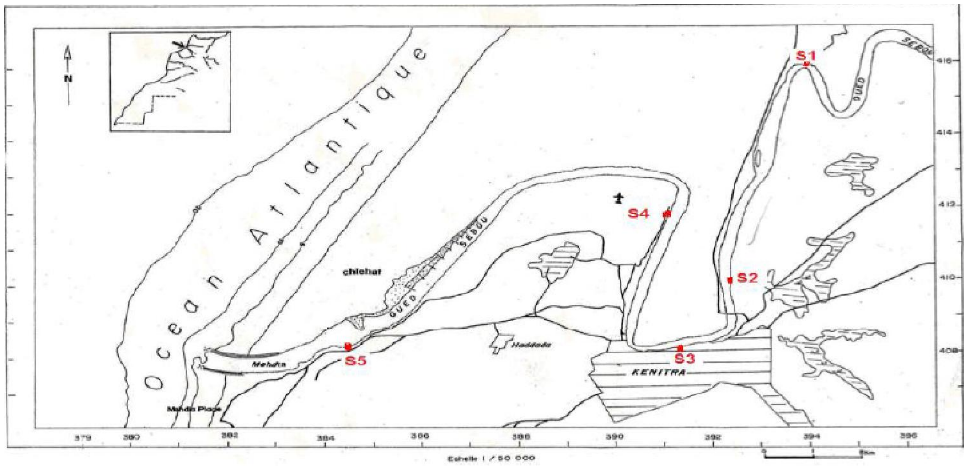

Figure 1 : Location of study sites in the estuary

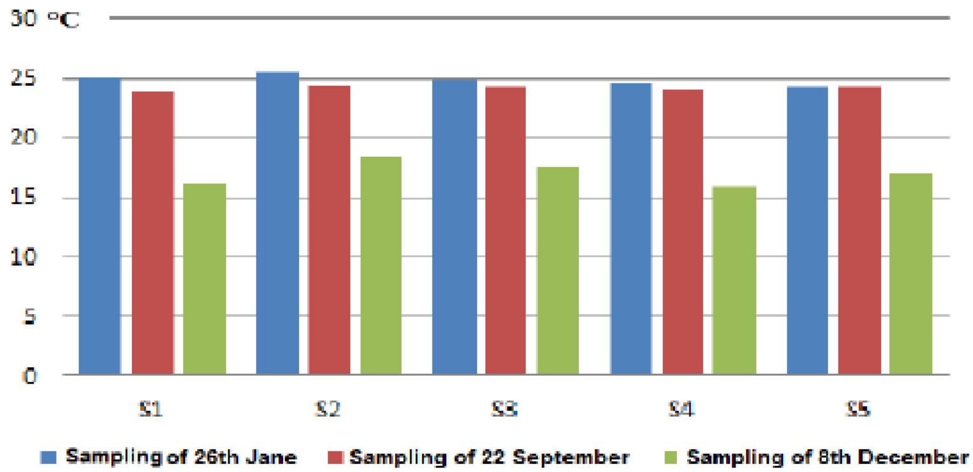

Figure 2 : Evolution of the temperature in the water during three sampling periods

TABLE 1 : Evaluation of studied physicochemical parameters

parameters	Units	analytical methods
T°, pH, electrical conductivity	°C, ms/cm	Multi-parameter type Consort. Ref C838
Suspended matter (MES)	mg/l	Cellulose membrane filter (Φ = 0.45 microns)
DBO_5	mg/l O_2	Manometric method, respirometer at constant pressure (AFNOR F90 103)
DCO	mg/l	According to Standard NFT 92101: Oxidation by excess potassium dichromate
Nitrates	mg/l	Potentiometric titration
Ammonium	mg/l	Colorimetry
Orthophosphates	°F	Determination complexometric (EDTA) Volumetric dosing five strong acid (HCL).
Trace elements (Cu, Cr, Pb)	mg/l	Atomic absorption spectrometry type UNICAM 929AA Spectrometer.

