International Journal of Latest Research in Humanities and Social Science (IJLRHSS)
Volume 03 - Issue 12, 2020
www.ijlrhss.com || PP. 58-67

Chemical Evaluation of the Sedimentary Environment on the Functioning Quality of the Matete River in Kinshasa

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Abstract: This work presents the results for which the overall objective was to assess the chemical influence of the sedimentary environment of the Matete river in Kinshasa. This performance has been studied through understanding the behavior of metallic elements mainly emitted by natural phenomena and anthropogenic activities and currently present in the sediments of the Matete aquatic ecosystem. In particular: manganese of 57.7 ± 0.6 mg / kg and 129.8 × 102 ± 348.5 mg / kg before the rain and between 0.001 ± 0.0 mg / kg and 0.004 ± 0.00 mg / kg after the rain; iron in the range of 9.0 × 103 ± 30.2 and 481.7 × 103 ± 429.1 mg / kg before rain and 1.7 × 103 ± 80.9 and 2.5 × 103 ± 81.7 after the rain ; potassium is around 1.0 × 103 ± 9.7 and 556.9 × 101 ± 58.2 mg / kg before rain and 18.3 × 101 ± 21.3 and 2.5 × 103 ± 125.0 mg / kg after rain; cobalt is around <3.0 ± <0.2 mg / kg and <70.3 × 101 ± <1.5 before rain and around <3.0 ± <0.5 mg / kg after rain ; nickel is around <0.5 ± <0.1 and 4994.0 × 101 ± 48.2 mg / kg before rain and around 0.0001 ± 0.0 and 0.001 ± 0.0003 mg / kg after rain ; zinc is around <0.5 ± 0.1 and 187.5 ± 2.1 mg / kg before rain and 0.03 ± 0.01 and 0.06 ± 0.01 mg / kg after rain; copper around values <3.4 ± <0.6 and 140.8 × 101 ± 85.5 mg / kg before rain and between 0.001 ± 0.0 and 0.005 ± 0.0 mg / kg after rain; aluminum oscillates around 2.0 × 101 ± 1.7 mg / kg and 7047.0 × 101 ± 939.3 mg / kg before rain and around 0.05 ± 0.02 and 0.10 ± 0 .01 mg / kg after rain; chromium is between 18.1 ± 1.5 mg / kg and 13000.0 × 101 ± 980.2 mg / kg before rain and between 0.1 × 101 ± 0.1 and 0.7 × 101 ± 0.9 after rain; cadmium is <0.2 ± <0.1 mg / kg and <1.1 × 101 ± <2.5 mg / kg before rain and 0.1 × 101 ± 0.1 after rain and lead oscillates around <1.0 ± <0.1 mg / kg and 41.1 ± 0.2 mg / kg before rain and between 0.3 × 101 ± 0.8 and 3.0 × 101 ± 1.1 mg / kg after rain. The sediments of the Matete River are an integral part of its aquatic ecosystem and form a reservoir for many contaminants and may play a role in the deterioration of the proper functioning of the system through direct contact with organisms or indirectly through trophic transfer.

Keywords: evaluation, chemical quality, environment, sediment, functioning, Matete river, kinshasa.

I. Introduction

For over fifty years, pollution has been one of the major problems facing the modern world. Pollution is understood to mean the presence in the environment of dangerous chemicals and biologicals, generally created by man, the harmful effects of which can be felt for long periods of time all over the planet. In general, pollution is defined as the introduction by humans directly or indirectly of substances or energies in quantities that disrupt the ecological balances of receiving environments. This pollution can affect water and land. It can be visible (oil slicks floating in the sea) as well as less visible (heavy metals dissolved in aquatic systems). Waste discharges into waterways are reaching worrying proportions today. In order to save money, factories and urban areas discharge their wastewater directly into nature, without having previously treated it. There are also toxic products that end up in rivers, killing many forms of life. The flora and fauna using this water can in this case be considerably impoverished, not only quantitatively but also qualitatively (Slatni Ibtissem, 2014).

The physical alterations made to the watercourse are numerous and diverse: succession of numerous sills and dams, water diversion, recalibration and rectification of small and medium-sized rivers, protection of banks and extraction of aggregates. They have contributed to a decline in the general quality of rivers, both morphological and ecological. This deterioration results in a decrease in biodiversity, to the detriment of the most sensitive species, or in a disturbance of the characteristic populations of a watercourse.

