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Evaluation of the impact of car traffic on agricultural activities in the vicinity of the bypass road in DR Congo

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Abstract

The study was carried out with the aim of assessing the impact of car traffic on agricultural activities in the vicinity of the lorry road. The results of the qualitative analysis in leafy vegetables showed the metallic trace elements (MTE), which are also found in soils (Cd, Pb and Zn). This proves there's soil-plant transfer of MTE. The results of the quantitative analysis obtained showed that Zn has the highest levels of all the MTE determined followed by Pb and at the end of Cd, and the samples taken at 5 m from the road have very high levels of Cd, Pb and Zn which even far exceed the values of the standard as those taken at 15m. This shows that, indeed, the soil close to the road is more exposed to pollutants from car traffic.

The determination of MTE levels in vegetables grown in Lubumbashi near the bypass road makes it possible to assess the risks of contamination of the food chain on the one hand and the development of appropriate bioremediation techniques on the other.

Keywords: road; vegetables; identification of MTE

Introduction

Road traffic, corrosion of vehicles or road infrastructure are causing environmental contamination by metals such as lead and zinc. Unlike most organic contaminants, metals are non-biodegradable and potentially toxic substances (Delmas, 2000) [6]. Mining is one of the most important sources of heavy metals in the environment. High levels of these metals can be found in and around metal-bearing mines, due to the discharge and dispersion of tailings into nearby agricultural soils and waterways. This may pose a potential risk to people living in mining areas (Lee, 2001) [14].

It has been found that the area under the south-eastern trade winds has soils enriched with lead and other heavy metals, from the deposition of metallic dust from the Likasi road (Muyumba, 2014) [21]. Responsible for the location of the original clear forest of Miombo, by a short steppe in which we find many species of the cupricole flora (Malaisse, 1997) [15] as well as vast areas of bare ground. The different sources of emissions combined (factories, traffic) and the local fallout are more important in urban and peri-urban areas. They have thus led to making urban soils (public or private gardens) or those of industrial zones (workers' gardens in particular) soils presenting risks because of the contamination of vegetable plants growing there (Bourrelier & Berthelin, 1998) [3]. According to Alloway (1997) [2], Pagotto (1999) [23], Delmas (2000) [6] & Adriano (2001) [1], emissions of polluting and non-polluting substances from road infrastructure are generated by several types of sources: vehicles in circulation on the infrastructure.

(Exhaust, fluites, tire wear, brakes, corrosion) the abrasion of the road by sudden braking or not; the wear and tear of road equipment (slides, road signs, etc.). Understanding the phenomena of pollution and their prediction requires a good knowledge of the sources of pollutants, their geographical distribution; and the nature of the pollutants emitted.

In 2008, more than 30 vegetable sites were surveyed in the urban and peri-urban areas of Lubumbashi, with a total of 8,308 vegetable growers, 74% of whom were women. These sites were supported by the FAO HUP (Horticulture Urbaine et Périurbaine) project (SENAHUP, 2008) [25]. Cabbage is grown all year round and is one of the leafy vegetables that occupy a high total area. However, due to its soil requirements, the cultivation of sweet potato leaves is often practised in rainy season and covers only a small area. Nevertheless, the topographical position of the soils at the roadside makes them various waste traps enriched in MTE: Road traffic, corrosion of vehicles or road infrastructure. Since some of the soil is contaminated at the roadside, contamination of plants by root absorption, or by deposition of MTE-charged dust on the aerial parts is possible and should be studied in depth. For example, residents living in the vicinity of Kiwele and Changwe avenues exposed to chemical pollutants from the transport of CHEMAF mining products had nosebleed and respiratory cases (Kasanya, 2016) [12]. In the United States and Canada, an increase in cases of respiratory illness has been observed in women aged 35 to 75 living in the vicinity of copper electric smelters (Mattson & Guidotti, 1980) [16]. Sweet potatoes from the Sambwa and Kamalondo crop sites contained high levels of copper in their tissues (Kalamba, 2010) [10]. The purpose of this article is to assess the levels of MTE in soils and leafy vegetables near the bypass road in Lubumbashi.