- S2: It is located near the Sharifian Oil Company and wastewater collection MCPC Society, it receives the impact of industrial discharges of these units;
- S3: It is situated downstream the port of Kenitra, it receives the wastewater from of Kenitra city;
- S4: It is situated between the ore port and fishing port;
- S5 is located near the mouth of the estuary.

For dates of 22/09/2007 to 08/12/2007 and 23/06/2007, many water samples were taken at low tide. We collected these samples along the banks of the river

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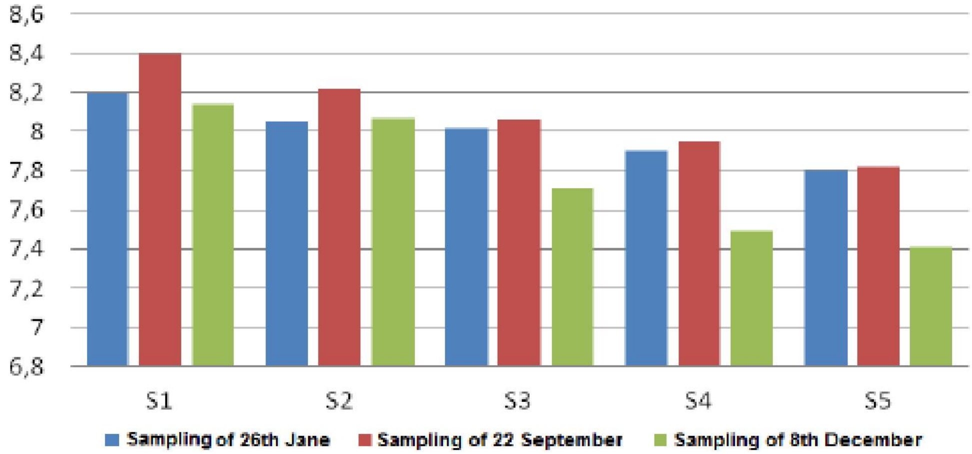

Figure 3 : Evolution of the pH in the water during three sampling periods

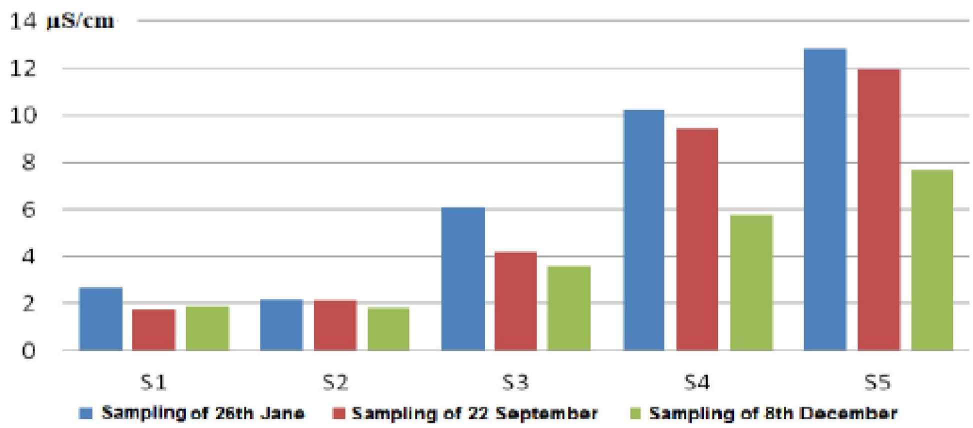

Figure 4 : Evolution of the electrical conductivity in the water during three sampling periods

against the current in 20 cm depth. We have placed the water in glass vials rinsed with distilled water and several Once with the estuary water. In every station we have collected three samples and have acidified those with nitric acid to 4% for to evaluate metal element concentrations. According to a general guide for the conservation and the handling of samples (ISO 5667 / 3 - 1994), the samples were stored at 4 °C in a portable icebox. The evaluation of each parameter was performed according to the principle indicated in the table 1.

