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# Evaluation of pollution due to the transport of mining products; case of CHEMAF in Ruashi and Kampemba communes

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**Abstract**

The study was conducted in order to assess the pollution due to the transport of mining products and to know if the dust from ores and mining discharges are loaded with MTE and to assess their impact on the environment.

The results of the qualitative analysis on the dust in the air highlighted the metallic elements in traces. This made it possible to identify the elements Cu, Cd, Co, Pb, As, Cr, Se, Sn, Ni and Zn, which elements are also found in mining and ore waste. This proves that there is transposition of MTE from mining and ore discharges to the air breathed by the inhabitants of the neighborhoods crossed by this mining transport.

The results of quantitative analysis showed that copper has the highest contents of all determined MTE followed by cobalt and zinc. The soil analysis results show that during the dry season the MTE are much more concentrated on the surface of the soil and infiltrate with difficulty, whereas during the rainy season rainwater and the acidity of mining discharges are at the basis of the mobility of MTE that infiltrate soils.

The samples taken 5 m from the road show very high Cu, Cd, Pb and Zn contents which even far exceed the standard values than those taken 15 m away. This reveals that the soil near the road is indeed more exposed to receiving pollutants from mining transport.

Determining the levels of MTE in the air makes it possible to assess the risks of contamination of the trophic chain on the one hand and on the other to develop appropriate remediation techniques.

**Keywords:** Pollution, CHEMAF, Ruashi, MTE

## 1. Introduction

Road traffic is the source of environmental contamination by heavy metals. Unlike most organic contaminants, metals are non-biodegradable and potentially toxic substances (Delmas, 2000) [1]. Mainly resulting from industrial activity and the circulation of various means of transport, atmospheric fallout represents the main source of trace metal elements (TEM) in urban areas. In addition to these anthropogenic fallout, there is natural background noise linked to wind erosion of soils and volcanic eruptions (Hardy, 2005) [3]. In the Democratic Republic of Congo, the transport of mining products is done by means of non-covered mining trucks which, during their movement, experience losses of minerals in different forms.

As the content of these trucks contains minerals or mining waste, no doubt the resulting materials in the form of losses can also be loaded with BAT which can cause enormous damage to the environment and affect, in one way or another, population health. Indeed the company Chemical of Africa (CHEMAF) located in the province of Haut-Katanga, and more precisely in the city of Lubumbashi, transports its various ores from the Kalukuluku quarry (at Ruashi) to the hydrometallurgical plant, located in the Industrial district on USOKE Avenue; in return, it brings mining waste back to Kalukuluku (MINERAL INFO, 2016) [11]. This operation contributes to the ejection, migration and dispersion of ETM in the environment, indeed the mining trucks loaded with ores or mining waste lose a certain quantity by spillage and/or flight, especially at places where they are almost shaken. Situation responsible for the bleeding of the noses and cases of respiratory diseases of the inhabitants residing in the vicinity of Kiwele and Changwe avenues exposed to chemical pollutants due to the transport of mining products of this company. (Kasanya, 2016) [7]. It was noted that the sector located under the trade winds from the east has soils enriched in lead and other heavy metals, by the fallout of metalliferous dust emanating from the Likasi road (Muyumba, 2014) [12] and the bypass road (Kasanya *et al*l, 2022) [6] Situation responsible for the replacement of the original clear forest of Miombo, by a short steppe within which we find many species of the copper flora (Malaisse, 1997) [9] as well as vast areas of bare ground. The various combined emission sources (factories, traffic) and local spillovers are greater in urban and peri-urban areas. Aerosols of anthropogenic origin come from various human activities, such as coal or oil combustion, metal production (mining and smelting activities), iron and steel industries, incineration waste, agricultural fertilizers, cement production, wood combustion, or even the transport of uncovered products (Nriagu and Pacyna, 1988) [14].

In this context, many studies have focused on the air quality near areas where mining products are transported, road traffic or in urban areas (Okuda *et al*, 2004; Figueiredo *et al*. 2007) [15, 2]. Given that part of the soil is contaminated along the roads (Muyumba, 2014; Kasanya *et al*., 2022) [12,6], the contamination of plants by root absorption, or by the deposit of dust loaded with MTE on the aerial parts is possible and should be the subject of in-depth study. Thus, it has been found that the waters which run off the Swedish highways were the source of the contamination of the glacial eskers located in the surroundings (Norrstrom AC. and Jacks, 2009) [13]. In the United States and Canada, an increase in cases of respiratory disease has been noted among women aged 35 to 75 residing in the vicinity of electrical copper smelter facilities (Mattson & Guidotti, 1980) [10]. This article aims to assess the levels of BAT contained in dust, soil and leafy vegetables near transport areas of Chemaf mining products in the vicinity of Kiwele and Changwe avenues in Lubumbashi.