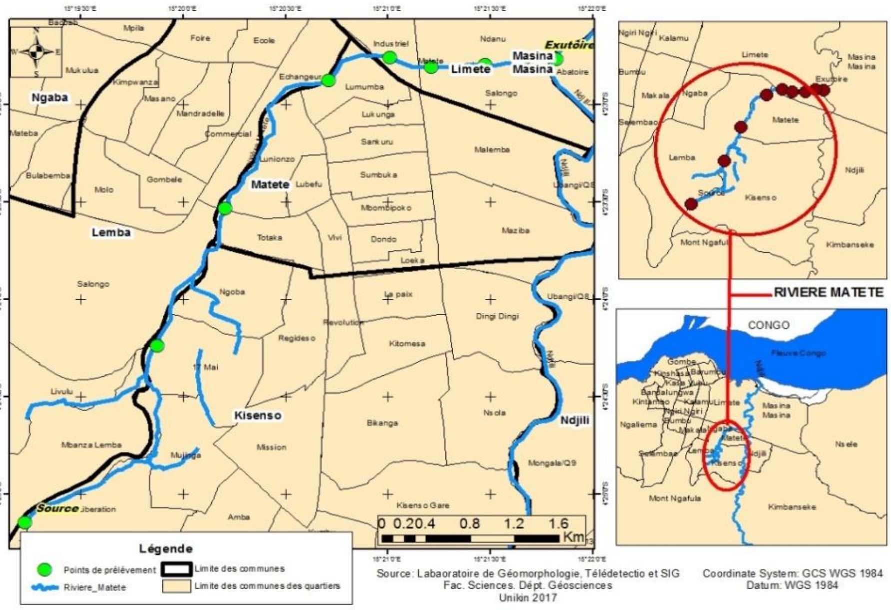
The sediments of the Matete ecosystem in Kinshasa are an integral part of its aquatic ecosystem and form a reservoir for many contaminants and can play a role in the deterioration of the proper functioning of the system through direct contact with organisms or indirect through transfer. trophic.

The overall objective of this study is to assess the chemical influence of the sedimentary environment of the Matete river in Kinshasa. This objective is accompanied by the specific objectives below:
- Identify and collect sediment samples from the Matete river;
- determine the physicochemical parameters of the sediments of this river;
- Determine its influence on the degradation of the Matete ecosystem;
- Produce a decision support tool.

II. Material and Methods

The samples taken were mud from the Matete river (see map 1).

Sample collection sites



The sediment cores were collected from the bank to the middle of the Matete River using nine Plexiglas corers 10 cm in diameter and 50 cm in length (see Figure 1).

The corer is driven vertically into the sediment to the maximum possible depth and then extracted after taking the precaution of closing its upper part with a PVC stopper. Once removed from the sediment bed, the base of the tube is also closed with an identical plug. Depending on the nature of the sedimentary substrate in the river, the length of the cores recovered varies from site to site.

Figure 1: Sampling of sludge from the Matete river

Back in the lab, the supernatant water was removed and each core was air-cut into slices. The slices were homogenized, placed in previously cleaned glass bottles and then sent to the Ecotoxicology Laboratory of the Department of Environmental Sciences of the Faculty of Sciences for drying and then to the Central Analysis Laboratory (LCA) of the CGEA / CREN-K for analyzes (see figure 2a and b).

Figures 2a and b: Drying of sludge from the Matete river in the Ecotoxicology laboratory of the Department of Environmental Sciences

Sludge samples from the Matete River were taken and weighed using a KERN brand precision balance before and after being oven dried at 105oC for 24 hours to constant weight.

The physico-chemical analyzes by X-ray fluorescence were carried out at the central analysis laboratory of CGEA / CREN-K in order to determine the concentration of aluminum, cadmium, and lead, etc. in the various sludge samples. The samples were therefore measured by an X-ray fluorescence spectrometer, using the four secondary targets, namely successively Molybdenum (39.76KV voltage and 0.88mA current), Aluminum oxide (49.15 KV voltage and 0.7mA current), Cobalt (35.79KV current) and finally HOPG Crystal from Bragg (17.4KV voltage and 1.99mA current) from the palladium anode.

