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Lead, Cadmium and Arsenic Contamination Levels of Crops Produced at Kasavubu Vegetable Perimeter/Saio "The Case of *Amaranthus hybridus*"

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ABSTRACT

The study aims at evaluating the level of vegetable crops' contamination located along high-frequency motorized roadways. The useful area for a secure culture will be determined according to the threshold of toxic metal traces. The findings show that: the level of vegetable crops contamination varies according to the distance separating the roadways from the cultivated plants; the lead rate is inversely proportional to the distance which separates the vegetable crops from Kasavubu and Saio roadways. In the soil, lead concentrations are higher than in vegetables and irrigation water. The non-soil renewal after the harvest period could justify

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Contamination Heavy metals Urban environment Vegetable crops	the accumulation of lead in the soil. Cadmium is only detected in soil samples taken less than 3 m away from the road. Tire wear could be the real cause, the kinetic Cadmium differential and Arsenic is zero, while an inverse correlation was observed between the physicochemical parameters (pH, OM, and TOC) and the metals under study. The correlation between lead in soil and vegetables is justified by the same source of contamination. This is not the case for trace metals in irrigation water and vegetables. The useful area for safe cultivation is set at 50 m away from the frequent motorized road.

INTRODUCTION

According to the estimates of Institut National de Statistique (National Statics Institute of Statistics) in the DRC, the city of Kinshasa had 6,062,000 inhabitants in 2000. Referring to the the1973 statistics which report the figure of 1,198,720 inhabitants, the demography recorded an exponential growth (Flouriot, 1975; Lelo, 2008; Wagemakers et al., 2010). Currently, the population is estimated at over 10 million (Musibono et al., 2011).

Due to the increase sharp of the world population in general, and urban in particular, food for cities has become a basic problem (Bricas and Seck, 2004; Mougeot, 2005). This urban population growth concerns both capitals and secondary cities (Aubry et al., 2010).

The population of the City of Kinshasa consumes around 155,500 tons of vegetables a year, with an increase of 3 to 5% per year. In order to meet this need, the population resorts to urban agriculture. This activity is a response to poverty and food insecurity (FAO, 2007).

Ignored for a long time, urban agriculture is increasingly seen by urban planners as one of the means to tackle food inequality. It provides income to urban populations (Dubbeling, 2009, Musibono et al., 2011).

Growingin cities, edible plants involve exposure to constraints such as optimizing the available space and controlling the exposure of populations to pollutants often observed in different environments (soil, water, air). As cities are densely populated, the likelihood of human exposure to the present pollutants is relatively high. Scenarios of human exposure to pollutants commonly observed in urban areas are particularly the ingestion of water from polluted wells or the consumption of vegetable plants grown on polluted soils (Shahid et al., 2016) or having intercepted enriched atmospheric particles in metals (Schreck et al., 2014; Xiong et al., 2016).

Environmental pollution is still widely observed in urban areas following historical pollution of lead, Cadmium, or very persistent mercury in soils (Leveque et al., 2015, Dumat et al., 2016) or atmospheric deposition of particulate pollutants. Over long distances (Schreck et al., 2013). Many chemicals can circulate or accumulate in garden soils (Schwartz, 2013), and finally, vegetables (Uzu et al., 2014; Clinard et al., 2015; Xiong et al., 2016).

Air pollution by heavy metals is riffed in urban areas, not only because of industry concentration and domestic households but also because of the density of motor vehicle traffic (Hanane et al., 2015). The main metallic pollutants emitted in the road environment come from fuels, tires, linings, and brakes (Pagotto, 1999; Deletraz, 2002). The use of lead in gasoline, however, is still common in developing countries (Menkes and Fawcett, 1997). The entry of lead into the manufacture of batteries and fuels led to an increase in its atmospheric concentration (Rhue et al., 1992).

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Pollutants from automobile traffic or district heating can be deposited on plants or soil or even be absorbed by plant roots (Wieczorek et al., 2005; Kalavrouziotis et al., 2007). On the one hand, trace metallic elements (Pb, As, Hg, Cd, Zn, Cu, Ni, and Cr) accumulate as circulation increases. On the other hand, hydrocarbons, oils, rubbers constitute polycyclic aromatic hydrocarbons (PAHs) (Barriusto et al., 1996, Barbaste et al., 2004). Regardless of road traffic, contaminants from fertilizers, pesticides, and nature are absorbed by vegetation and then end up in the trophic chain (Atidegla et al., 2011).

An assessment of the air pollution of crops and the use of untreated urban solid waste, fertilizers, and pesticides are needed to improve the quality of vegetables grown in market gardening sites in Kinshasa.

The curves obtained for the trace metals will make it possible to distinguish two zones:

- Red zone characterized by a high rate of contamination compared to standards;
- Useful area where contaminants in crop plants are at the minimum acceptable trace level.

If the circumcised area is red, the municipal or urban authority will have to draw up legislation on urban agriculture.

The study aims at evaluating the quality of vegetables grown near Kasavubu and Saïo roadways and consumed in Kinshasa.

Site

Located on the crossroads of KASAVUBU and SAIO avenues in KASAVUBU municipality, this site is frequently used by motorized vehicles. It is also used as a house for street children who discharge excrement and urine there.

Figure 1. Cultivation site

Market gardeners cultivate amaranth (*Amaranthus hybridus*), spinach (*Basella alba*), sweet potato (*Ipomoea batatas*), and sorrel (*Hibiscus acetocella*). Market gardeners use well water for watering. Regarding fertilization, they use litter, poultry droppings, or other chemical fertilizers (NPK, urea, etc.) and untreated household waste to optimize yield. The choice of *Amaranthus hybridus* cultivation is justified by the fact that it represents 90% of market gardening activities in Kinshasa (Wekole, 2018).

MATERIALS

Soil and plant samples were retrieved according to the distance separating them from the road (between 3m and 100m). After removal of plant debris and roots, soil samples collected from organo-mineral horizons (0-10cm) of the soil were dried at room temperature, then crushed and sieved

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through the 2mm mesh. The vegetable samples were dried out of direct sunlight and then crushed. The sauce was used for the analysis of the cooked vegetables. The water sample was taken from the wells selected on the basis of their position relative to the road.