## 2. Material and Methods

We conducted our studies on the company Chemical of Africa (CHEMAF) located in the province of Haut-Katanga, and more precisely in the city of Lubumbashi, transporting its various ores from the Kalukuluku quarry to the hydrometallurgical plant, located in Industrial district on USOKE Avenue ; in return, it brings the mining waste back to Kalukuluku. The Kalukuluku deposit covers an area of 250 hectares. It is located about 12 km east of the city of Lubumbashi and 6 km from the town of Ruashi and at an altitude of 1275 km between the meridian 25°37' East longitude and the parallel 11°4' of southern latitude. The mine is owned by the company CHEMAF, which also has a processing plant in Usoke, located about ten kilometers from the site.

### 2.1 Sampling

The two avenues Kiwele and Changwe constitute a long stretch of 12 km this distance was measured using a kilometer motorcycle, we divided this distance into five almost equal portions which correspond to five different sites numbered from 1 to 5. It is on these five sites that the dry deposits, rejects, ores and soils were sampled. For the sampling of wet deposits, the distance was this time divided into ten almost equal portions which correspond to ten different sites numbered from H1 to H10. These wet deposits were collected in OWEN gauges. The ore samples were numbered from M1 to M5, those of the rejects from R1 to R5 and the dry deposits from A1, B1, C1 to A5, B5, C5 respectively.

The fifteen samples of air dust (dry deposits) were taken taking into account the direction of the wind according to the technique consisting in using the assembly of figure I described below.

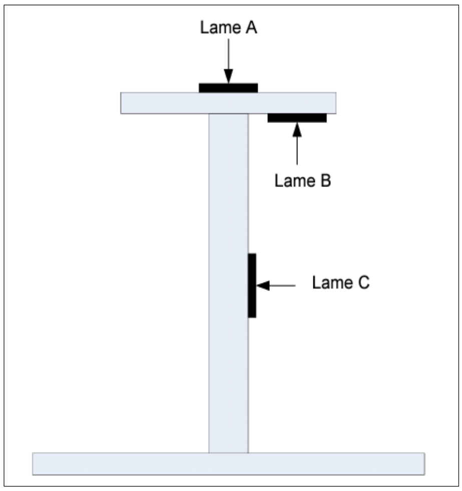


**Fig 1:** Description of the assembly used to collect dust from the air (Source: KANIKI, 2008) [4]

Posts about 1.8 m high are placed with three containers in which petroleum jelly is applied. They are exposed for a given period to the open air, the dust present in the air is thus "fixed" by the petroleum jelly.

- The device (Slide A) is placed horizontally, coated side up. It captures the dust that falls.
- The device (Slide B) is placed horizontally, coated side down. It captures dust resuspended from the ground.
- The device (Blade C) is placed vertically and captures dust brought directly by the wind and which does not necessarily settle. In our work, the face of the container directed vertically is induced.

Soil samples were taken using a trowel and a spatula up to 10cm deep, both in stainless steel. These samples were stored in new plastic bags, commonly called "05" on which identification labels are attached. Samples taken in the dry season at depth were numbered Gc1 to Gc3 and those taken away from the road were numbered Gd1 to Gd3. The samples

collected away from the road in the rainy season were numbered from Fc1 to Fc3.
The pre-treatment of samples of ores, rejects and soils was carried out according to the ISO 11464 standard (ISO, 1994)

### 2.2. Statistical Analysis
The results obtained were subjected to an analysis of variance (ANOVA) with the statistical software XLSTAT-Pro7.5 and the means were compared using the T test for paired samples at the probability threshold P = 5%. MTE contamination of soils and dust in the air was diagnosed by following Canadian standards for metals for ambient air & French for residential soils (Environment Canada, 2012).

## 3. Results and Discussion
The results of the analysis of samples of mining waste taken from the pavement of Kiwele and Changwe avenues are shown in Table 1

**Table 1:** MTE chemical and physico-chemical analyzes of mining waste samples

| N° | Sample | pH | MTE content in mining waste (ppm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cr | As | Sn | Co | Cu | Ni | Zn | Cd | Pb |
| 1 | R1 | 5 | 7 | 20 | 26 | 32 | 55 | 23 | 26 | 10 | 17 |
| 2 | R2 | 5.5 | 6 | 22 | 23 | 45 | 60 | 20 | 28 | 12.1 | 17.3 |
| 3 | R3 | 5 | 8 | 25 | 26 | 36 | 52 | 22 | 28 | 10.5 | 16 |
| 4 | R4 | 5 | 8.1 | 21.2 | 24 | 51 | 61 | 22 | 27.3 | 12.5 | 15 |
| 5 | R5 | 5 | 7.5 | 22.5 | 24 | 38 | 58 | 20.8 | 25.6 | 12.2 | 15.7 |
| Moyenne | | 5.1 | 7.3 | 22.1 | 25 | 47 | 57 | 21.6 | 26.9 | 11.5 | 16.2 |