Materials and Methods

Lubumbashi, known as the copper capital, is the capital of the Haut-Katanga mining province and the second city of the Democratic Republic of Congo after Kinshasa (the capital city). We conducted our studies on the bypass road. It has a length of 26 km and constitutes a deviation of the national road N°1 (RN1) in its part crossing the city of Lubumbashi, from Likasi to Kasumbalesa.

The bypass road, also known as the truck road, has been leased so that highly loaded vehicles are no longer visible on unsuitable arteries, but also to solve the problem of traffic jams caused by trailers passing through the city. (http:// www. acgt.cd).

Sampling

We took for site of sampling the road of the heavyweights, on a stretch between Biayi extended avenue located 5 km from Likasi road and Saint Augustin avenue in the Karavia quarter in Annexe township. This section has a distance of 15 km, and it was measured with a motorcycle mileage.

We have divided this distance into three equal portions, corresponding to three different sites. The soils and vegetables were collected from these three sites. Soil and vegetable samples were taken in the vicinity of the road, left and right, following the direction of the Likasi road to Kasumbalesa.

We have selected 6 gardens which are located on the inhabited section of which 3 to the east and 3 others to the west of the road. Concerning soil samples, for each garden, we took a sample 10 m from the road. The 3 samples of the eastern gardens were numbered from RG1 to RG3 and the 3 other samples of the western gardens were numbered from RD1 to RD3. For the middle garden on both sides of the road, two additional samples were taken: 5 m and 15 m from the road. The additional samples from the Eastern Mid Garden are designated RG4 and RG5 while those from the Western Mid Garden are designated RD4 and RD5.

Cabbage (*Brassica oleracea*) and sweet potato leaf (*Ipometa batatas*) vegetables called "Matembele" are widely grown in gardens found near the truck road. These cabbage and sweet potato leaf vegetables have been in 6 gardens, 3 in the east and 3 in the west of the road. A total of 2 kg of vegetables of each species were purchased per garden, at a rate of 500g of vegetables per bed. The vegetables from 4 beds in the same garden were mixed to form a sample. Soil samples were taken with a small boom up to 10cm deep. These samples were stored in new plastic bags, commonly referred to as "05", on which identification labels were attached. Each sample of vegetable leaf was rinsed 3 times with tap water according to the practice of cleaning vegetables from any Lubumbashi citizen.

Laboratory analysis

Plant samples were dried at 60°C in the oven. The plants were analysed for Pb, Cd and Zn. The dry plants were ground at the oscillating tungsten carbide ring crusher. Extractive is a 50/50 mixture of HNO3 (nitric acid) and HClO4 (perchloric acid). Five grams of the sample reduced to powder, are hot attacked by 50 ml of extractive, until complete evaporation. Ten millilitres of HCl (10%) are then added to the residue, which is transferred to the line in a 50 ml flask in the manner of Mpundu and al. (2013) [20]. The MTE assay was carried out in atomic absorption using a spectrometer (Jobin-Yvon JY 70Type II) from the OCC laboratory.

Statistical Analysis

The results obtained were subjected to a variance analysis (ANOVA) with the statistical software XLSTAT-Pro7.5 and means were compared using the T-test for matched samples at the probability threshold P = 5%. MTE contamination of soils and leafy vegetables was diagnosed using Dutch & French soil standards and thresholds for leafy vegetables (Mench & Baize, 2004; Kabata- Pendias & Pendias, 2001 cited by Mpundu, 2013)[20].