During the rainy season, the sampling took place between April 10 and15, 2019, i.e. 25 days later. The second phase took place during the dry season (July 2019).

METHODS

The physicochemical parameters: total organic carbon and Organic matter of the soil were deduced using the weight difference method before and after kiln incineration (Abderrazzak (2012). The physicochemical parameters of the well water were determined in situ using the HACH HQ 40d brand multi-parameter probe. The soil pH was determined using a pH meter with "combined pH electrodes". The pH (H_2O) is measured in a soil-water suspension while the pH-KCl is determined in a 1N soil-KCl suspension using the ST 10 0HAUS brand pH meter.

The analyzes of the trace metals (Pb, Cd, and As) were carried out by molecular absorption spectroscopy using the DR 2000 spectrophotometer with digital reading applying the Beer-Lambert law, the detection limit of which is 0.02 mg/L.

The heavy metals transfer to plants was evaluated using the transfer factor according to Tangou (2016):

$$F = \frac{Plant\ metal\ concentration}{metal\ concentration\ in\ soil}$$

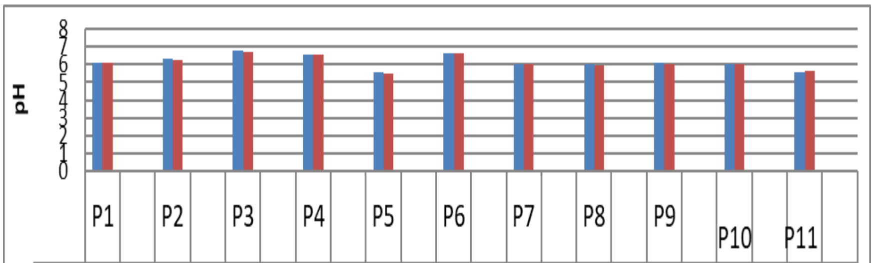
To evaluate the relationship that exists between different analyzed parameters, a statistical correlation study by PEARSON was used to find out if these parameters have the same origin or if the observed difference is due to chance. The ORIGIN 8 software was used for this assessment.

The Student's Test was applied to assess the variability of the parameters (distance between red zone and useful zone) during the two seasons. It was calculated on the basis of a Microsoft Excel program (Ancelle, 2008).

RESULTS

Physicochemical parameters for well water

a. pH



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
SP	6.1	6.3	6.7	6.6	5.6	6.6	6	6	6.1	6	5.6
SS	6.1	6.3	6.7	6.5	5.5	6.6	6	6	6	6	5.6

Figure 2. pH of well water

This figure shows the pH of the different wells used for watering the vegetables for both seasons. In well P3, the high pH (6.74) and well P5 a low pH compared to the other wells.

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a. Dissolved oxygen

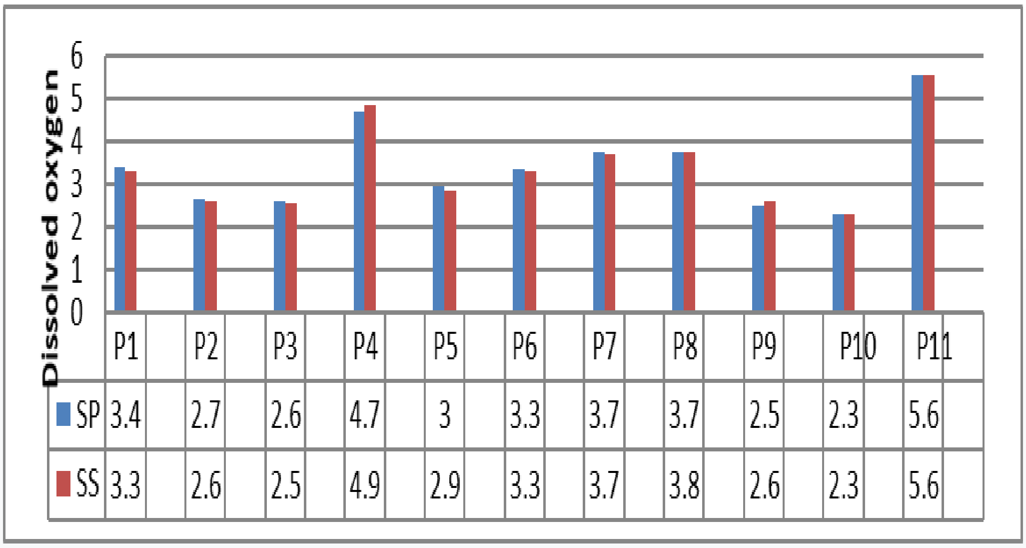

Figure 3. Evolution of dissolved oxygen in different water wells

This Figure reveals that the dissolved oxygen values in the different wells used for watering the vegetables during the two seasons vary between 2.28 (P10) and 5.58 (P11).