The results in Table 1 show that copper has the highest average levels (57 ppm) of all the TEMs studied, followed by cobalt and then zinc (47 ppm and 26.9 ppm respectively), while chromium shows the lowest concentration (7.3 ppm).
According to Table 1, the results of the chemical analyzes indicate that the mining waste produced by the CHEMAF mining industry and transported by the mining transport trucks are loaded with MTE. The pH results in this same table show that the mining discharges are acidic. This shows the tendency of these metals to ionise, and therefore to pollute the environment, and the standard for the ambient air (in $\mu g/m^3$) show that even in the mining waste present, they are there at a harmful to living organisms.

**Table 2:** Chemical and physico-chemical analyzes of MTE in ore samples

| N° | Sample | pH | MTE content in ores | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cr ppm | As ppm | Sn ppm | Co % | Cu % | Ni ppm | Zn ppm | Cd ppm | Pb ppm |
| 1 | M1 | 7.1 | 241 | 270 | 99.5 | 19,2 | 37,8 | 1951 | 2315 | 20 | 28 |
| 2 | M2 | 6.9 | 257 | 216 | 78 | 20,9 | 39,5 | 1524 | 2635 | 25 | 30 |
| 3 | M3 | 6 | 246 | 206 | 82 | 21,6 | 38,8 | 2054 | 4062 | 28 | 28 |
| 4 | M4 | 7.2 | 238 | 300 | 128 | 20,55 | 40,5 | 1870 | 3065 | 27 | 32 |
| 5 | M5 | 6.8 | 268 | 336 | 120 | 23,57 | 40 | 2080 | 4532 | 29 | 36 |
| ***Moyenne*** | | **6.8** | **250** | **266** | **101.5** | **21,2** | **39,5** | **1896** | **3322** | **26** | **31** |

After carefully examining Table 2, we found that the results of the chemical analyzes indicate that the majority of the metals are there in very high content rather than at trace levels, apart from a few metals like Cd and Pb. which have low concentrations. The results in Table 2 show, as before (Table 1), that the average copper content is the highest (39.5%) followed by those of cobalt (21.2%) then those of zinc (3322ppm), while the cadmium content is the lowest (26 ppm). The environmental danger consists in putting the inhabitants of the residential areas of the Ruashi commune and that of Kampemba in the abundant presence of these metals, knowing their impact on human life. The politico-administrative authorities should be sensitive to this.

**Table 3:** Chemical and physico-chemical analyzes of MTE in soil samples (rainy season)

| N° | Sample | pH | MTE content in soils (ppm) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Cr | Cu | Zn | Cd | Pb |
| 01 | Gc1 | 5.9 | 170 | 503 | 330 | 6 | 140 |
| 02 | Gc2 | 5 | 150 | 455 | 310 | 4 | 130 |
| 03 | Gc3 | 6 | 105 | 320 | 302 | 3 | 99 |
| 04 | Gd1 | 5.5 | 168 | 498 | 350 | 8 | 160 |
| 05 | Gd2 | 6.5 | 142 | 380 | 323 | 5 | 140 |
| 06 | Gd3 | 6.9 | 110 | 295 | 297 | 2 | 103 |
| Moyenne | | 5.97 | 140,83 | 408,5 | 318,7 | 4,67 | 128,7 |
| **French standard** | | **-** | **150** | **100** | **300** | **2** | **100** |

Values exceeding those of the standard

The analysis results in Table 3 clearly indicate the presence of TEMs in this soil studied, an environment with an acid pH. It shows not only that these MTE exceed the tolerable threshold, apart from Cr in Gc2, Gc3, Gd2, Gd3 and Pb in Gc3, but it is necessary to underline the pollution of the environment in these metals. Because, in fact, the soils sampled during the rainy season are not only acidic but they actually contain the aforementioned MTE.
A non-negligible presence MTE such as copper, zinc, lead and cadmium, the presence of which, in fairly high levels, constitutes a danger for the population. Indeed, the samples Gc1, Gd1 and Gc2 have very high contents of Cd, Pb, Zn and Cu which even far exceed the values of the standard. This reveals that the superficial part is indeed more exposed to receive chemical fumes from mining transport, which infiltrate on a large scale through the runoff of slightly acidic rainwater.