RESULTS AND DISCUSSION

Temperature

The temperature values have varied according the seasons and have not shown the large variations within the same campaign (Figure 2). However, in the stations upstream the mouth, the temperature has slightly increased. This increase is due to the declining influence of the marine water temperature, which is colder in the downstream. Also, the effect of continentality and the relatively high temperature of the cooling water of MCPC machines and the thermal station would also be a cause of this variation.

pH

During the three seasons of sampling, the pH ranged between 6.8 and 8.4 in all stations studied (Figure 3). These values remain within the range of pH levels (6.5 and 8.5) reported by several authors whose Tazouti (2004)[12], Ezzaafrani (2004)[11] and Ed-Darwish (2006)[13].

Generally, this relative stability of the pH is due to the tampon system developed by carbonates and bicarbonates that are important in this environment[9,14].

The slight difference of pH values recorded upstream the estuary and those noted downstream the estuary is explained by the fact that the headwaters of the estuary are more influenced by the mass of pollutants transported by the Sebou. Indeed, because of their high or-

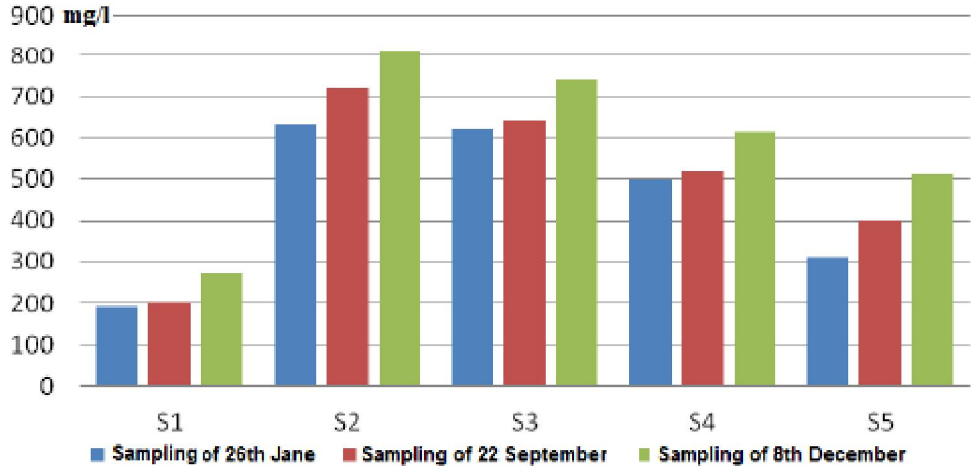

Figure 5 : Evolution of the suspended solid concentration in the water during three sampling periods