a. Conductivity

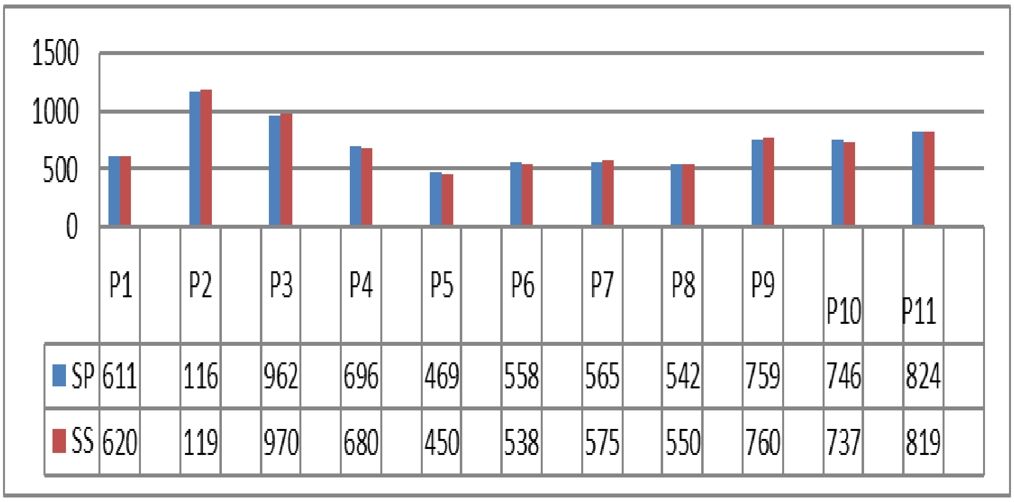

Figure 4. Conductivity values in different water wells

This Figure shows the different conductivity values in the wells used for watering vegetables. Thus, whatever the season, the P2 well has a high value (1164) and the P5 well has a lower value compared to the other wells.

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a. Temperature

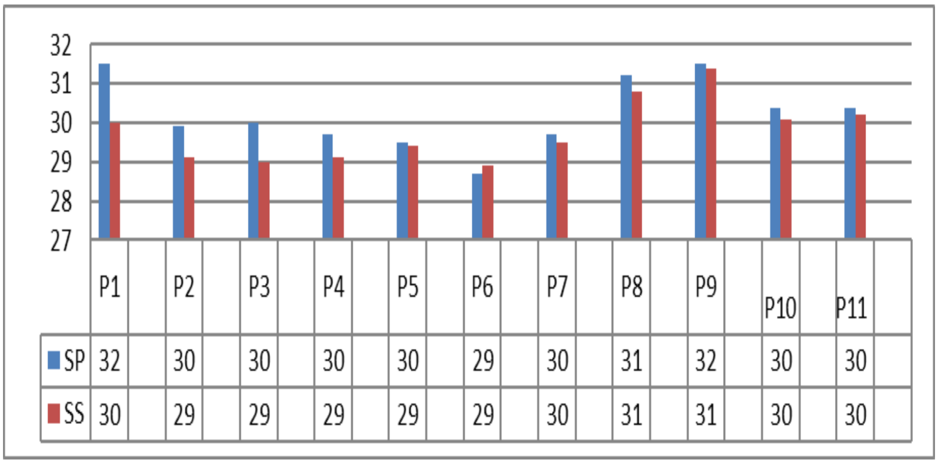

Figure 5. Different temperature values in different water wells

This figure shows different temperature values in water wells used for watering vegetables. Whatever the season, wells P1 and P9 have high-temperature values (31.5 ° C) while well P6 (28.9 ° C) a low value compared to the other wells.

a. Heavy metals in well water (Pb, Cd and As)

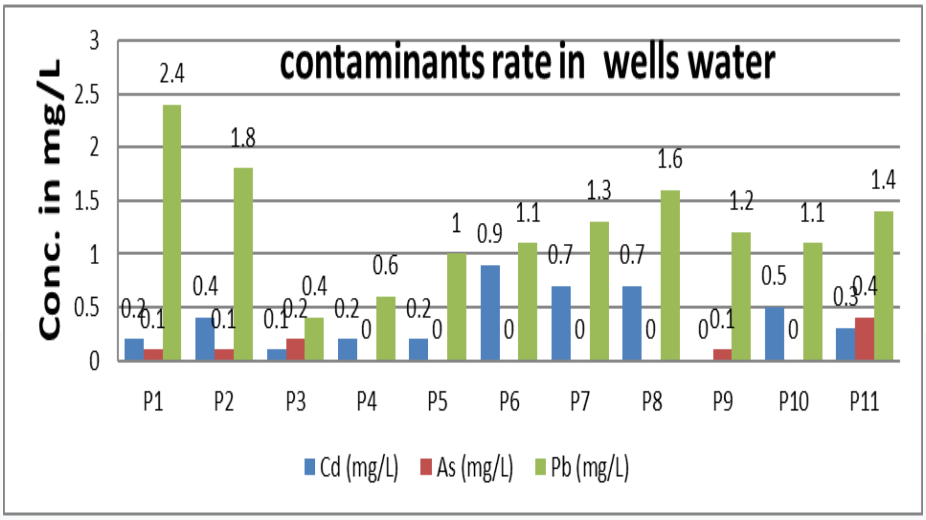

Figure 6. Contaminant rates (Pb, Cd, and As) in different water wells

The results of this Figure indicate that:

- The arsenic values are zero for wells P4 to P8 and P10. But from P1 to P3, P9 and P11 vary between 0.1 to 0.4 mg / L.
- A high value of Cadmium in wells 6 (P6) and 12 (P12) and low in wells 3 (P3). It was found that in wells 9 (P9), the cadmium value is almost zero compared to the analysis method used;
- Lead values are considerable in wells P1 and P2 near the road compared to wells P3 to P11 which are further away from the road.

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Soils

a. Organic substances in the soil

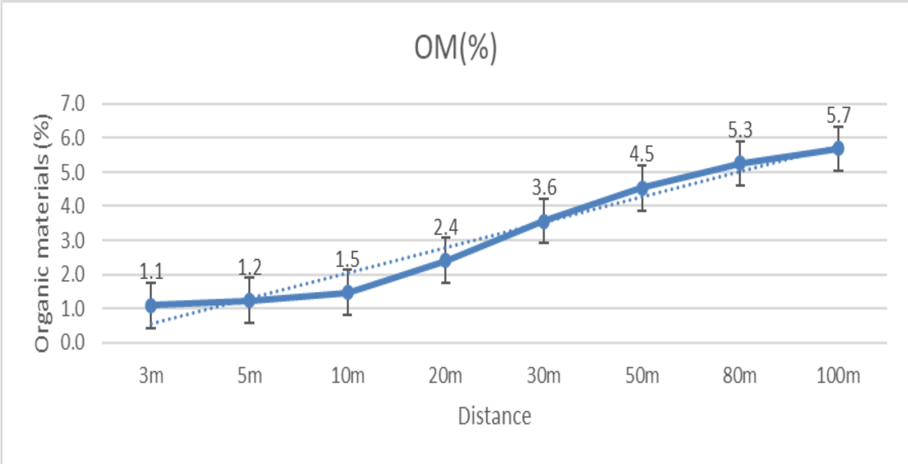

Figure 7. Evolution of organic substances in the soil regarding the distance function

