

Polluted Waters Use in the Urban Agriculture and Its Impact on the Quality of the Grown Vegetables

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Abstract: Urban agriculture has become a common practice in major urban agglomerations, particularly in the mining region of Katanga, in the Democratic Republic of Congo (DRC). However, this agriculture is based on the production of vegetables grown on the soil contaminated by industrial water and domestic wastewater, wherein one finds heavy metals and pathogenic microbes capable of endangering the consumer's health. This work has been carried out in view of contributing to the consumer's health protection and endeavours at establishing, based on physicochemical and mineral analyses of water samples, the soil used in the urban agriculture and edible plants, a link between the use of contaminated waters in the urban agriculture, the build-up of heavy metals in the soil and the possible contamination by heavy metals of vegetables grown (amaranths and broccolis) in the Kasungami district and consumed by the population living in the City of Lubumbashi (DRC). The results given by the analyses of water, soils and vegetable samples revealed that, apart from cobalt, other heavy metals were present in water used in the urban agriculture to concentrations below quality standards. As for the soil, it contained heavy metals to concentration reputed phytotoxic. However, only the broccolis were contaminated with lead, contrarily to amaranths in which heavy metals were present to concentrations below quality standards. These findings enabled concluding that urban agriculture of vegetables encountered in the large agglomerations of the DRC could endanger the consumers' health and measures need to be taken in view of preventing heavy metal from entering the food chain.

Keywords: Urban agriculture, contaminated waters, soil pollution, contaminated vegetable, human health endangering.

1. INTRODUCTION

Urban people around the world are not only confronted with the problem of protein deficiency, which is related to the issue of hunger [1]. They are also exposed to food contamination, especially in urban centres where farming of vegetables and other fresh foods such as tomatoes, amaranth, spinach, cucumbers, broccoli, carrots, and fruits is increasingly practiced on the soils that border watercourses [2-8]. Toxic metals, brought by agricultural soils or contained in the water used at farms, accumulate in the organic tissues of various edible plants and farmed animals used as food for humans [8-10]. However, whatever the extent of the health problems, which have arisen in the industrialized and developed or developing countries up to the Second World War, none of them has been as distressing as the environment pollution associated with modern technology and the development achieved in recent decades by the mining and metals processing industry [10-12]. This increasing and worrying pollution with which both governments and the population are confronted in all developed and developing countries is

generally the outcome of the mismanagement of mineral wastes together with wastes released by households and biomedical centres [12-14]. This increasing pollution is also the result of an accumulation of wastes in relationship with the individual consumption brought about by the population growth mainly in the developing countries and the development of industries, particularly those involved in mining and processing of raw materials [12-15]. Indeed, these industries daily release effluents that generally contain pollutants involved in the deterioration of the quality of air, water and soils resulting in increased food poisoning problems [12, 16]. In Katanga region (DRC), ancient and recent researches related to the mining industry have enabled realizing that the mismanagement of mineral wastes is responsible for the pollution of mineral origin that daily threatens the wildlife and the population's health [11, 17, 18]. Besides, previous researches on the pollution undergone by watercourses used as spillways for domestic and industrial wastewaters had succeeded establishing a close link between the contamination by heavy metals and pathogenic microorganisms of vegetables consumed in the cities of Lubumbashi and Likasi and this, provides proofs of the establishment of not friendly environmental practices in the urban agriculture mainly through the use of polluted soils and waters for growing edible plants [2, 3]. In addition, ancient researches have enabled identifying health problems associated

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with the consumption of foods affected by faecal contamination or polluted by heavy metals and especially by cadmium and lead [2, 3]. Consequently, monitoring the quality of vegetables produced around urban centres has revealed necessary in view of protecting the consumers' health threatened by the consumption of contaminated food while keeping in mind that the health of the population has no price. It is important to prevent heavy metals from entering the food chain through the watering of edible plants using contaminated waters and soils [4, 5, 19]. The present work seeks to determine whether broccolis and amaranths grown along the Kafubu River, which is located in the Kasungami district, and consumed in the City of Lubumbashi could result in food poisoning. To achieve this, samples of broccolis and amaranths and those of the soil and water used in the urban agriculture were subjected to physicochemical and mineral analyses. It is expected that the results from

their characterization enable establishing a link between the pollution undergone by the water together with the build-up of heavy metals in soil used in urban agriculture as well as the contamination of broccolis and amaranths by toxic metals involved in the food poisoning [5, 7].