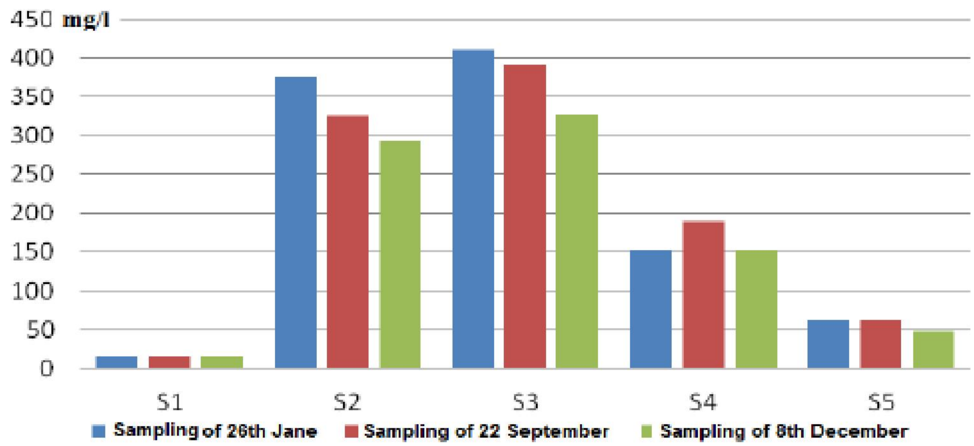

Figure 6 : Evolution of the BOD5 in the water during three sampling periods

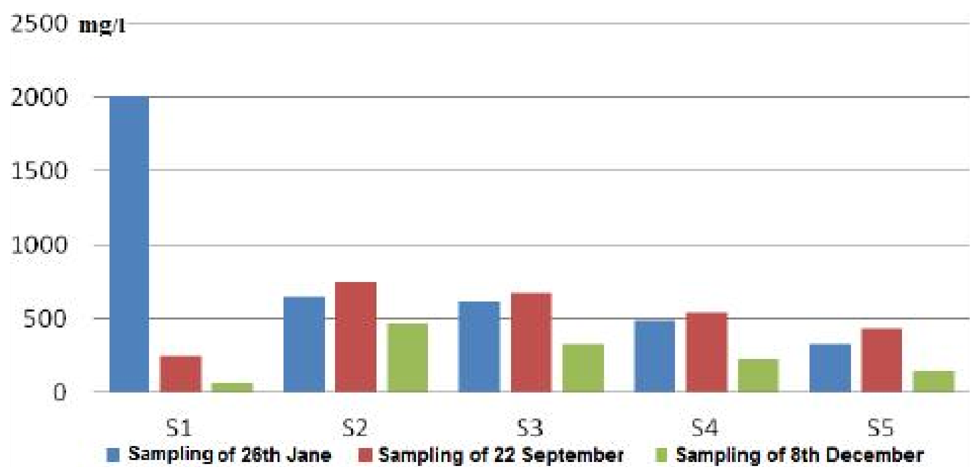

Figure 7 : Evolution of the COD in the water during three sampling periods

ganic matter,content, these waters are characterized by relatively high pH. In opposite, the waters closest to the estuary mouth have the less alkaline pH because of their low load of organic matter and better oxygenation of ocean waters[14].

Electrical conductivity

From the upstream to the downstream estuary, the conductivity values (Figure 4) have progressively increased. So, the degree of the water salinity seems to be a determining factor of the conductivity. During the studied seasons, the lowest conductivities were noted in the station S1 (1,9) while larger values (> 10 µS/cm)

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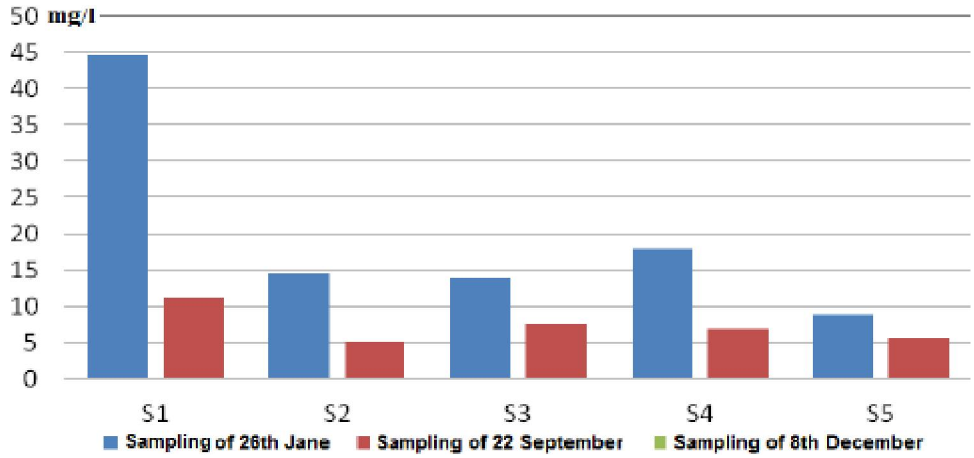

Figure 8 : Evolution of the Nitrate concentration in the water during three sampling periods