Figure 7 illustrates the evolution of organic substances in the soil in the function of distance. It reveals that from 30m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

a. Total organic carbon in soil

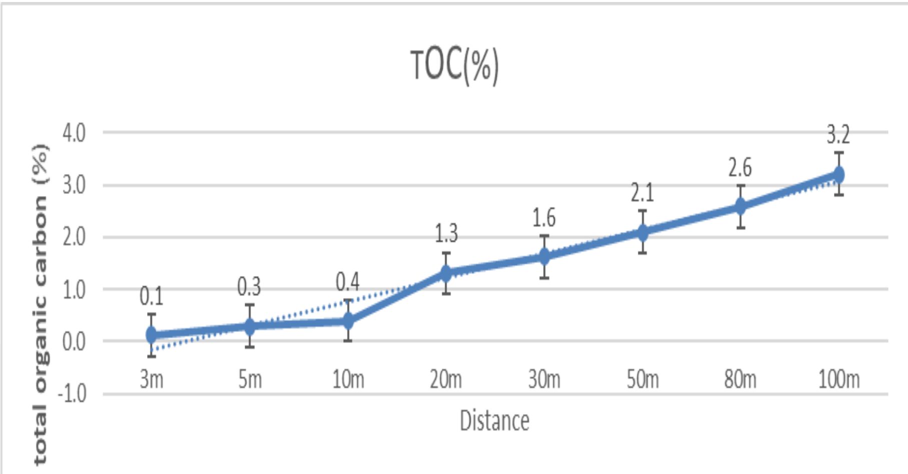

Figure 8. Evolution of total soil organic carbon in function to distance

Figure 8 indicates the evolution of Total Organic Carbon in the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

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a. Soil pH (0-10cm)

pH in the water-soil suspension

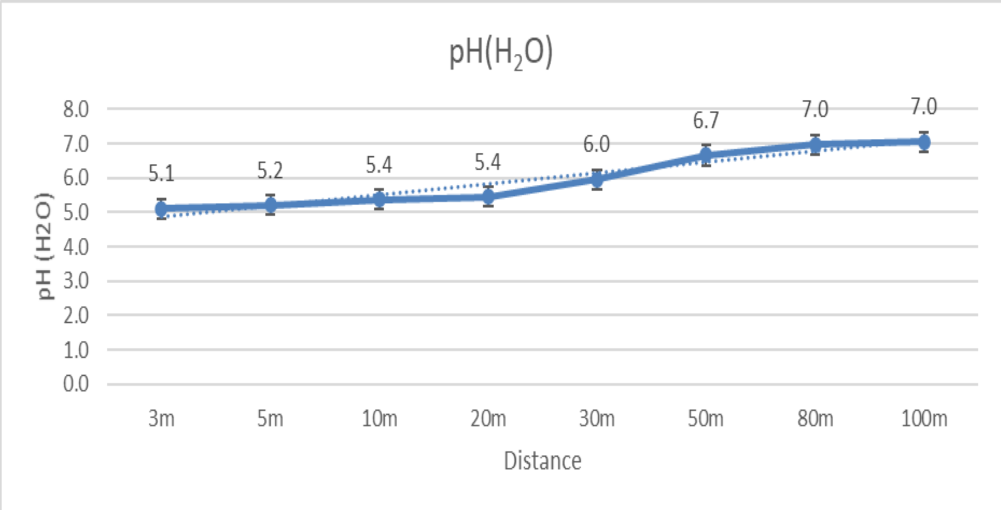

Figure 9. Evolution of soil pH in the water-soil suspension

Figure 9 shows the pH (H_2O) values in the soil in the function of distance. It reveals that from 50m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

pH in the water-KCl suspension

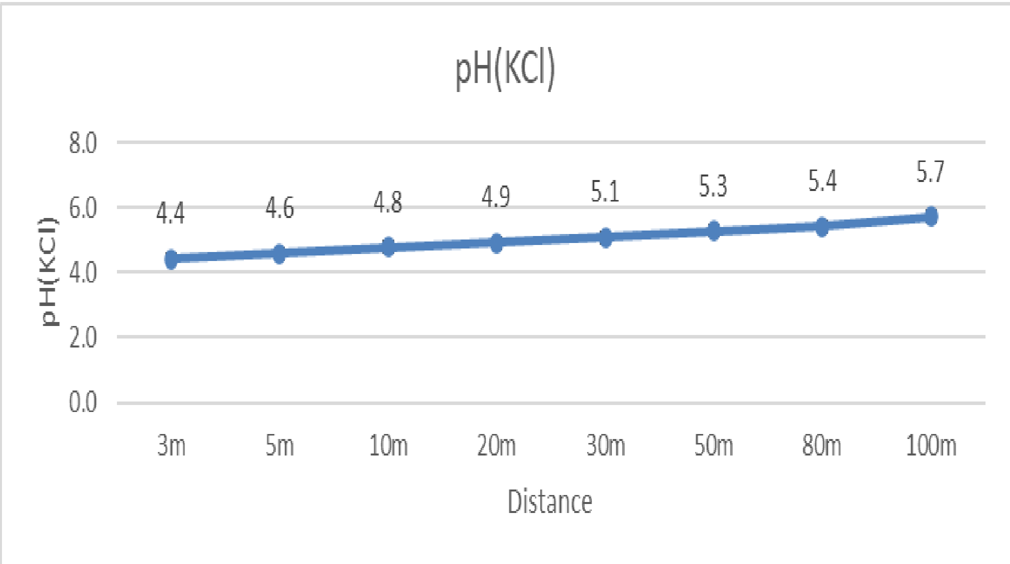

Figure 10. Evolution of the pH in the water-KCl suspension

Figure 10 shows the pH (KCl) values in the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