III. Results

III.1. Characterization of sludge (sediment) samples from the Matete river

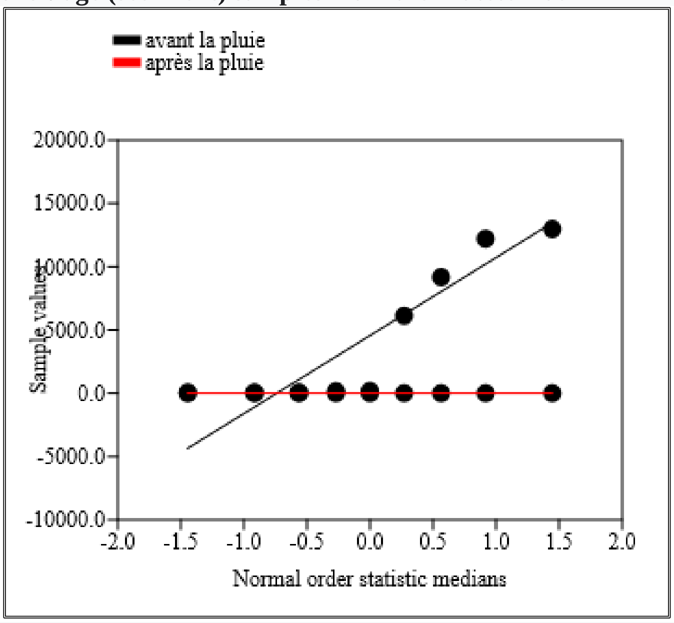


Figure 1. The manganese values of the different sediment sampling sites of the Matete River

The manganese values in the sediments of the Matete River oscillate between 57.7 ± 0.6 mg / kg and 129.8 × 102 ± 348.5 mg / kg before the rain and between 0.001 ± 0.0 mg / kg and 0.004 ± 0.00 mg / kg after rain ($p = 0.00820079 \leq 0.05$).

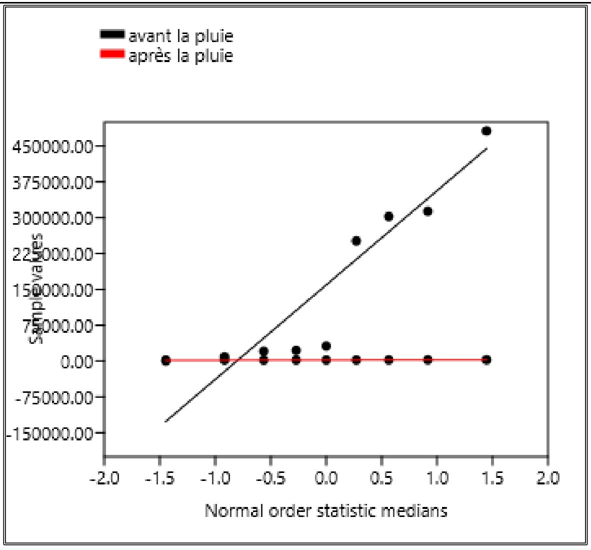


Figure 2. The iron values of the different sediment sampling sites of the Matete River

The iron concentration in the sediment samples from the Matete River is within the range of 9.0 × 103 ± 30.2 and 481.7 × 103 ± 429.1 mg / kg before rain and 1.7 × 103 ± 80.9 and 2.5 × 103 ± 81.7 after rain ($p = 0.00341534 \leq 0.05$).

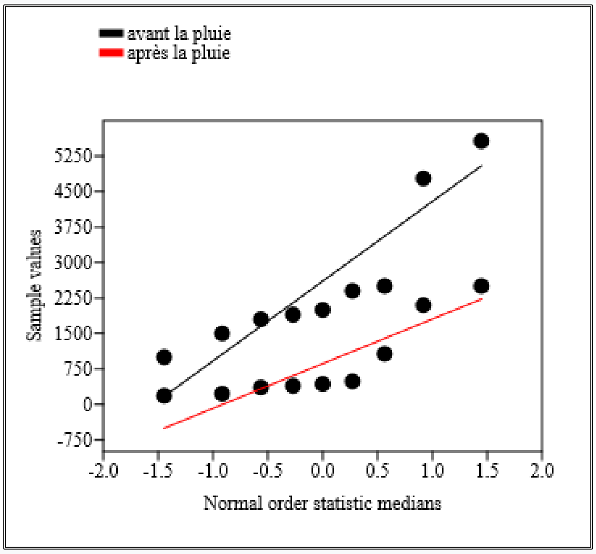


Figure 3. The potassium values of the different sediment sampling sites of the Matete River