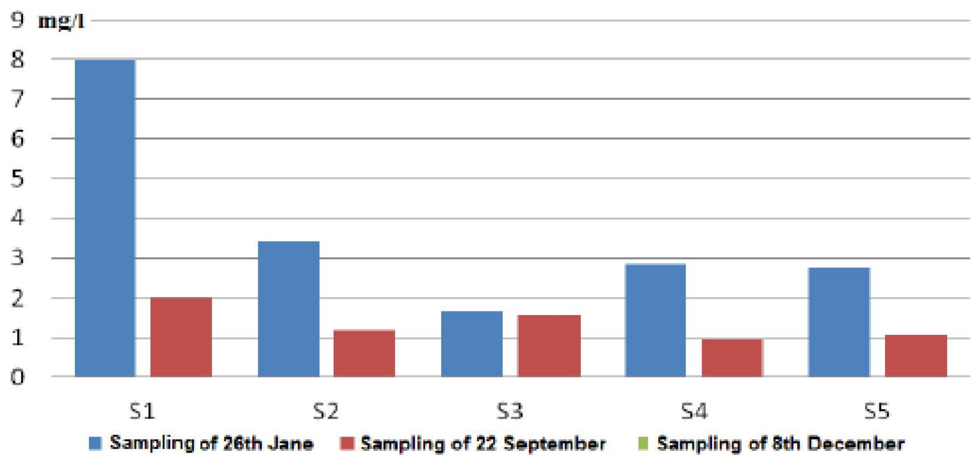

Figure 9 : Evolution of the Ammonium concentration in the water during three sampling periods

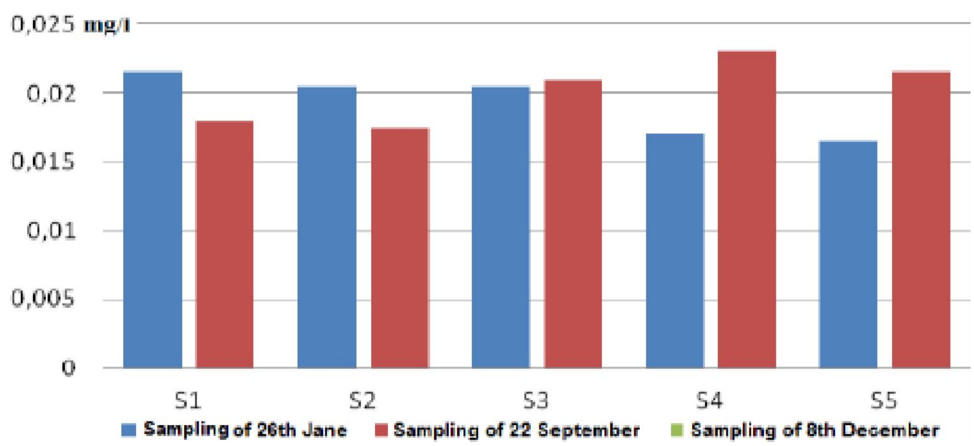

Figure 10 : Evolution of the Copper concentration in the water during three sampling periods.

were noted in the S5 that is situated at the mouth. The similar results were reported by Ed-Darwish (2006)[13].

Suspended solids (SS)

Generally, the suspended solids content in water links to the hydrological sequences in the rivers (floods and droughts)[15] and of the nature of the pollution load discharged. Indeed, the time evolution of the contents of this substance revealed low values recorded in August in the station S1 which is located away from pollutant discharges and maximum values are recorded in December in S2 and S3 (Figure 5) which are located at the outlet discharges of industrial and domestic wastewater[16].

Biochemical oxygen demand (BOD5)

As it is shown in Figure 6 the values of BOD5 have varied according the seasons and according the stations. Indeed, these values were low in winter and important in summer. Similarly, because of the urban discharge importance in station S3, and the MCPC plant industrial discharges in S2, the values were high. In contrast, because of the effect of the dilution of sewage waters by the tidal action, the stations S1 and S2 which are situated near the mouth, have shown the low values of BOD5[17].