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Lead in soil

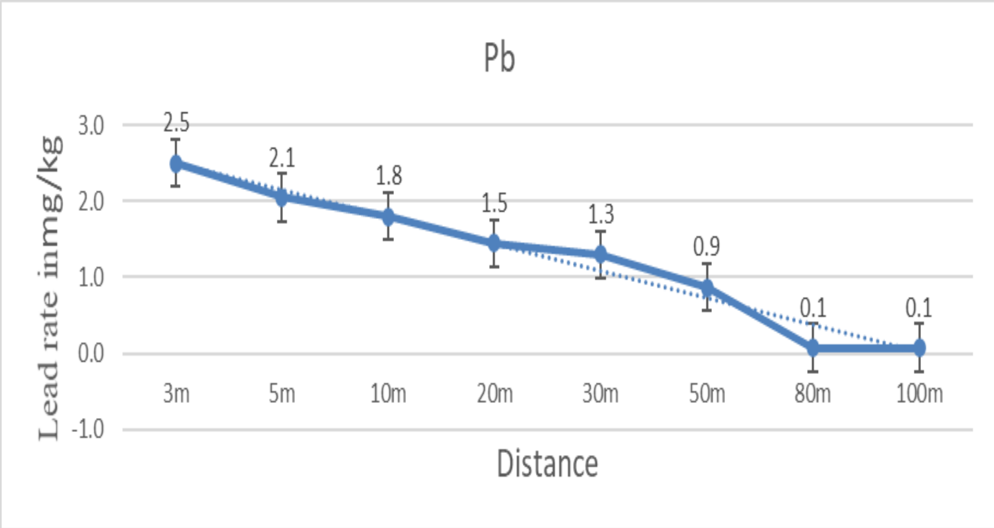

Figure 11. Evolution of lead into the soil in the function of distance

Figure 11 shows the evolution of Pb into the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

Cadmium in soil

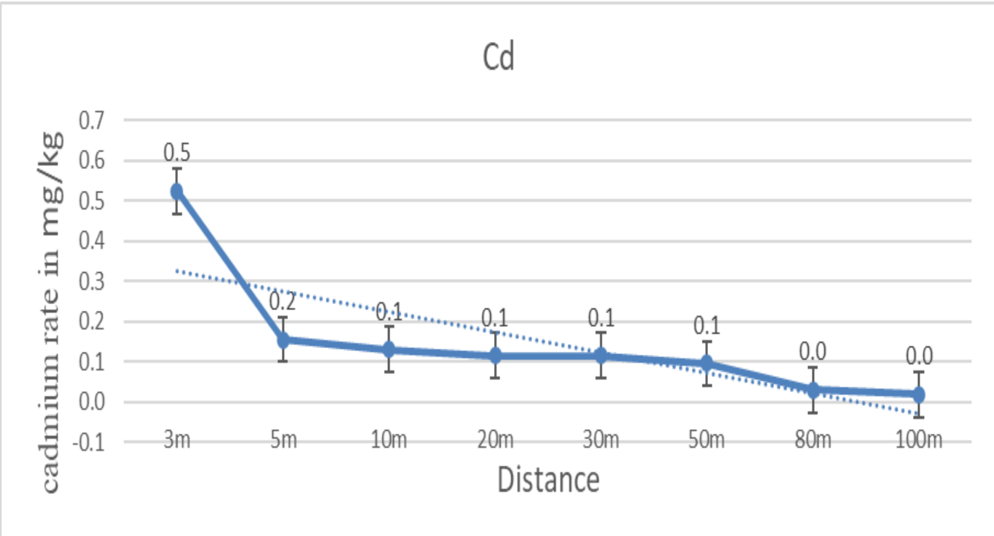

Figure 12. Evolution of Cadmium in the soil

Figure 12 shows the evolution of Cd into the soil in the function of distance. It reveals that from 5m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

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Arsenic in soil

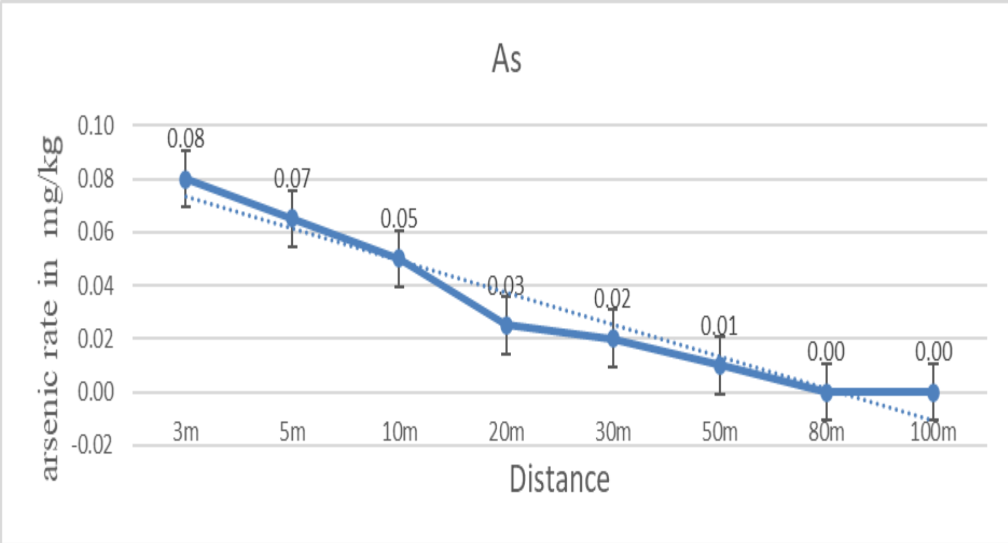

Figure 13. Evolution of Arsenic in the soil

Figure 13 shows the evolution of Arsenic in the soil regarding the function of distance. It reveals that from 10m, the standard error bar differs from the value recorded at 3m. The trend line decreasing.