2. MATERIALS AND METHODS

2.1. Research Area's Description

This research has been carried out in the Kasungami district (Figure 1), located in the city of Lubumbashi, Katanga region (DRC). Kasungami is a peripheral area, which is not correctly urbanized. Its population is estimated at more than 800 000 involved in the urban agriculture. The vegetables consumed by the population of the city of Lubumbashi are mainly grown in Kasungami. Commonly known as the "Cinq ans (in French)" district, Kasungami is separated from

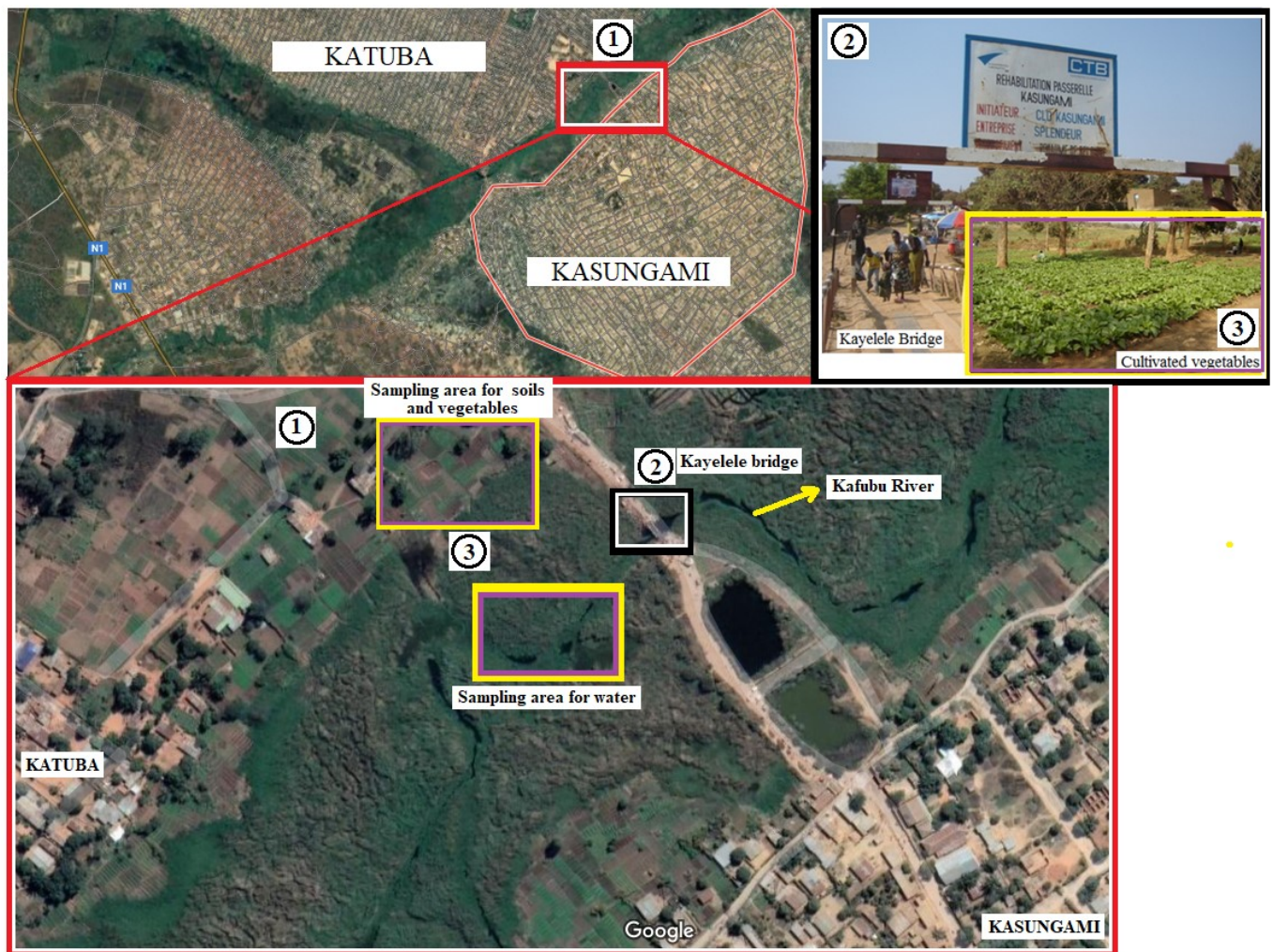


Figure 1: Vegetables grown near the Kayelele Bridge in the Kasungami District (DRC).

the rest of the city of Lubumbashi by the Kafubu River, which constitutes the spillway for industrial and domestic wastewaters. To get in Kasungami, people have to cross the Keyelele Bridge in the vicinity of which vegetables are cultivated along the Kafubu River.

2.2. Sampling Procedure Description

The sampling consisted in withdrawals of representative samples of water, soils, and vegetables intended for physicochemical analyses. The sampling campaign was conducted during the period of 35 days.