The potassium values in the sediment of the Matete river are around 1.0 × 103 ± 9.7 and 556.9 × 101 ± 58.2 mg / kg before the rain and 18.3 × 101 ± 21.3 and 2.5 × 103 ± 125.0 mg / kg after rain ($p = 0.00058855 \leq 0.05$).

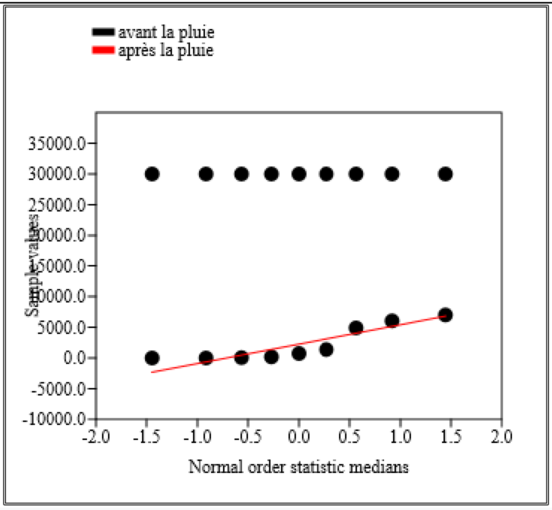


Figure 4. Calcium values from the different sediment sampling sites of the Matete River

The different samples of the sediment from the Matete river have values around <0.3 × 105 ± <85.7 mg / kg before the rain and between <1.0 × 101 ± <0.3 and 700.6 × 101 ± 5.6 mg / kg after rain (p = 3.2319 × 10-40 ≤ 0.05).

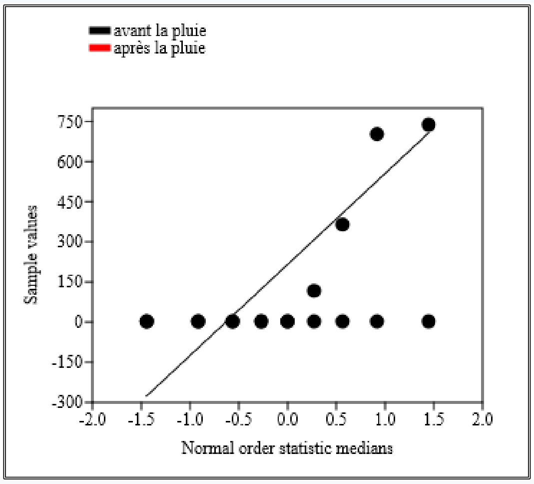


Figure 5. The cobalt values of the different sediment sampling sites of the Matete River

Cobalt values in the sediment samples from the Matete River are around <3.0 ± <0.2 mg / kg and <70.3 × 101 ± <1.5 before rain and around <3.0 ± <0.5 mg / kg after rain (p = 0.04092049 ≤ 0.05).

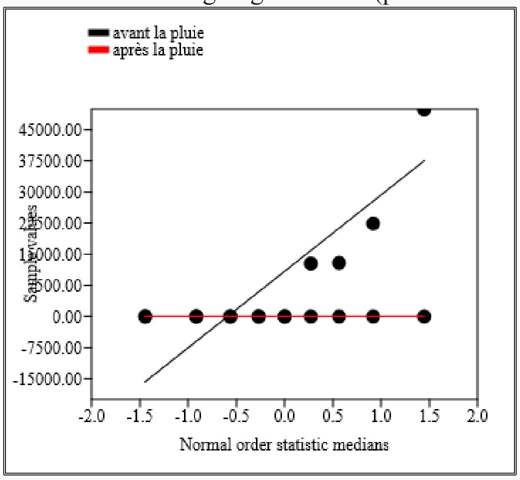


Figure 6. The nickel values of the different sediment sampling sites of the Matete River

Nickel concentrations in the sediment of the Matete River are around <0.5 ± <0.1 and 4994.0 × 101 ± 48.2 mg / kg before the rain and around 0.0001 ± 0.0 and 0.001 ± 0.0003 mg / kg after rain (p = 0.0521024 ≤ 0.05).

