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Contamination of the Waters of the Kamatanda River by Trace Metals from Artisanal Mining Activities

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ABSTRACT

The purpose of this study is to verify the pollution of the Kamatanda River caused by the artisanal miners of the Kamatanda mine in the town of Likasi in the south of the Democratic Republic of Congo. To achieve this, water samples were taken every April for two years. The results of the physicochemical and chemical parameters recorded at the various sampling points show significant contamination during operations, i.e., the year 2018, reflected by high levels of trace metals such as As, Cd and Cr; and low levels during a period of cessation of operations, April 2019.

Keywords: contamination, trace metals, mining activities, waters

INTRODUCTION

The contamination of the environment, more particularly of the soil and surface water of the large mining agglomerations of Katanga by industrial effluents is not new (SNC-Lavalin, 2003; Vande *et al.*, 2005). Water pollution has increased, chronically or accidentally, due to urbanization, the development of industry and intensive agriculture. Half of the world's rivers are polluted (Raissouni *et al.*, 2016; Fouad *et al.*, 2014). In the last year, the contamination index of the Kamatanda River has increased as a result of artisanal mining activities along its length. In fact, the Kamatanda River is used as a washing ground for artisanal mining and as a wastewater outlet for a local metallurgical plant *GECAMINES* (Générale des Carrieres et des Mines). Many researchers in the Democratic Republic of Congo have been interested in metal pollution of ecosystems (Muteba, Nyembo, & Mwadiavinta, 2011; Lootens & Lumbu, 1986; Banza, 2003; Kitobo, 2009; Chipeng, 2010; Kisanguka, 2010; Tshibanda, 2012). Rainwater runoff and infiltration into the soil lead to pollution in waterways. Increasingly, groundwater, theoretically less vulnerable than surface water, is also contaminated, often for a long time due to the slow renewal of groundwater.

Faced with these major challenges, we have committed ourselves to studying this danger that the population of this region is running, as this water is used upstream as well as downstream, for market gardening and also for consumption by the surrounding population.

MATERIALS AND METHODS

Methodology

This paragraph includes the study area and the sampling. We would also like to point out that for the analysis of our samples we used ICP.

Our samples were collected in the Likasi city area. This town is located in the central part of the Congolese and Zambian copper arc. The region is very hilly, especially in the area of the deposit (François, 1973). Its subsoil is very rich in mineral substances including cobalt

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ores (heterogenites) and copper ores (malachite, cuprite, chrysocolla, chalcopyrite) and others. Surrounded by numerous valleys where the water of the Kamatanda River flows into the Buluo River (Kayumba & Mwamba, 2013).

Geographic location

Located approximately 7 km to the northeast and 37 minute walk from the town of Likasi, the Kamatanda mine is on the road bearing the same name of Kamatanda. One part of the mine belongs to the company Générale des Carrieres et des Mines and the other part is privately owned by the farmers; the latter is the site of our study (Kumwimba, 2009).

Table 1: Geographical coordinates and activities of our study site

Sampling points	Reasons for choosing the station	Geographic coordinates in degrees	Type of activities nearby
L1	Is located downstream of the erosion gully of the artisanal quarry	26,766307 -10,94749	Irrigation canal and agricultural areas
L2	Is located on the right bank of the Kamatanda River, downstream of L1, and is used to monitor TM concentrations in the Kamatanda River.	26,76461 -10,949638	Irrigation canal and agricultural areas
L3	Is located on the right bank of the Kamatanda River, downstream of L2, and tracks TM concentrations on the Kamatanda River.	26,764648 -10,9510495	Irrigation canal and agricultural areas
L4	Is located on the right bank of the Kamatanda River, downstream of L3, and tracks TM concentrations on the Kamatanda River.	26,76572 -10,95395	Agricultures

In order to achieve the objectives, the location of the water sampling points is designed to better cover the study area. The samples taken will be subjected to spectroscopic and potention-metric analyses. Figure 1 shows the position of the different sampling points.

Mode of sampling

The rhythm of sampling is once a year i.e. 09/04/2018 and 05/04/2019. The samplings were carried out rather far from the banks, from the downstream to the upstream in the opposite direction of the water current, by using a sterilized plastic can. They were carried out in the current of the main channel. The samples taken were kept in sterilized polyethylene bottles of 500 ml. The conservation of the samples is delicate taking into account the weak contents in elements. The collected samples are then deposited in the laboratory for analysis within 24 hours after sampling.

Measurement of Chemical Parameters

Acidity was measured with a Mettler pH meter. The chemical analysis was done on the emission spectrometry using an Ispectrometer coupled to a mass spectrometer brand Perkin Elmer in the laboratory of the Congolese Office of Control (OCC).