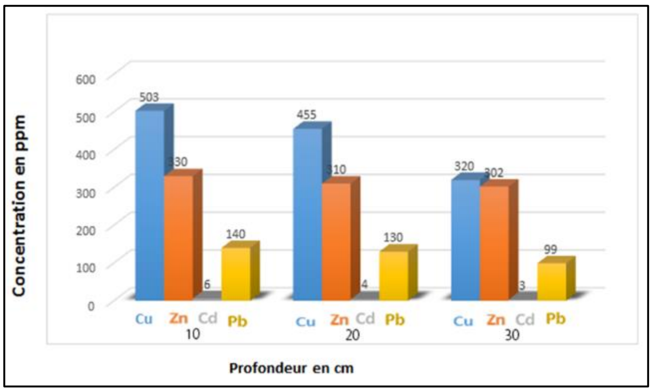


**Fig 2:** Evolution of MTE concentrations deep in the soil (soil samples taken during the rainy season)

It follows from figure II that the contents of copper, zinc, cadmium and lead decrease slightly as one goes deeper into the ground, that is to say as one moves away from the surface. of the ground. This situation was also noted by MUYUMBA (2014) [12] who, in his license thesis analyzed the MTE in depth of the ground. This reveals that the superficial part is indeed more exposed to receiving chemical fumes from mining transport which infiltrate on a large scale by means of the runoff of rainwater made acidic by mining discharges. The acidity of mining waste has a significant influence on the mobility of MTE in the soil during the rainy season. This leads to the easy contamination of everything that lives on this soil, such as cultivated vegetables.

**Table 4:** MTE chemical and physico-chemical analyzes of soil samples

| N° | Echant | pH | MTE content in soils (ppm) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Cr | Cu | Zn | Cd | Pb |
| 01 | Gc1 | 6.7 | 200 | 560 | 450 | 15 | 170 |
| 02 | Gc2 | 6.9 | 99 | 250 | 150 | 6 | 80 |
| 03 | Gc3 | 7.1 | 15 | 50 | 28 | 1,5 | 22 |
| **Moyenne** | | **6.9** | **104,7** | **286,7** | **209,3** | **7,5** | **90,7** |
| **Mean** | | **-** | **150** | **100** | **300** | **2** | **100** |

**: Values exceeding those of the standard**

Table 4 indicates the presence of TEMs in this soil of our study**.**

It appears that the MTE contents in the Fc1 and Fc2 samples are higher than those of the Fd3 sample,

This table shows the evolution of the concentrations of TEMs away from the road. These results corroborate those of Kitobo (2009) [8], who in his doctoral thesis, found that the MTE contents decreased as one moved away from the Kipushi concentrator.

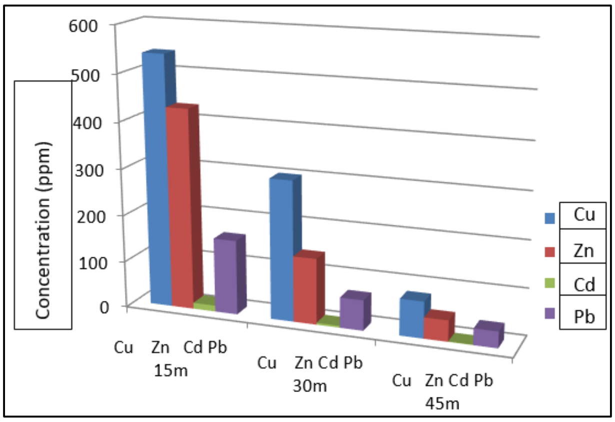


**Fig 3:** Evolution of MTE concentrations away from the road (soil samples taken during the dry season)

It follows from figure III that the contents of copper, zinc, cadmium and lead decrease as one moves away from the road. This situation was also observed by Kasanya and al (2022) [6] who found that the MTE levels decreased as one moved away from the bypass road. This reveals that indeed, mining transport is indisputably the source of pollution and the populations living around Kiwele and Changwe avenues are the most exposed to this pollution.

**Table 5:** Average values of physico-chemical parameters of soils sampled during the rainy and dry seasons

| MTE | rainy season | Dry season | P |
|---|---|---|---|
| Cu | 391,0(b) | 286,7(a) | 0,0411 |
| Zn | 323,3(b) | 209,3(a) | 0,0542 |
| Pb | 134,3(b) | 90,7(a) | 0,0427 |
| Cd | 5,0(b) | 7,5(a) | 0,0324 |
| *Cr* | 140,0(b) | 104,7(a) | 0,0585 |
| *pH* | 6,3(a) | 6,9(a) | 0,9872 |

For each parameter, values that have different letters in the same row are significantly different according to the paired-samples t-test at the probability threshold (P = 5%).

Table 5 presents the average values of physico-chemical parameters of the soils sampled during the rainy and dry seasons. It appears that the comparison of the means of the chemical parameters (MTE) obtained, by the T test for paired samples, showed for all the parameters, the existence of significant differences for the samples taken in the rainy season and for those of In the dry season, the high values of the physico-chemical parameters in the rainy season could be attributed to large-scale infiltration by means of the runoff of rainwater made acidic by mining discharges. These results are consistent with those of Kasanya *et al.* (2022) [6] who had attributed the high values of physico-chemical parameters in the rainy season to effluent inputs from the SOMIKA company into aquifers and groundwater by infiltration.