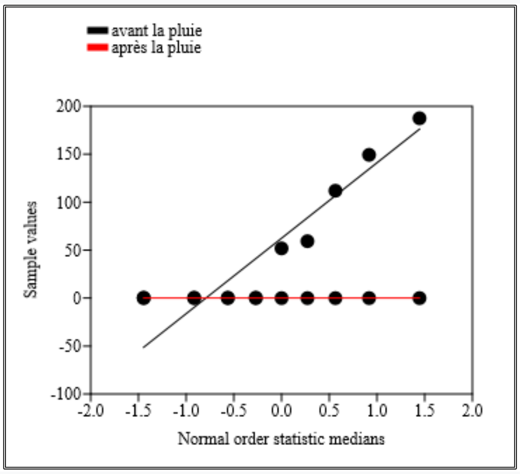


Figure 7. Zinc values from the different sediment sampling sites of the Matete River

The sediment zinc value of the Matete river is around <0.5 ± 0.1 and 187.5 ± 2.1 mg / kg before the rain and 0.03 ± 0.01 and 0.06 ± 0 .01 mg / kg after rain (p = 0.00356063 ≤ 0.05).

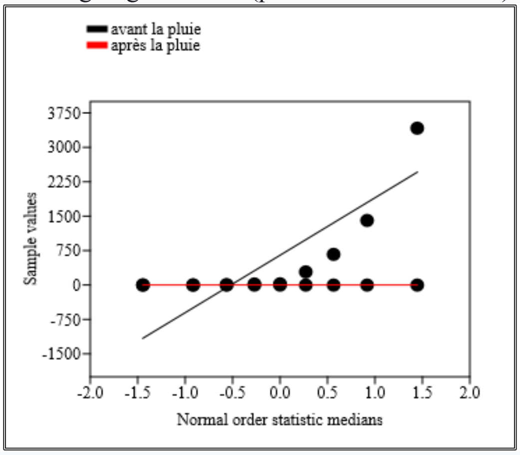


Figure 8. The copper values of the different sediment sampling sites of the Matete River

The sediment of the Matete river has a copper concentration around the values <3.4 ± <0.6 and 140.8 × 101 ± 85.5 mg / kg before the rain and between 0.001 ± 0.0 and 0.005 ± 0 , 0 mg / kg after rain (p = 0.0397789 ≤ 0.05).

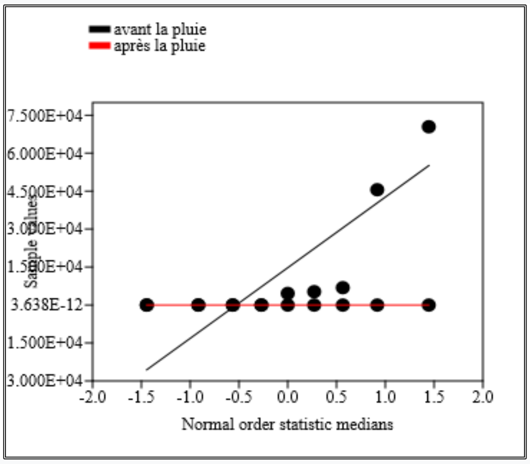


Figure 9. The aluminum values of the different sediment sampling sites of the Matete River

The concentration of aluminum in the different sediment samples from the Matete River oscillates around 2.0 × 101 ± 1.7 mg / kg and 7047.0 × 101 ± 939.3 mg / kg before the rain and around 0.05 ± 0.02 and 0.10 ± 0.01 mg / kg after rain (p = 0.04708752 ≤ 0.05).