Vegetable

Average Pb, As and Cd in *Amaranthus hybridus*

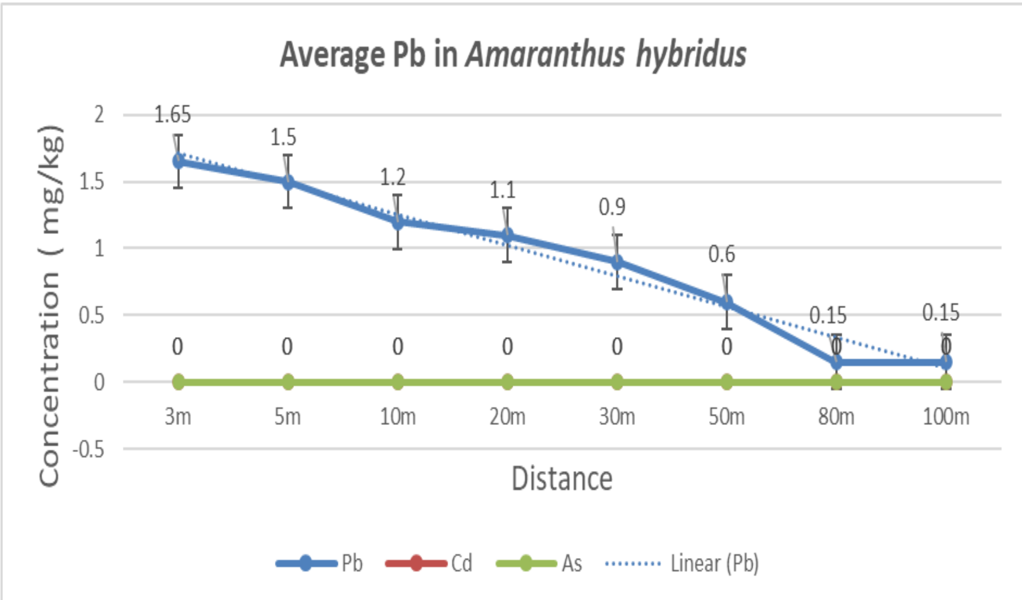

Figure 14. Evolution of ETM in Amaranth

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Figure 14 shows the level of contaminating trace metals in Amaranth. It reveals that from 10m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

Table 1 below indicates that the lead transfer factor from soil to vegetables varies from 0.6 to 5.7 range from 3 to 50 m from the

The absence of Cadmium and Arsenic levels from 3m from the road is justified by the fact that the exhaust fumes only emit lead from the fuel.

roadway. No transfer factors for Cadmium and Arsenic were observed.

Table 1: Transfer factor (F)

Distance (m)	Kasavubu and Saio Crossways		
	Cd	As	Pb
3	n.d	n.d	0,6
5	n.d	n.d	0,7
10	!n.d	n.d	0,7
20	n.d	n.d	1,0
30	n.d	n.d	1,2
50	n.d	n.d	5,7
80	n.d	n.d	5,0
100			5,0

Disappearance of contaminants compared to distance

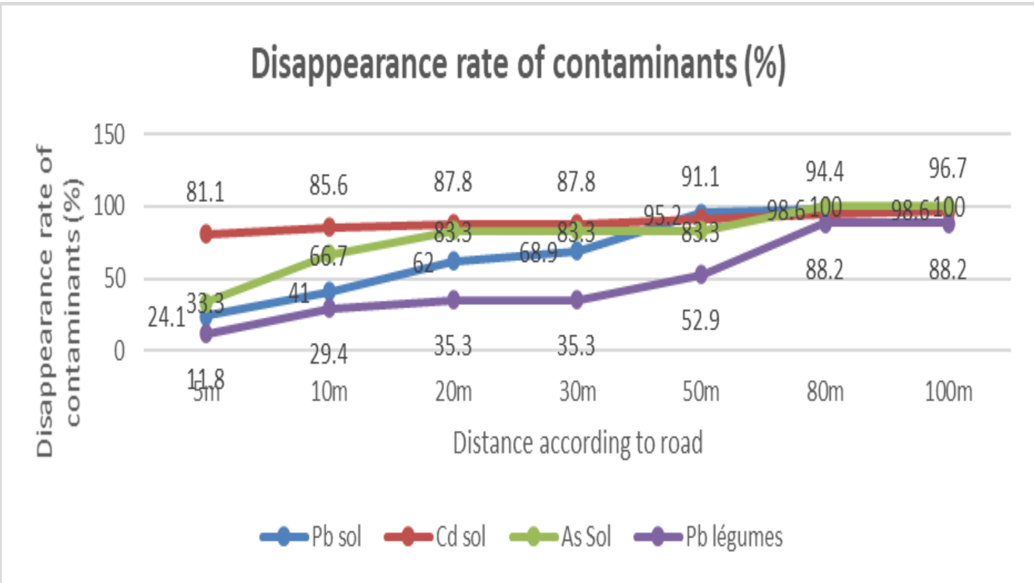

Figure 15. Disappearance rate of contaminants compared to the distance

At a distance of 5m, the disappearance rate is respectively estimated at 81.1% (Cd), 33.3% (As), 24.1% (Pb of the soil), and 11.8% (Pb of vegetables). The rate of disappearance is proportional to the distance. At 100m, the disappearance rate is 100% for As (soil), 96.7% for Cd (soil), 98.6% for Pb in soil, and 88.2% of Pb in vegetables.