**Table 6:** Chemical and physico-chemical analyzes of MTE from air dust samples (dry season)

| N° | Sample | pH | MTE content in air dust (µg/m3) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cr | As | Sn | Cu | Ni | Zn | Cd | Pb |
| 01 | A1 | 7.1 | 1.0 | 2.0 | 1.5 | 6.0 | 0.0 | 2.0 | 1.8 | 0.7 |
| 02 | B1 | 6.9 | 0.0 | 6.0 | 2.0 | 7.0 | 2.0 | 2.5 | 2.3 | 3.0 |
| 03 | C1 | 7.1 | 2.0 | 2.5 | 1.6 | 8.0 | 3.0 | 1.9 | 4.5 | 5.0 |
| 04 | A2 | 7.2 | 2.5 | 4.0 | 1.8 | 5.0 | 4.0 | 1.7 | 1.7 | 1.5 |
| 05 | B2 | 7.1 | 5,0 | 4.0 | 2.0 | 7.0 | 5.0 | 2.0 | 1.1 | 1.0 |
| 06 | C2 | 7.0 | 4.0 | 1.0 | 1.8 | 10.0 | 0.5 | 3.0 | 4.2 | 7.0 |
| 07 | A3 | 7.3 | 8.0 | 6.0 | 7.0 | 7.0 | 2.0 | 6.0 | 2.0 | 1.6 |
| 08 | B3 | 7.0 | 4.0 | 2.0 | 1.9 | 6.0 | 5.0 | 6.0 | 1.0 | 3.5 |
| 09 | C3 | 7.0 | 5.0 | 3.9 | 3.2 | 14.0 | 5.0 | 7.0 | 4.0 | 3.4 |
| 10 | A4 | 7.3 | 3.0 | 8.0 | 3.0 | 9.0 | 2.5 | 4.0 | 1.4 | 8.0 |
| 11 | B4 | 7.0 | 2.0 | 3.0 | 4.0 | 10.0 | 5.0 | 4.0 | 2.0 | 2.0 |
| 12 | C4 | 7.2 | 3.0 | 4.0 | 6.0 | 16.0 | 3.5 | 3.0 | 6.0 | 3.5 |
| 13 | A5 | 7.0 | 4.0 | 2.0 | 4.0 | 8.0 | 3.0 | 6.0 | 2.0 | 3.0 |
| 14 | B5 | 7.3 | 2.0 | 5.0 | 7.0 | 8.0 | 5.0 | 4.0 | 2.4 | 4.0 |
| 15 | C5 | 7.1 | 3.0 | 2.0 | 5.0 | 15.0 | 7.0 | 3.0 | 5.0 | 5.0 |
| **Moyenne** | | **7.0** | **3.3** | **3.8** | **4.4** | **9.0** | **3.8** | **4.2** | **3.1** | **4.0** |
| **CAAS** | | **-** | **3.3** | **8.11** | **4.41** | **5.11** | **5.03** | **1.22** | **1.08** | **3.7** |

**: Values exceeding those of the standard**

**CAAS: Canadian Ambient Air Standards**: Source: Environment Canada (2012) available at www.ec.gc.ca/inrp-npri/default.asp? lang= Fr (Page consulted on 03/04/2022)

After examining Table 6, we find that dust from the air trapped during the dry season does indeed contain studied MTEs. Copper being the element with the highest average content (9ppm), while cadmium has the lowest (3.1ppm).

This high copper content would be due to the fact that the CHEMAF company processes copper ores.

Samples C1, C2, C3, C4 and C5 effectively contain MTE such as Cd, Pb, Zn, Ni, As, Co and Cu found in significant content in mining wastes and ores. The contents of these BAT are higher, even exceeding the limit values of the standard. This proves that indeed, mining transport on Kiwele and Changwe avenues contributes under the effect of the wind to the ejection, migration and dispersion of MTE in the environment and more particularly in the air.