Chemical oxygen demand (COD)

The high values of COD are observed in stations S2 and S3 which are located at the outlet of industrial and domestic wastewater (Figure 7). Those high values can be explained by the wealth of the MCPC wastewater by organic and of mineral matters and those of the collectors of sewage from Kenitra city, that are easily oxidized. Moreover, there is a significant reduction of COD in the winter in the moment of the rainwater, whereas it increases in the fall. The values of COD therefore vary depending on the stations and seasons[17].

Nitrates

The results show the existence of a nitrate concentration gradient which is decreasing from upstream to the downstream the estuary. The high nitrate level upstream is probably related to the leaching action of the agricultural lands which are highly charged of nitrates, of animal waste or vegetable debris. These materials enrich the water in organic nitrogen compounds. In addition, these levels of nitrate are relatively high in September and low in December. This seasonal difference in yields is probably due to variation of the flow of the river (Figure 8). Note that McGowan (2007)[17] and Domingues et al.[18] have reported that Nitrate and ammonium are the most important nitrogen sources for phytoplankton growth.

Ammonium (NH4 +)

The ammonium concentrations decrease from the upstream to the downstream estuary (Figure 9) and vary according to seasons. These concentrations were higher in September and low in December. This last difference can be attributed to the importance of the quantity of freshwater on December that muddies the waters of the estuary. Moreover, it was reported[18], the nitrate and ammonium are the most important nitrogen sources for phytoplankton growth and the ammonium adsorption by sediments plays an important role in the cycle of nitrogen in the estuarine tidal flat ecosystem[19]

Concentrations of three heavy metals in water

Copper

The values recorded are very low and ranged from 0.015 (recorded in S4) to 0.024 mg / l recorded in S5) (Figure 10). The weakness of these copper concentrations can be explained by the fact that the copper in ion-free status is scarce when the pH value in the estuary is between 6.5 and 9. This interval of pH favors the complexation of the copper with various complexing agents include: carbonates, oxides and silicates[21].

Moreover, in September the levels of copper have decreased from upstream the estuary at the downstream estuary, while the reverse was noted in December. This behavior can be explained by the fact that copper, like other metals (As, Cr, Pb, Cd), has significant variations in its levels during the transition from the freshwater to the saltwater[22]. This same phenomenon was reported by Ezzaafrani (2004)[12]; Tazouti (2004)[11]; and Ed-Darwish (2006)[13].

Lead

The noted concentrations are below the limit of quantification of the measuring device (3 μ / l). These low values can remove any risk of disrupting the ecological balance by this toxic metal[11].

Furthermore, such low values of the order of μ / l, were also reported by many authors such as Ezzaafrani (2004)[11] and Ed-Darwish (2006)[13]. Aloso, the low concentrations of lead can be explained by the presence of higher levels of sulfates and carbonates that causes the precipitation of lead on estuarine sediment[20].

Chrome

The results have shown that chromium has appeared in very low concentrations. Indeed, all samples have shown the levels below 0. 6μg, limit of quantification of the device, except two samples which have shown 0.0006 and 0.0011 mg / l. Note that low values of the order of several g were reported by Tazouti (2004)[12] and Ezzaafrani (2004)[11].

CONCLUSION

The pollution in Sebou estuary has reached worrying proportions. This pollution is accentuated by the dredging action which increases the water turbidity and changes physical, chemical and biological characteristics of the environment such as the decreased concentration of dissolved oxygen in water. Without control the dredging operation and of the discharges of pollution loads and heavy metals dumped into the estuary of Sebou River the pollution could reach levels of pollution that threatens the river surrounding and the sea. Indeed, the self-purifying capacity of the estuary would be insufficient. Thus, the dredging operation should take into consideration the ecological balance of this coastal zone.

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