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Statistical analysis findings

a. **Kasavubu / Saio Pearson correlation coefficient**

These results are presented in Table 2 below:

Table 2. Pearson's correlation coefficient for Kasavubu / Saio

	pH (KCl)	M.O.	C.O.	Cd/sol	As/sol	Pb/sol	Pb/lég
pH (H_2O)	0,86887	0,95795	0,91669	-0,53556	-0,7906	-0,9118	-0,90243
pH (KCl)		0,9026	0,94944	-0,76078	-0,92459	-0,9438	-0,91623
M.O.			0,97608	-0,57616	-0,85742	-0,94115	-0,96991
C.O.				-0,64825	-0,9249	-0,95793	-0,95632
Cd/soil					0,83958	0,77057	0,6536
As/soil						0,96173	0,87519
Pb/soil							0,92393

Table 2 indicates that there is a negative correlation between the physicochemical parameters and the trace metals under study. In contrast, lead from soil and lead from vegetables show a strong correlation (0.92393).

a. **Pearson correlation coefficient of water**

These results are presented in Table 3 below:

Table 3. Pearson correlation coefficient of water

	Water Cd	Water As	Water Pb
Water Cd	1	-0,40203	0,15445
Water As		1	0,06212
Water Pb			1

Table 3 indicates that there is a weak correlation between trace metals in water wells, linked to the same geochemical origin. So, they don't have the same origin.

DISCUSSIONS

The pH of water wells varies between 5.57 and 6.74, values less than 6.8; therefore, slightly acidic but favorable to aquatic life (5-9.0) and consistent with the pH of groundwater.

The dissolved oxygen values of these wells vary between 2.51 and 5.58mg O_2 / L. They are lower than those of domestic Maghrebian waters (2.42 mg / L) and lower than the guideline values for physical, chemical, and thorough treatment (> 30 mg / L) (Drouart et al., 1999). This indicates the

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presence of microorganisms in these wells. They are also lower than those of the surface water of the Lukaya River (6.7-6.94 mg / L), almost equivalent to that of groundwater where only fish and insects can live (Ngadi et al., 2014).

The soil pH in the soil-H_2O suspension varies increasingly from 5.12 to 7.3 during the two seasons with average values varying between 5. 1 to7. 0. This pH, whose standard error bar stands out at 50 m from the initial value at 3 m, shows that the soil is weakly acidic (6.8). The soil is, therefore, suitable for vegetable crops because the plants assimilate the nutrients soluble in water at this pH. It appears that after 50 m from the road, the pH meets the standards required for topsoil. But, at a distance of fewer than 50 m from the roadways, the soil is acidic. This is due to exhaust gases like CO_2, NO_X, SO_X, etc. These gases dissolve in water, forming corresponding acids with an impact on crops, as the acidic pH increases the Phyto-availability of metals.

The pH (KCl) is a weak acid (<5.6) from 3 to 100 m, due to the abundant captions released by the complex composing of the soil with a tendency to form acid salts, such as aluminum or silicon and others which combine with the soil and thus form absorbent complexes. The pH thus found with KCl as a solvent is called the actual potential pH of the soil. Average pH – KCl values range from 4.4 to 5.7. Although its value at 20m differs from its initial value at 3m, it is not useful for characterizing market gardening soil.

Concentrations of organic substances increase with increasing distance from the road. These values vary from 1.0 to 6.9 % during the two seasons with average values oscillating between 1.1 to 5.7 %. At 30 m, its average value differs from that of 3 m and becomes acceptable for market gardening. Exhaust fumes have almost a negative impact on organic matter, indicative of the organic carbon needed by the plant. These results are consistent with those of cultivated agricultural soil from Saarbrucken in Germany (1 to 3 %) (Schwartz, 2013).

Varying increasingly with the distance from the road, the total organic carbon ranges from 0.15 to 4% during the two seasons, with average values ranging from 0.1 to 3.2% with a value of 1.3 % differing from the initial value. The presence of proteins, polysaccharides, humic compounds from untreated waste is used to amend the soil and is indicative of organic pollution (presence of carbon), as well as sunburnt substances from gasoline combustion, including benzene, toluene, and others. They also influence the bioavailability of metals such as cadmium and arsenic. The more organic the soil is, the less the metals will tend to go into solution. The results obtained are lower than those of market gardeners from Loraine in France, whose values exceed 4% (Schwartz, *Op. cit*.).

The average values of lead in the soil vary decreasingly, whether it is from Kasavubu or Saio, during the rainy or dry season. Its average values vary between 2.5 to 0.1 mg / kg. These values are lower than those for Tshamalenga garden soil (530 mg/kg) (Banza, 2002) and even the guide values (100 mg/kg) for market gardening soil (Kabata-Pendias et al. 2001; Boukhars et al., 2000 and Tremel-Schaub et al., 2005), and those Polish market garden soil near road traffic, between 3.41 and 1520 mg/kg (Ademe, 2017). These values are close to those of market garden soils of Abidjan (3 mg/kg) and lower than soils of Ebrié, 0.12 mg/kg (Vandjiguila et al., 2012) and higher than soils of Ezazou village in Cote d'Ivoire (4.9 mg/kg), (Nguelieu, 2017). Lead in the soil forms compounds which are insoluble in water at pH> 5 and also, its leaching and deep contamination is less at this pH.

In vegetables, the level of lead decreases with increasing distance. Its average values vary respectively between 1.65 to 0.0 mg/ kg. The change in the lead is inversely

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proportional to the distance from the road. Airborne contamination is the main source of lead contamination of vegetables from exhaust fumes. The lead values in the leaves of *Amaranthus hybrithus* obtained are lower than those obtained by the influence of phytosanitary products 4 mg/kg. This shows that vegetables grown under conditions of strong anthropogenic contamination contain high amounts of trace elements including lead (Schwartz et al., 2000).

The values obtained are lower than those of Lubumbashi near the mining areas (3.1 mg/kg) in Tshamalenga and Shinkolobwe (5.352 mg/Kg) (Banza, 2002). These values are beyond the thresholds required for human consumption in accordance with European standards, 2011 (0.1 mg/kg) cited by OPALA (2017) and those described by Banza (Op.cit). Similar work carried out in the market gardening perimeters located along the heavily trafficked roads in Kinshasa by Musibono (2003) reported that the vegetables grown on these sites are polluted by the lead contained in the smoke released by the vehicles itself coming from gasoline containing tetraethyl lead. He further noted that the lead content in both soil and vegetables decreases with increasing distance from the main pathways.