**Table 7:** Chemical and physico-chemical analyzes of MTE from air samples (rainy season)

| N° | Sample | pH | MTE content in air (µg/m$^3$) (µg/m$^3$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cr | As | Sn | Cu | Ni | Zn | Cd | Pb |
| 01 | H1 | 6.9 | 1.0 | 1.5 | 3.0 | 7.0 | 1.0 | 2.0 | 1.3 | 1.0 |
| 02 | H2 | 6.7 | .0. | 0.5 | 0.0 | 6.5 | 0.0 | 2.5 | 1.2 | 0.5 |
| 03 | H3 | 7.0 | 0.9 | 2.0 | 2.0 | 6.0 | 2.0 | 1.5 | 0.9 | 2.0 |
| 04 | H4 | 6.8 | 0.0 | 0.0 | 1.1 | 5.9 | 0.0 | 1.2 | 1.5 | 1.5 |
| 05 | H5 | 6.9 | 0.5 | 0.4 | 2.0 | 7.1 | 0.0 | 2.0 | 1.5 | 1.2 |
| 06 | H6 | 7.0 | 0.0 | 0.2 | 1.8 | 6.9 | 0.0 | 2.2 | 1.5 | 0.0 |
| 07 | H7 | 6.9 | 0.0 | 0.0 | 0.6 | 5.6 | 0.0 | 1.5 | 1.3 | 1.2 |
| 08 | H8 | 6.7 | 0.0 | 0.0 | 0.0 | 5.5 | 0.5 | 1.0 | 1.2 | 1.0 |
| 09 | H9 | 7.0 | 1.5 | 2.0 | 3.0 | 5.0 | 1.0 | 1.2 | 0.5 | 0.4 |
| 10 | H10 | 6.5 | 1.5 | 0.7 | 1.0 | 5.0 | 1.0 | 0.5 | 0.5 | 1.0 |
| **Mean** | | **6.84** | **0.5** | **0.7** | **1.0** | **6.1** | **1.0** | **2.0** | **1.0** | **1.0** |
| **CAAE** | | **-** | **3.3** | **8.11** | **4.41** | **5.11** | **5.03** | **1.22** | **1.08** | **3.7** |

**: Values exceeding those of the standard**

The data in Table 7 show that the wet deposits collected during the rainy season are loaded like the dry deposits with MTE; the contents of certain MTE are negligible. This finding is identical to that of Mattson & Guidotti (1980) [10] who found in the United States and Canada that electrical foundry installations emitted higher copper levels in the dry season than in the rainy season. This would be due to the fact that the rain inhibits the dryness of the ores and mining waste dumped on the roadway of Kiwele and Changwe avenues making them unable to fly in the air and turn into dust.

**Table 8:** Mean values of physico-chemical parameters of dust collected during the rainy and dry seasons

| MTE | rainy season | Dry season | P |
|---|---|---|---|
| Cu | 6.1(b) | 9,0(a) | 0,0631 |
| Zn | 2.0(b) | 4,2(a) | 0,0672 |
| Pb | 1,0(b) | 4,0(a) | 0,0457 |
| Cd | 1,0(b) | 3,1(a) | 0,0624 |
| Ni | 1,0(b) | 3,8(a) | 0,0255 |
| Sn | 1,0(b) | 4,4(a) | 0.0523 |
| As | 0,7(b) | 3,8(a) | 0.0253 |
| Cr | 0,5(b) | 3,3(a) | 0,0485 |
| *pH* | 6,3(a) | 6,9(a) | 0,0272 |

For each parameter, values that have different letters in the same row are significantly different according to the paired-samples t-test at the probability threshold (P = 5%).

Table 8 presents the average values of physico-chemical parameters of dust samples taken during the rainy and dry seasons. It appears that the comparison of the means of the chemical parameters (MTE) obtained, by the T test for paired samples, showed for all the parameters, the existence of significant differences for the samples taken in the rainy season and for those of In the dry season, the high values of the physico-chemical parameters in the dry season could be attributed to the ejection, migration and dispersion under the effect of the wind of MTE in the environment and more particularly in the air.

**Table 9:** Extraction of MTE in ore and tailings samples

| Contents of ETM before and after extraction (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | As | Co | Cu | Zn | Cd | Pb |
| **M*** | **before** | 265.6 | 211679.2 | 393048.8 | 3321.8 | 25.8 | 30.8 |
| | **after** | 106.24 | 190701.98 | 340380.26 | 714.187 | 25.6 | 28.52 |
| ***R**** | **before** | 22.14 | 47.14 | 57.2 | 26.98 | 11.46 | 16.2 |
| | **after** | 8.86 | 42.468 | 49.74 | 5.621 | 5.73 | 14.63 |

M*: composite sample representing the ore samples.
R*: composite sample representing the samples from the mine tailings

Based on the analysis of the results in Table 9 : It appears that zinc is the most mobile and bioavailable element in mining and ore waste since its passage in large proportion in the extract followed by silver, arsenic, barium, cadmium, copper, cobalt and lead. Cadmium is more mobile than lead in sample R while in sample M it is lead which is more mobile because the cadmium content hardly decreases. The zinc, silver and barium contents decrease significantly when we consider the ratio of the contents before and after extraction while the cadmium, copper, cobalt and lead contents also decrease but not in a perceptible way.