Results and Discussion

The results of the analysis of the agricultural soil samples taken at the roadside of heavy goods vehicles have been included in Table 1

Table 1: Chemical and Physico-Chemical Analyses of Soil Samples

Sample	Soil MTE Levels (ppm)			
	pH	Cd	Pb	Zn
RG1	6.5	3.3	306.4	2987.9
RG2	5	3.2	286.6	3152.4
RG3	6.8	2.8	290.0	3002.5
RG4	7.2	4.7	398.3	4657.8
RG5	6.6	2.3	169.5	2325.6
RD1	6.8	1.8	110.5	2930.4
RD2	7.4	1.9	99.2	1682.6
RD3	6.7	2.1	106.2	1390.5
RD4	5.8	2.7	128.0	2583.1
RD5	6.7	1.1	58.9	1368.7
Standards Dutch		**2**	**530**	**720**
ASS		**2**	**100**	**300**

ASS: Agricultural Soil Standards (France)
Colour values exceed thresholds

Table 1 shows the results of the chemical and physicochemical parameters of agricultural soils taken at least 15 m from the road. This shows that the MTE levels (Cd, Pb and Zn) exceed the tolerable threshold for agricultural soils; zinc levels are all above the Dutch standard, when it is clear that no concentration of lead exceeds the standard while having the highest concentration of 398.3 ppm. This presence at fairly high levels of the studied MTE poses a danger to the population. In fact, the RG4 and RD4 samples taken at 5 m from the road, have very high levels of Cd, Pb and Zn that even far exceed the values of the standard. This shows that, indeed, the soil close to the road is more exposed to pollutants from car traffic that infiltrate on a large scale by the sound of slightly acidic rainwater. Results for zinc corroborate those of Delmas (2000) [6] who found that soils along National Road 12 near the city of Houdan about 50 kilometres from Paris in France contained concentrations (ppm) 2580 150 of this metal higher than recommended by the Dutch standard (720 ppm).

With respect to the position of the soils relative to the road, Table 2 indicates that the MTE levels observed in soil samples taken east of the road are higher than those found in soil samples taken west. This could be explained by the fact that the wind direction in our framework is from west to east. These results are consistent with those of Muyumba (2016) [6], who had found that MTE in the west polluted the ground to a distance of 15 m on the C line beyond the B line, as the wind direction was from east to west in his study area. These results also corroborate those of Kasanya et al (2021) [12] who found that water downstream of karst zones was more loaded in Ca and Mg than water upstream.

Table 2: Mean MTE values (ppm) in soils collected east and west of the road

MTE	Soils collected east of road	Soils collected west of road	p
Cd (ppm)	3.3(a)	1.9(b)	0.023
Pb (ppm)	290.2(a)	100.6(b)	0.211
Zn (ppm)	3225.2(a)	1991.1(b)	0.001

For each parameter, values that have different letters in the same line are significantly different depending on the T-test for matched samples at the probability threshold P = 5%.

It follows from Figures I, II and III that the Zn, Cd and Pb levels decrease as one moves away from the road. This situation was also noted by Muyumba (2014) [21] and Kasanya (2016) [11], who, in their dissertations, analyzed the MTE away from the road. This reveals that indeed, car traffic is undoubtedly the source of pollution with the sources cited in the literature review and the populations living around the road of heavy goods vehicles are the most exposed to this pollution.

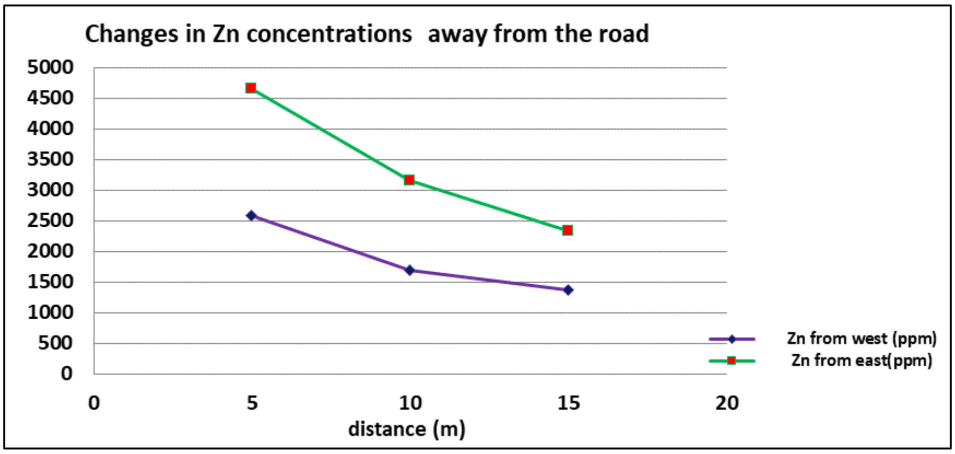

Fig 1: Changes in Zn concentrations away from the road

It follows from Figure I that the levels of zinc decrease as one moves away from the road.