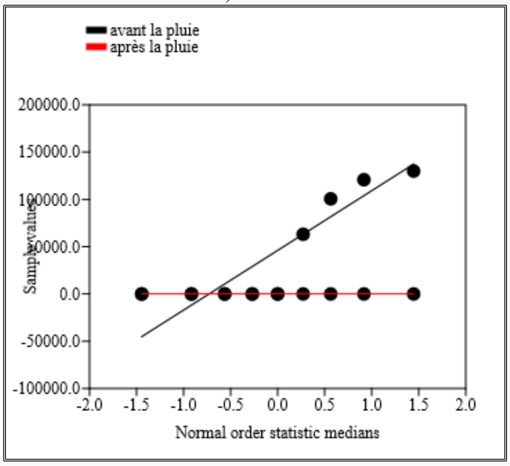


Figure 10. The chromium values of the different sediment sampling sites of the Matete River

The chromium content in the sediment samples from the Matete River is between 18.1 ± 1.5 mg / kg and 13000.0 × 101 ± 980.2 mg / kg before rain and between 0.1 × 101 ± 0 , 1 and 0.7 × 101 ± 0.9 after rain (p = 0.00945871 ≤ 0.05).

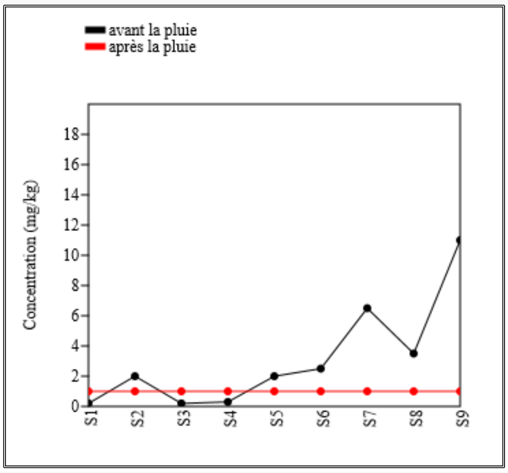


Figure 11. Cadmium values from the different sediment sampling sites of the Matete River

Cadmium values in river sediments are around <0.2 ± <0.1 mg / kg and <1.1 × 101 ± <2.5mg / kg before rain and 0.1 × 101 ± 0, 1after the rain (p = 0.05579164 ≤ 0.05).

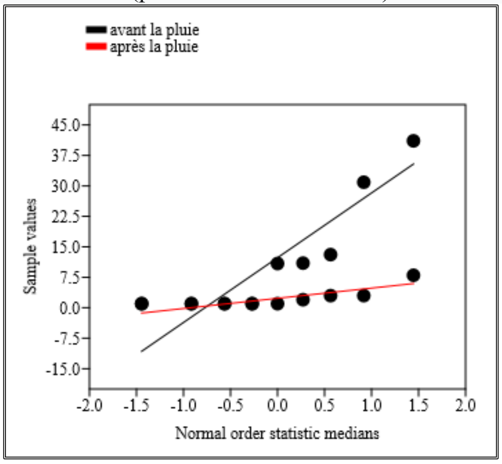


Figure 12. The lead values of the different sediment sampling sites of the Matete River

The lead concentrations in the different samples of the sediment of the Matete river oscillate around <1.0 ± <0.1 mg / kg and 41.1 ± 0.2 mg / kg before the rain and between 0.3 × 101 ± 0.8 and 3.0 × 101 ± 1.1 mg / kg after rain ($p = 0.0436234 \leq 0.05$).

III.2. Discussion

Under the natural conditions of the Matete River, this aquatic ecosystem has pH values between 6.6 ± 1.2 and 7.5 ± 2.0 in the dry season and 6.7 ± 0.6 and 7.8 ± 1 , 1 in the rainy season. Changes in pH are therefore a function of photosynthetic activity which subtracts CO2 from the medium. In addition, the variations in pH observed influence the behavior of the different metals (bioavailable or the ionic form which is the form very toxic to the life of living organisms). While the temperature values of the samples from the Matete River oscillate respectively around 25.9 ± 1.1 oC and 27.5 ± 1.9 oC before the rain and 25.8 ± 0.9 oC and 27.5 ± 2.1 oC after rain. This is not surprising because the Matete River is in a tropical area. Climate change could explain up to 10% of the decrease in aluminum concentrations in Czech lakes (Skjelkvåle, 2003).