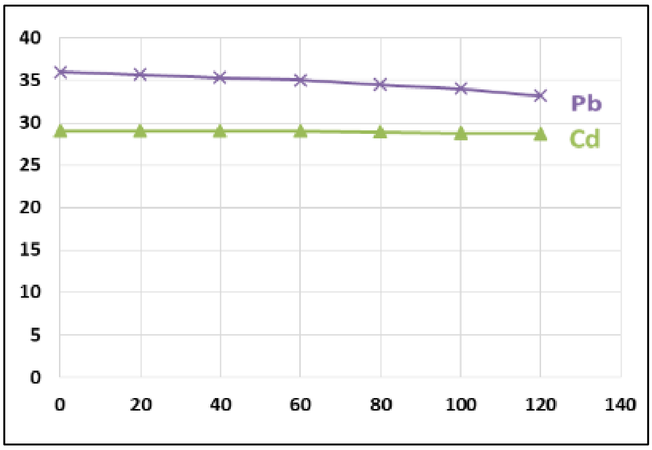


**Fig 4:** Kinetics of ore leaching in distilled water

It follows from figure IV that the Pb and Cd dissolve slowly.

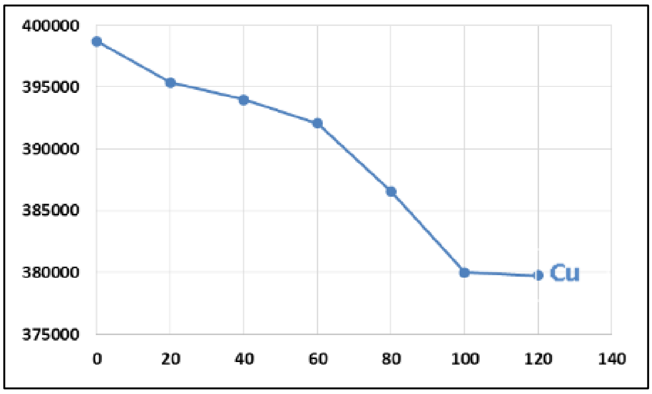


**Fig 5:** Kinetics of ore leaching in distilled water

It follows from figureV that Cu solubilizes better than Pb and Cd.

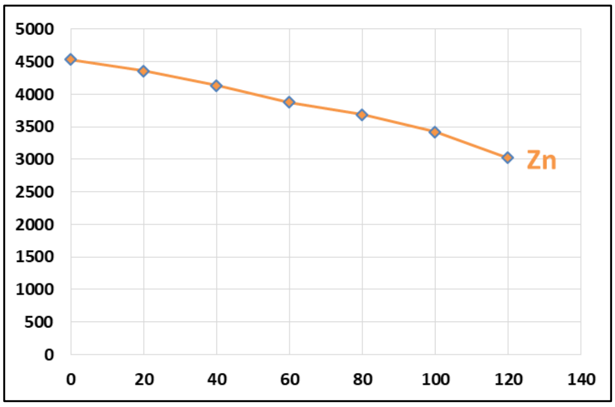


**Fig 6:** Kinetics of ore leaching in distilled water

It follows from figure VI that Zn is solubilized better than the other MTE studied.

It follows from figures IV, V and VI that zinc is the most mobile element, followed by copper. The kinetic profile of cadmium and lead is almost identical in the ores.

The kinetic profiles of the MTE observed for the samples of the mining wastes and the ores are identical, which further confirms that the MTE of the surface soil derive from mining transport.

These observations show that the elements analyzed would be found in several chemical forms with different solubilization rates. These same observations were also noted by KANIKI (2008) [4] who, in his doctoral thesis, followed the kinetic profile of MTE in mineralo-metallurgical discharges. The rapid solubilization would be attributable to the water-soluble salts and the adsorbed elements. Zinc, for example, should therefore be essentially in a water-soluble form. Slow solubilization highlights the presence of compounds that are very slowly soluble in water and whose equilibrium conditions can only be achieved after a sufficiently long time. Pb, for example, should therefore be essentially in a water-insoluble form. It can also be noted that by carrying out the extraction on the different leaching residues, kinetic curves were obtained characterized by a very slow dissolution.

**Conclusion**

The main objective pursued in this work was to assess the pollution due to the transport of mining products and to know if the dust from ores and mining waste are loaded with MTE and to assess their impact on the environment.

The results of the qualitative analysis on the dust in the air highlighted the metallic elements in traces. This made it possible to identify the elements Cu, Cd, Co, Pb, As, Cr, Se, Sn, Ni and Zn, which elements are also found in mining and ore waste. This proves that there is transposition of MTE from mining and ore discharges to the air breathed by the inhabitants of the neighborhoods crossed by this mining transport.

The results of quantitative analysis showed that copper has the highest contents of all determined MTE followed by cobalt and zinc.

The results of soil analysis show that during the dry season the MTE are much more concentrated on the surface of the soil and infiltrate with difficulty, hence the air pollution while during the rainy season the rainwater and the acidity of the mining discharges are the basis of the mobility of the MTE which infiltrate easily, hence the pollution of the soil. The same soil results again show that the part of the soil close to the road is more polluted. This further confirms that the source of pollution remains mining transport.