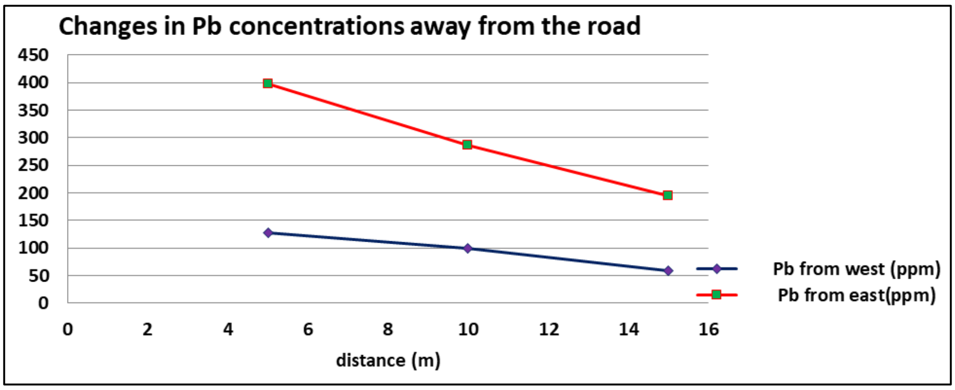

Fig 2: Changes in Pb concentrations away from the roadway

It follows from Figure II that lead levels decrease as one moves away from the road.

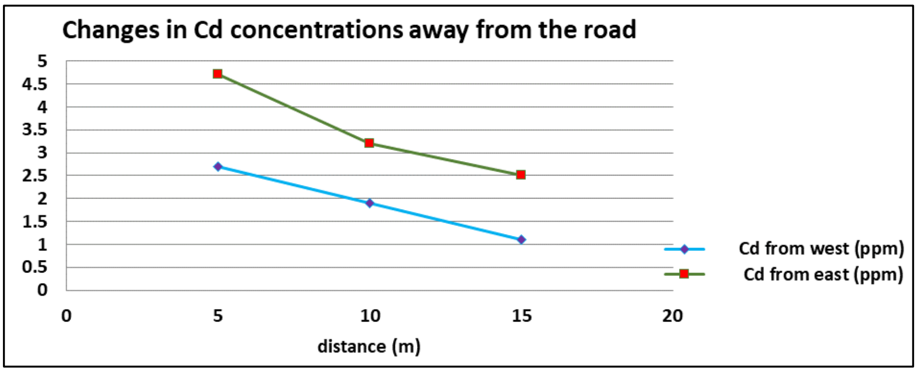

Fig 3: Changes in Cd concentrations away from the road

It follows from Figure III that the Cd content decreases as one moves away from the road.

Table 3: Average MTE values (ppm) in vegetables (cabbage or sweet potato leaf) near Lubumbashi Truck road

Garden	Sample of vegetable	MTE content of vegetables (ppm)		
		Cd	Pb	Zn
JET1	Cabbage1	2.8	12.0	152.6
	Potato leaf1	1.7	10.3	111.3
JET2	Cabbage2	3.2	13.4	123.2
	Potato leaf2	3.8	11.3	98.6
JET3	Cabbage3	4.1	14.6	106.5
	Potato leaf3	1.4	9.8	83.8
JOT1	Cabbage1	1.2	6.8	52.3
	Potato leaf1	0.8	7.3	64,7
JOT2	Cabbage2	0.3	4.6	45.5
	Potato leaf2	0.6	5.3	53.6
JOT3	Cabbage3	0.0	2.1	36.9
	Potato leaf3	0.8	4.8	51.0
Thresholds		**2**	**10**	**95**

Colour values exceed thresholds

As in the case of soil samples, the MTE levels in Table 3 show that the zinc content is more significant overall in plants, followed by the lead content, while the cadmium content is the lowest. The concentrations of vegetables grown in the east far exceed the thresholds.