Lead values in vegetables are lower than those in soils and water. All lead values in well water vary between 0.4-2.4 mg/L. These concentrations are higher compared to the limit values (0.2 mg/L) for discharges into aqueous tributaries and the guide values (0.01 mg/L), WHO, 2004. And these concentrations are lower compared to the values defined for irrigation water (5.0 mg/L), (Fatta, Op. cit).

The lead transfer factor from soil to vegetables varies from 0.6 to 5.7, falling within the range set values (0.01 and 10) (Tangou, 2016). Only the value from 50m from the roadways reveals the transfer of soil to the plant because the transfer factor F (5.7) is greater than 5.6. Unlike those of Arsenic and Cadmium, where no transfer is possible because factor F is almost zero. Therefore, at this pH the availability of Cd and as for plants is not possible. According to Bourg and Lock (1995), Cd forms chelate complexes and its absorption becomes independent of pH (Babich et al., 1977).

The cadmium concentration decreases significantly from 5m from the road and stabilizes thereafter. The average cadmium level varies between 0.5 to 0.0 mg / kg. At 5m, it stands out from the value at 3m from the road. These values are greater than 3 m (0.9 mg/kg rainy season and 1.0 mg/kg dry season) of the road than those of arable soil (0.7 mg/kg) (Rousseau 1986 cited by Kabata-Péndias et al., 2001) and to the reference values applicable in Wallonia according to the Flemish regional regulations on the matter (0.2 mg/kg), AFNOR, 2005 cited by Nguelieu (2017), lower than the latter from 5m (0.17 at 0.03 mg/kg), and the French standard for agricultural soil (2 mg/kg). These values are lower than that of Tshamalenga garden soil (1.45mg/kg) (Banza, 2002) and even the guide values (2 mg/kg) for market gardening soil (Kabata-Pendias et al., 2001, Boukhars *et al.,* 2000 and Tremel-Schaub et al., 2005). This situation is due to tire wear at the edges of the main roads but does not affect the entire garden. The Cadmium transfer factor from the soil to the vegetables is zero.

Only wells P6 to P8 (0.7-0.9mg/L) have Cadmium values beyond WHO standards for human consumption (0.03 mg/L) (WHO, 2004). Values higher than those predicted for irrigation water (0.01mg/L), Fatta, (2014) and the limit values for discharges into aqueous tributaries (0.05 mg/L) (Lepot et al., 2013). But these values did not influence the Cd of vegetables analyzed.

Arsenic concentrations decrease less with distance from the road; its average values vary from 0.08 to 0.00 mg/kg. An almost low value in the soil compared to the soil of Tshamalenga (10 mg/kg) Banza, 2002.

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The arsenic values of well water are higher than those predicted for surface water (Vandjiguila et al., 2012), for irrigation water (0.1 mg /L) (Fatta, 2014), and the limits of the value (1 mg/L) for discharges into aqueous tributaries (Lepot et al., 2013).

The Student's T of the parameters analyzed showed that whether it is in Kasavubu or Saio, rainy or dry season, the difference is not significant. The values found are averages of these parameters.

The Student's T of the parameters analyzed showed that whether it is in Kasavubu or Saio, rainy or dry season, the difference is not significant. The values found are averages of these parameters.

Pearson's coefficient was applied between physicochemical parameters and trace metals. From this correlation came the following result:

There is an inverse correlation between the trace metals and the physicochemical parameters (pH, Organic matter, and Total organic carbon), i.e. the more the trace metals decrease, the more the physicochemical parameters increase as indicated in Figure 15 below. These parameters influence the trace metals in soils.

Lead, Cadmium, and Arsenic in soil have a very weak correlation, so they do not have the same source of contamination. This weak correlation can be linked to the same geochemical source. Lead in soil has a strong correlation with that in leafy vegetables, so they have the same source of contamination, which comes from anthropogenic sources including exhaust smoke from motor vehicles. Leaching is the main cause of the difference in concentration between lead in soil and that in vegetables; this corroborates the results of Neibor et al., 1980, who found a correlation between the lead content in soil and that in plants.

The trace metals (Pb, Cd, and As) in the water from different wells used for irrigation are not correlated, and therefore do not have the same origin.

CONCLUSION

The main objective of the study was to assess the level of contamination of *Amaranthus hybridus* with toxic metallic trace elements including Pb, Cd and As in order to deduce the safe culture distance or the useful area. Results obtained show that the average level of lead in the soil decreases with distance from the road in all seasons. It ranges from 2.5 to 0.1 mg / kg. In vegetables, the average level of lead decreases with increasing distance. It ranges from 1.65 to 0.00 mg / kg. In addition, lead is more concentrated in green vegetables than in the sauce of cooked vegetables. The lead transfer factor from soil to vegetables varies from 0.6 (3 m) to 5.7 (50m).

The average level of Cadmium in the soil between 3 and 10 m decreases with distance from the road in all seasons. It ranges from 0.5 to 0.00 mg / kg. The Cadmium transfer factor from the soil to the vegetables is zero. The cadmium level is higher in wells 6 (P6) and 12 (P12) and low in wells 3 (P3). Its value is zero in wells 9 (P9)

The average level of Arsenic in the soil decreases a bit with the distance from the Kasavubu and Saio roads. It ranges from 0.1 to 0.00 mg / kg. The arsenic transfer factor from soil to vegetables is zero

Point 0 of these toxic elements is located around 50m from the road. The decrease in these elements is observed relative to the molecular weight of each. The heaviest finish their race at an intermediate distance and the lightest reaches 40-50m. This disappearance also depends on the initial concentration. The disappearance of lead was observed from 40-45m.

The useful area for healthy market gardening is estimated at 50m from the roadway. At this distance, more than 80% of the metallic trace elements (TME) disappeared during the

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process. The transfer factor of the lead concentration from the soil to the vegetables is estimated at 5.7 because the pH is 7.09 favoring mobility.

We recommend to the municipal authority a strict ban on vegetable cultivation within 50m of high-frequency motorized roads to protect the population against carcinogenic contaminants.

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