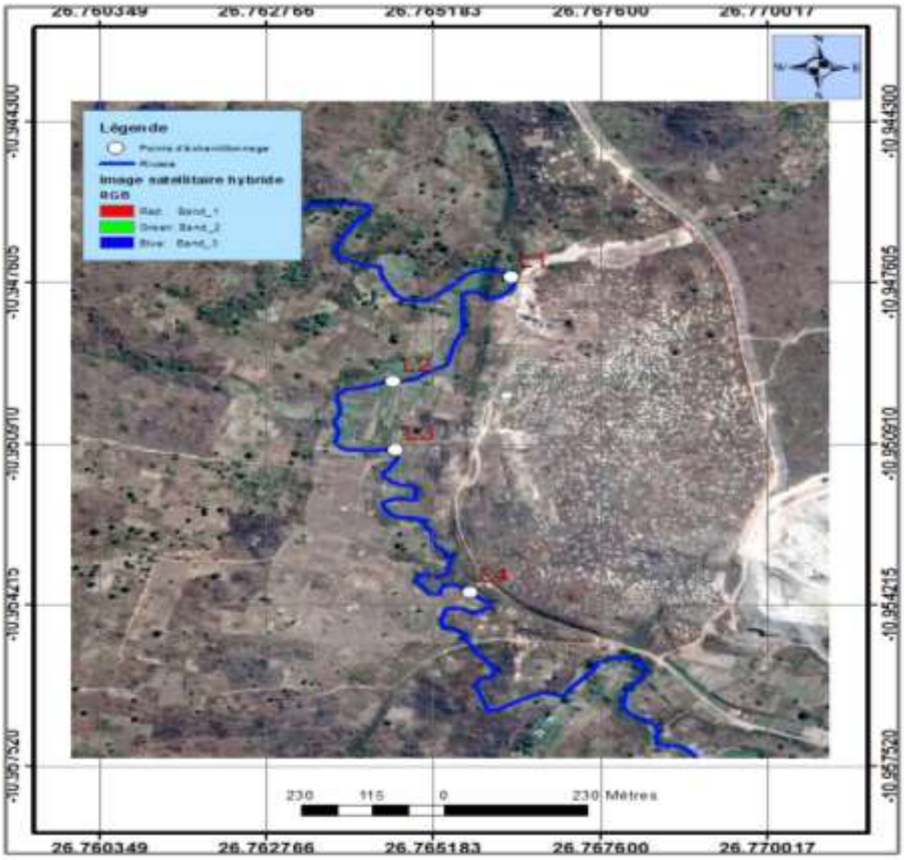

Figure 1: Sampling Map

RESULTS

pH of the Water Samples

The pH values of the water samples for all four sampling points ranged from 6.22±033 to 8.30±0.47 (Table 2).

Table 2: pH measurement

Period	pH					N.E.U	R.M
	L_1	L_2	L_3	L_4	Mean		
Avril 2018	7.45±0.33	6.70±0.33	6.80±0.33	6.22±0.33	6.79±0.33	6.50-9.00	6.00-9.00
Avril 2019	8.30±0.47	6.67±0.47	7.17±0.47	6.45±0.47	7.15±0.47		

The pH values above, gives us an average of 6.79±0.33 during the mining activities (April 2018), which is due to the metal particles in suspension; while the average of 7.15±0.47. The pH indicates the absence of atmospheric pollutant gases including CO_2 that would come from industrial processing, in the first case the samples were taken in the dry season not yet the pollution of dry season burns and secondly not gaseous effluents because the area of exploitation is located in the northwestern site.

Assessment of Trace Metals

Chemical analyses were carried out in order to determine the contents of metallic pollutants, notably lead, cadmium, chromium, zinc, copper, cobalt and arsenic. The results of the analyses (table and chart) are presented as one sample per year and per site in our sampling plan. The results highlighted the metal parameters for both study years.

Table 3: TME content (mg/l) of water in 2018

ETM	N.U.E	R.M	L_1	L_2	L_3	L_4
As	< 0,050	1,000	**7.962**±1.140	**6.023**±1.140	**10.27**±1.140	**11.39**±1.140
Cd	< 0,005	0,100	**0.041**±0.012	**0.047**±0.012	**0.020**±0.012	**0.050**±0.012
Co	< 1,000	-	<0.000	0.056±0.023	<0.000	0.047±0.023
Cr	< 0.050	-	**0.181**±0.049	**0.100**±0.049	**0.192**±0.049	**0.125**±0.049
Cu	< 1,000	0,300	0.013±0.012	0.017±0.012	0.011±0.012	0.055±0.012
Zn	< 5,000	1,000	0.074±0.023	0.083±0.023	0.041±0.023	0.142±0.023

For April 2018 (Table 3), we found that the levels of Arsenic, Cadmium and Chromium exceeded those of the European Union standard, with successively high values of 10.27mg/l, 0.050 mg/l and 0.192mg/l; and compared to the mining regulations of the Democratic Republic of Congo only the Arsenic values were high.