The manganese values in the sediments of the Matete River oscillate between 57.7 ± 0.6 mg / kg and 129.8 × 102 ± 348.5 mg / kg before the rain and between 0.001 ± 0.0 mg / kg and 0.004 ± 0.00 mg / kg after rain. While the iron concentration is within the range of 9.0 × 103 ± 30.2 and 481.7 × 103 ± 429.1 mg / kg before rain and 1.7 × 103 ± 80.9 and 2, 5 × 103 ± 81.7 mg / kg after rain. On the other hand, the potassium values oscillate around 1.0 × 103 ± 9.7 and 556.9 × 101 ± 58.2 mg / kg before rain and 18.3 × 101 ± 21.3 and 2.5 × 103 ± 125.0 mg / kg after rain. Calcium values revolve around <0.3 × 105 ± <85.7 mg / kg before rain and between <1.0 × 101 ± <0.3 and 700.6 × 101 ± 5.6 mg / kg after the rain. These elements are major and essential for the growth of aquatic plants and animals and are very concentrated in sediments and also unavailable for aquatic algae due to high levels of aluminum in the environment and the bacterial process (natural and chemical coagulation) . However, there is a low presence of floating macrophytes in this lake ecosystem. As a result, these conditions could affect photosynthetic processes and, which in turn would influence the development of life in the Matete River. This is what Reynolds (1984) justifies that they are mineral salts, the only form in which plants are generally able to absorb the biogenic elements N, P, Si, etc. ... the main ones are the ion ammonium (NH4 +), nitrate ion (NO3-), nitrite ion (NO2-) and phosphate ions (H2PO4-, HPO42) and Koski-Vähälä and Hartikainen (2001) state that these compounds resulting from the processes of coagulation are concentrated in the deep layers of the sediment and are made available to the algae when the sediment is resuspended.

Cobalt values in the sediment samples from the Matete River are around <3.0 ± <0.2 mg / kg and <70.3 × 101 ± <1.5 before rain and around <3.0 ± <0.5 mg / kg after rain. These values are greater than the guide value for freshwater environments set at 8 µg / L (Cicad, 2006). The sedimentation of this element is due to the process of coagulation of suspended matter by aluminum. Borovec (2000) reports that adsorption is greater on fine sediments (<0.1 mm). The main fixation processes on the fine sediment (<4 µm) would be, by increasing importance, ion exchange, co-precipitation and adsorption with manganese oxy-hydroxides then carbonates, adsorption on the mineral matrix and finally bonds with iron oxides and hydroxides as well as with organic matter and sulphides. Nickel concentrations are around <0.5 ± <0.1 and 4994.0 × 101 ± 48.2 mg / kg before rain and around 0.0001 ± 0.0 and 0.001 ± 0.0003 mg / kg after the rain in the sediment.

The majority of its nine sites obey the French standard AFNOR 44041 which sets 400 mg / kg of dry matter, while at sites S5 (1292.0 × 101), S7 (2241.0 × 101), S8 (1277.0 × 101) and S9 (4994.0 × 101), these values are above the norm. Industrial activities on the one hand and the denouncement of this river for lack of a wastewater management policy on the other hand would be responsible for the sedimentation of this ecosystem. These values are above that of Bodo (1989) who demonstrated that nickel concentrations in Canadian lake sediments varied by less than 10 mg / g (dry weight) in deep or uncontaminated sediments. The sediment zinc value of the Matete river is around <0.5 ± 0.1 and 187.5 ± 2.1 mg / kg before the rain and 0.03 ± 0.01 and 0.06 ± 0 , 01 mg / kg after rain. These values are lower than the Afnor 44041 standard set at 6000 mg / kg of dry matter and European directive no86-278 of 12 June 1986 set at 2500 to 4000 mg / kg. These values are clearly higher than those of Nadem, et al, (2015) who demonstrated that the zinc contents in the sediments of the Bouregreg estuary have a maximum value in station S3 (378.98 mg / kg) followed from station S1 (269.91 mg / kg) and station S2 (140.33 mg / kg). Copper has values around <3.4 ± <0.6 and 140.8 × 101 ± 85.5 mg / kg before rain and between 0.001 ± 0.0 and 0.005 ± 0.0 mg / kg after rain. rain. Only S9 (1408) has a value within the range of European directive no86-278 of June 12, 1986 set from 1000 to 1750 mg / kg and the remains are below the Afnor 44041 standard set at 2000 mg / kg of dry matter. If its sediments are in an oxic condition, copper is adsorbed mainly on iron and manganese oxides and on organic matter (Xue et al., 1997, Chapman et al., 1998). In weakly alkaline waters, sediments loaded with copper constitute a problem in relation to the risk of acidification of the environment (acid rain) (Barroin, 1999). In the event that a large fraction of the copper is attached to the organic fraction, the mineralization of the latter under oxic conditions leads to a concomitant release of small organic ligands to which the copper is attached.