Samples of leafy vegetables do indeed contain MTE such as Cd, Pb and Zn found in significant levels in soils. The levels of these MTE are higher even exceeding the limit values of the standard. This proves that indeed, the traffic of cars on the truck road contributes under the effect of the wind to the ejection, migration and dispersion of MTE in the environment. This observation of environmental pollution due to car traffic is identical to that of Kuledi (2017) [13] who found that the soil near the petrol stations in Lubumbashi town centre contained a quantity of lead. Our results also agree with those of Kalamba (2010) [10] who found that sweet potatoes from the Sambwa and Kamalondo crop sites contained high levels of copper.

By comparing the mean MTE values found in the two species, the analysis of variance shows that MTE levels are similar between cabbage and sweet potato vegetables (Table 4).

Table 4: Mean MTE values (ppm) in cabbage and sweet potato vegetables ETM Cabbage Sweet Potato Leaf

MTE	Cabbage	Sweet potato leaf	p
Cd (ppm)	2.07(a)	1.52(a)	0.796
Pb (ppm)	8.92(a)	8.13(a)	0.683
Zn (ppm)	86.17(a)	77.17(a)	0.632

For each parameter, values that have different letters in the same line are significantly different depending on the T-test for matched samples at the probability threshold P = 5%.

The variance analysis in Table 4 shows that the total MTE levels are similar between cabbage and sweet potato vegetables. Our results corroborate those of Mpundu (2013)

[20], which found that the concentrations observed in amaranth vegetables sold in the Lubumbashi markets were identical to those found in chard vegetables. This could be explained by the fact that leaf vegetables and flower vegetables absorb nutrients in almost the same way.

With respect to the topographical position of vegetables relative to the road, MTE levels observed in cabbage and sweet potato leaf vegetables grown east of the road are higher than those found in leafy vegetables grown west (Table 5).

Table 5: Mean MTE values (ppm) in vegetables (cabbage or sweet potato leaf) grown east or west of the road

MTE	Vegetables grown east of road	Vegetables grown west of road	p
Cd (ppm)	2 .83(a)	0.62(b)	0.023
Pb (ppm)	11.90(a)	5.15(b)	0.211
Zn (ppm)	112.67(a)	50.67(b)	0.001

For each parameter, values that have different letters in the same line are significantly different depending on the T-test for matched samples at the probability threshold P = 5%.

As regards the position of the gardens in relation to the road, Table (5) shows that the MTE levels observed in the vegetables collected east of the road are higher than those found in the vegetables harvested west. This could be explained by the fact that the wind direction in our framework is from west to east. These results are consistent with those of Ntita (2012) [22], which found that leafy vegetables downstream of liquid effluents were more polluted in MTE than those grown upstream.

Based on the estimate of average daily intakes (AJM) in MTE by the consumption of vegetables grown on the soil of the Lubumbashi gardens, the last joint report of the FAO and the WHO on the prevention of chronic diseases in 2003, recommends consumption of at least 400 g of vegetables and fruits per person per day (Combris & Volatier, 2007; FAO, 2008) [4, 7]. Based on data on total vegetable production from vegetable growing sites under the umbrella of SENAHUP (SENAHUP, 2008) [25], and the population of Lubumbashi in 2008 (FAO, 2008) [7], the apparent daily consumption of vegetables could be estimated at 23.5 g per person. With the exception of vegetarians, the average amount of vegetables consumed by Lubumbashi citizens is very weak. The average intakes obtained from the individual consumption of 400 g of vegetables grown near the truck road are shown in Table 6.