The kinetic study showed that MTE have an almost similar profile in mining discharges, ores and soils characterized by rapid solubilization of zinc and relatively slow for copper, cadmium and lead. Mercury is only slowly solubilized.

Finally, to comprehensively assess the environmental impact in relation to man and the ecosystem, a multi-criteria analysis on a standardized three-level scale was carried out.

The results obtained show that by taking into consideration the complex criterion associating the three indicators (leaching rate, pollutant content and toxicity), none of the samples treated can be considered as low risk. Mine tailings are high risk.

**Outlook**

Since even the remote places of Changwe and Kiwele Avenues are affected by pollution due to the transport of Chemaf mining products. That is why,

We will ask the politico-administrative authorities to convince the Chemaf Company to leave the Industrial District without delay so that the transport of mining waste and minerals no longer takes place in the residential Communes of Ruashi and Kampemba.

And we will ask our legislator in the DRC to set the limit values of MTE (Standards) in residential soils and in the air of residential neighborhoods.

This work gives the level of air pollution at the site of Changwe and Kiwele avenues in Ruashi commune. It constitutes an orientation for future researchers who should think about the analysis of the blood of the inhabitants of Ruashi commune, the study of the real speciation of pollutants, the simple extraction with $CaCl_2$ and the sequential extraction of MTE, to the production of pollution maps, and to think of site depollution techniques.

**Références**


1. Delmas GC. Influence des conditions physico-chimiques sur la mobilité du plomb et du zinc dans le sol et un sédiment en domaine routier ; Thèse de doctorat. Université de Pau et des Pays de l'Adour ; c2000, 21-39, 68-78, 157-160.
2. Figueiredo AMG, Jacks G. Concentration and fractionation of heavey metals in roadside soils receiving de-icing salts; The Science of the Total Environment. 2007;218(2-3):161-174.
3. Legret M, Colandini V, Demare D, Balades JD, Madiec H. Pollution par les métaux lourds liée à l'infiltration des eaux de ruissellement urbaines dans une chaussée poreuse à structure réservoir. Environmental Technology. 1994;15(12):1183-1191.
4. Kaniki A. Caractérisation environnementale des rejets minéro-métallurgiques du copperbelt congolais; Thèse de doctorat; Université de Liège; c2008, 28-29, 108, 142-158, 170200.
5. Kasanya KJ, Ngoy wa Banza MJP, Kibesa MD, Kunda BA, Cabala YP, Ngosa MP, *et al*. Evaluation of the impact of car traffic on agricultural activities in the vicinity of the bypass road in DR Congo. IJMRGE. 2022;03(04):374-380.
6. Kasanya KJ, Ngoy wa Banza MJP, Kunda BA, Ngosa MP, Lukuna LA, Mwelwa NJ. Treatement of well water polluted with metallic trace elements by Moringa seeds: Case of Kisanga district in the Democratic Republic of Congo. IJMRGE. 2022;03(04):356-362.
7. Kasanya KJ. Evaluation de la pollution due au transport des produits miniers; cas de CHEMAF dans les communes Ruashi et Kampemba. Mémoire de Licence. Département de Chimie-physique, ISP-Lubumbashi; c2016 .p. 33-52.
8. Kitobo W. Dépollution et valorisation des rejets miniers sulfurés du Katanga: Cas des taillings de l'ancien concentrateur de Kipushi; Thèse de doctorat; Université de liège; c2009, 48-55, 126-128, 158-180.
9. Malaisse F. Se nourrir en forêt claire africaine. Approche écologique et nutritionnelle centre Les presses Agronomiques de Gembloux. ASBL. Gembloux.1665/3; c1997.
10. Mattson ME, Guidotti TL. Health risks associated with residence near a primary copper smelter: a preliminary report. American Journal of Industrial Medicine.

1980;1(3-4):365-374.
11. MINERAL INFO. L'informatisation du secteur minier: Exemple de la République Démocratique du Congo. Disponible sur; c2016. http://www.mineralinfo.org (Mars, 2016). p22
12. Muyumba NW. Etude sur l'émission et le transfert dans le sol des éléments traces métalliques en domaine routier; Mémoire de Licence. Département de Chimie-physique, ISP-LUBUMBASHI, 2014, 24-43.
13. Norrström AC, Jacks G. Concentration and fractionation of heavy metals in roadside soils receiving de-icing salts. Science of the Total Environment. 1998;218(2-3):161-174.
14. Nriagu JO, Pacyna JM. Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature. 1988;333(6169):134-139.
15. Okuda T, Gesselin P, Cordier S, Viau C. Daily concentrations of trace metals in aerosols in Beijing, China, determined by using inductively coupled plasma mass spectrometry equipped with laser ablation analysis, and source identification of aerosols. Science of The Total Environment. 2004;330(1-3):145-158.