Table 4: TME content (mg/l) of water for April 2019

ETM	N.U.E	R.M	L1	L2	L3	L4
As	< 0,050	1,000	0.012±0.002	0.010±0.002	0.016±0.002	0.006±0.002
Cd	< 0,005	0,100	<0.000	<0.000	<0.000	<0.000
Co	< 1,000	-	0.009±0.003	0.009±0.003	0.001±0.003	0.002±0.003
Cr	< 0.050	-	0.001±0.000	0.002±0.000	<0.000	0.001±0.000
Cu	< 1,000	0,300	0.010±0.002	0.004±0.002	0.004±0.002	0.004±0.002
Zn	< 5,000	1,000	<0.000	<0.000	<0.000	<0.000

For April 2019 (Table 5), we found that the trace metal content decreased significantly in all sampling points.

Table 5: Decrease in TM content (%) from April 2018 to April 20019

TM	L_1	L_2	L_3	L_4	Mean
As	99.849	99.834	99.844	99.947	99.869
Cd	100	100	100	100	100
Co		83.929		95.745	89.837
Cr	99.448	98.000	100	99.200	99.162
Cu	23.077	76.471	63.636	92.727	63.978
Zn	100	100	100	100	100

$$\% = \frac{(A-A')}{A} X100$$

A: Metal concentration during activities
A': Metal concentration after the activities

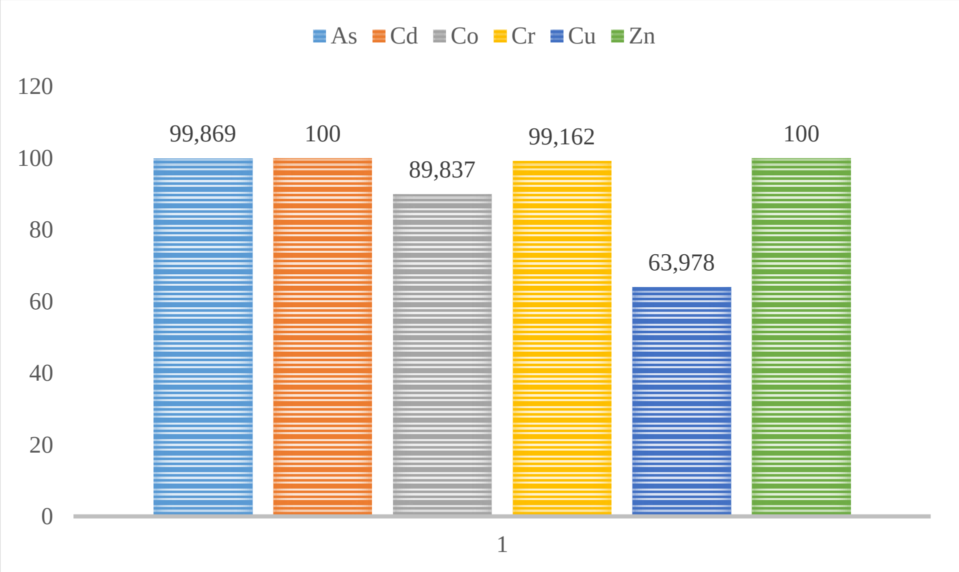

Figure 2: The average decrease in TMs in the Kamatanda River

Figure 2 gives us the percentage averages of the decrease in trace metal elements from the different sampling points. The contents of: As, Cd, Co, Cr and Zn decreased with an average of more than 90%, while that of Cu went to 64%.

CONCLUSION

At the end of this study, the results obtained on the quality of the water of the Kamatanda River seem to highlight the direct impact of pollution generated by artisanal miners in a nearby quarry. Indeed, this physical-chemical quality of the waters of the Kamatanda River revealed:

A significant pollution for April 2018 confirmed by the high values compared to the European Union standard (10.27, 0.050 and 0.192, Arsenic, Cadmium and Chromium), and the mining regulation (10.27and 0.192, for Arsenic and Chromium). This pollution could be accentuated by the activities of the quarry operators (leaching of ores, rainwater runoff).

A strong decrease of metallic trace elements for April 2019 confirmed by the values inferior to the standard and to the mining regulation. This decrease could be due to a cessation of artisanal mining activities and the flow velocity of the river in our study. The Kamatanda River waters for the year 2019 were found to be low in trace elements.

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