Table 6: AJM in MTE of 400g of vegetables (cabbage or sweet potato leaf) near the truck road in Lubumbashi

Field	Vegetable	AJM (µg)/person		
		Cd	Pb	Zn
JET1	Cabbage1	1120	4800	61040
	Potato leaf1	680	4120	44520
JET2	Cabbage2	1280	5360	49280
	Potato leaf2	1520	4520	39440
JET3	Cabbage3	1640	5840	42600
	Potato leaf3	560	3920	33520
JOT1	Cabbage1	480	2720	20920
	Potato leaf1	320	2920	25880
JOT2	Cabbage2	120	1840	18200
	Potato leaf2	240	2120	21440
JOT3	Cabbage3	00	840	14760
	Potato leaf3	320	1920	20400
DJT		**70**	**525**	**21000**

: Colour values exceed tolerable daily intake (TDI)

For gardens, Table 6 presents the AJM in MTE provided by the individual consumption of 400g cabbage or sweet potato leaf, which are generally higher than the TDI. Mench & Baize (2004) [17] noted that foods that alone provide AJMs beyond the TDI pose risks to consumption. AJMs supplied by corn consumed in the form of paste (fufu) and fish; the daily meal of a Lubumbashi resident, will have to be taken into account in the estimate of the weekly intake (DHI). Our results corroborate those of France, where the contributions of 32 µg in Cd and 40 µg in Pb to DHI were recorded by the consumption of cereals. Nevertheless, Bourrelier & Berthelin (1998) [3] and Mench & Baize (2004) [17] have shown that cereals do not accumulate a lot of metals in seeds compared to leafy vegetables.

On the other hand, the consumption of 23.5g of these vegetables (depending on the local production SENAHUP, 2008) [25], would reduce the AJM by 17 times compared to those obtained with the quantity of 400g. Surveys conducted by FAO and WHO experts have shown that many people are unable to consume 400g of vegetables per day (Combris & Volatier, 2007; FAO, 2008) [4, 7]. This is the case for many families in Lubumbashi who consume small amounts of vegetables a day. This low consumption of vegetables, could be a way to avoid if not to reduce the impregnation in MTE. In this case, the risks of contamination of the food chain via vegetables are increasingly reduced. Nevertheless, Mouchet et al. (2008) [17] indicate that the presence of vegetable crops in the vicinity of sources of contamination often leads to an examination, during environmental diagnostics, the levels of pollutants accumulated in vegetable plants consumed by the population. And the consumption of plants grown on soil polluted by MTE or in a potentially polluted environment is one of the most frequently considered ways of human exposure to MTE (Cui et al., 2004; Mpundu, 2010) [5, 19]. However, the further away the production site is from sources of contamination, the less risk there is of soil contamination (Robert M. and Juste, 1997; Mouchet et al, 2008; Mpundu, 2010) [24, 18, 19].

Conclusion

The study was initiated with the aim of assessing the impact of car traffic on agricultural activities in the vicinity of the truck road. The results of the qualitative analysis in the leafy vegetables showed the metallic elements in traces. This made it possible to identify Cd, Pb and Zn elements which elements are also found in the soils. This proves there's soil-plant transfer of MTE. Samples taken at 5 m from the road have very high levels of Cd, Pb and Zn, which even far exceed the values of the standard. This shows that, indeed, the soil close to the road is more exposed to pollutants from car traffic.

The results of quantitative analysis showed that Zn has the highest levels of all determined MTE followed by Pb and at the end of Cd. The levels of Cd, Pb and Zn elements exceed the tolerable threshold of agricultural soils; zinc levels are all above the Dutch standard.

As regards the position of the gardens in relation to the road, the levels of MTE observed in the vegetables taken east of the road are higher than those found in the vegetables harvested in the west. This could be explained by the fact that the wind direction in our framework is from west to east.

The risk of contamination of the food chain by the consumption of cabbage and sweet potato leaf vegetables grown near the truck road is not negligible following the high AJM obtained. These vegetables grown in the vicinity of the truck road show levels of Cd, Pb and Zn exceeding the norm. Based on our results, we were able to confirm that car traffic is the source of pollution of vegetables grown near the truck road. We believe that further studies should monitor the dishes of the Lubumbashi population to minimize the risks of MTE impregnation and to put in place adequate MTE soil-transfer reduction techniques to avoid the risk of contamination of the food chain by cadmium, lead and zinc.

It is also suggested that people grow their vegetables in sites far from sources of pollution.

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