The concentration of aluminum in the different sediment samples from the Matete River oscillates around 2.0 × 101 ± 1.7 mg / kg and 7047.0 × 101 ± 939.3 mg / kg before the rain and around 0.05 ± 0.02 and 0.10 ± 0.01 mg / kg after rain. This element is very abundant following the texture of the soil, repeated episodes of erosion of the bed and banks of the river and the absence of wastewater treatment plants in the city of Kinshasa. The chromium content in the sediment samples from the Matete River is between 18.1 ± 1.5 mg / kg and 13000.0 × 101 ± 980.2 mg / kg before rain and between 0.1 × 101 ± 0 , 1 and 0.7 × 101 ± 0.9 after rain. The values of the sites S5 (6312.0 × 101), S7 (12080.0 × 101) and S9 (13000.0 × 101) sampled before the rain are above the Afnor 44041 standard set at 2000 mg / kg of dry matter. This substance constitutes a kind of toxicity not available for algae during the dry season and dangerous during the rainy period. These values are also higher than those of Durali et al, (2007) who found concentrations ranging from 0.08 to 7.41µg / g of chromium in the sediment of the Tokat lakes. Cadmium values in river sediments are around <0.2 ± <0.1 mg / kg and <1.1 × 101 ± <2.5mg / kg before rain and 0.1 × 101 ± 0, 1after the rain. All these measured values are lower than the Afnor 44041 standard set at 40 mg / kg of dry matter. On the other hand, those of lead oscillate around <1.0 ± <0.1 mg / kg and 41.1 ± 0.2 mg / kg before the rain and between 0.3 × 101 ± 0.8 and 3.0 × 101 ± 1.1 mg / kg after rain. These data are below the Afnor 44041 standard set at 1600 mg / kg of dry matter. These values, although low by standards, are a major problem for the species that live there because they can accumulate in the sediments, be released into the pore waters and thus increase the concentration of soluble or suspended metals. , with a real danger for aquatic fauna and flora and they are higher (0.74 mg / kg) for cadmium and lower (54.04 mg / kg) for lead than those found by Hounkpatin Armelle et al. (2011) who worked on the same metals (lead and cadmium) in the sediments of the lake city of Ganvie. The sediments of the Matete River are an integral part of its aquatic ecosystem and form a reservoir for many contaminants and may play a role in the deterioration of the proper functioning of the system through direct contact with organisms or indirectly through trophic transfer. However, the concentrations of metallic trace elements in the sediment of the Matete River would be responsible for the amplification of the contamination of the ecological niche of certain species and also responsible for the disappearance of the ecological capital during the post-hatching period of the same species.

Conclusion and Perspectives

At the end of this work, the overall objective of which was to assess the chemical influence of the sedimentary environment of the Matete river in Kinshasa. The approach proposed to achieve this goal combined observational and experimental methods and the implementation of molecular absorption and X-ray fluorescence spectrophotometric determination techniques.

The samples were taken during the two seasons of each year and in the different sites and then taken to the Central Analysis Laboratory of CGEA / CREN-K) for analyzes.

In view of these results, we affirm the hypothesis that the sediments of the Matete ecosystem in Kinshasa are an integral part of its aquatic ecosystem and form a reservoir for many contaminants and may play a role in the deterioration of the proper functioning of the system. through direct contact with organisms or indirect through trophic transfer. However, the concentrations of metallic elements would be responsible for the amplification of the contamination of flora and fauna during the formation of the egg-laying basin and also responsible for the disappearance of ecological capital during the post-hatching period of certain species. As a result, it is considered a natural enclosure toxic to its fauna (farm ecosystem).

In view of the above, we recommend that the authorities do the following:

- pretreat and control industrial effluents before they are released into the receiving environment;
- apply the urban wastewater management policy in order to preserve the quality and balance of the receiving ecosystem;
- continue research on the chemical evaluation of sediments on the quality of the functioning of rivers in Kinshasa.

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