2.2.1. Water Sampling

Ten sites were selected in the vicinity of the Kayelele Bridge in view of collecting samples of water used for watering the vegetable grown along the Kafubu River. Water samples (each of 100 mL) were taken at 6:00 AM, 12 o'clock and 6:00 PM, respectively, using polyethylene made-bottles. On all of the selected 10 sites, 15 samples were collected, that is a volume of 1.5 L:

- 5 samples during the morning and named as W_1 , W_2 , W_3 , W_4 and W_5 ;
- 5 samples at twelve o'clock and named as W_6 , W_7 , W_8 , W_9 and W_{10} ;
- 5 samples again during the afternoon and named W_{11} , W_{12} , W_{13} , W_{14} and W_{15} .

The sampling of water has been conducted in duplicate.

2.2.2. Soil Sampling

In this case, 10 sampling points were selected from vegetable gardens bordering the Kafubu River to constitute 750 g samples each: S_1 , S_2 , S_3 , S_4 , S_5 , S_6 , S_7 , S_8 , S_9 and S_{10} .

2.2.3. Sampling of Vegetables

The vegetable gardens erected along the Kafubu River were sampled so that five samples of 100 g of fresh amaranth material (A_1 to A_5) and 200 g of broccoli (B_1 to B_5) were taken, respectively. These constitute the most cultivated vegetables consumed by the people from Kasungami and the City of Lubumbashi.

2.3. Samples Preparation

For water samples, after filtering 50 mL, using an ashless WHATMAN - (589/2) filter paper, in view of

removing suspensoids capable of clogging the sample aspiration capillary of the spectrophotometer. The aliquots (10 mL) of each sample were taken and poured in small plastic bottles for spectrophotometric determination of the chemical elements of interest. For the soil samples, aliquots of 2 g each were taken and placed in a beaker (250 mL) before being attacked with 20 mL HCl - 25%, 20 mL HNO_3 - 65% and 8 mL $HClO_4$ - 85%. After the samples attack with aqua regia, 100 mL of distilled water was added to each beaker before placing them on a heating plate for at least 10 minutes. The resulting solutions were allowed to cool down before transferring them to 250 mL graduated flasks. Subsequently, the volumes were supplemented with distilled water until the gauge mark before taking a 10 mL aliquot that was diluted 6250 times with distilled water in view of conducting the spectrophotometric analysis of the chemical elements of interest. For vegetables, the samples of amaranths and broccolis were placed inside a Memmert steam room (105°C) for drying before being weighted using an analytic balance of the mark Mettler Toledo. Subsequently, 5 g of the dry plant material was collected and subjected to calcination until the obtaining of ashes. 2 g of the ashes given by the calcination of the samples was attacked with 6 mL H_2SO_4 - 98%, 3 mL HNO_3 - 65%, 4 mL $HClO_4$ -85% and 2 mL HCL 25% in a 250 mL beaker. The acid attack was continued by placing the beaker containing the ashes on a heating plate until the obtaining of syrupy liquid, with white smoke clearing. Subsequently, the ashes' solution heating was stopped and the solution obtained cooled dow. Aliquots (10 mL) were collected and subjected to dilution, using the procedure implemented during the analysis of soil samples, before the spectrophotometric analysis of the chemical elements of our interest.

2.4. Physicochemical Analyses of Samples

Initially, these analyses consisted in the spectrophotometric measurement of the concentrations of targeted chemical elements (Cu, Co, Pb, Mn, Ni and Cd) in the various samples (water, soils and vegetables) using an Analytik Jena ASS 300 spectrophotometer equipped with hollow cathode lamps (multi-elements). Secondly, analyses were focused on the measurement of the water's quality parameters: pH, contents of matters in suspension, the dissolved oxygen, total nitrogen and the determination of the electric conductivity using a Consort C933 multiparameter analyser and a HACH spectrophotometer for the determination of total nitrogen.

3. RESULTS AND DISCUSSIONS

The results presented and discussed in this section of the paper deal with the physicochemical characterization of soil and water samples from the Kafubu River. The water abstracted from a river is used for the watering of vegetables grown in the Kasungami district and sold to consumers living in the City of Lubumbashi. The same results are also in relationship with the mineral analysis of broccolis and amaranths samples in view of determining their respective heavy metal concentration levels.

3.1. Determination of Physicochemical Quality of Water Samples

Analysis of water samples collected in the vicinity of the Kayelele Bridge in the early morning hours, at noon and the last hour of the afternoon led to the results given in Table 1.

The chemical composition of the samples changes with the sampling time. These variations in the physicochemical characteristics of the water subjected to analysis can derive from changes affecting the water chemical composition given that the river daily receives different types of wastewaters coming from households as well as those released by the copper industry of which the Kafubu River constitutes the spillway. As a result, significant variations in the pH and the electrical conductivity of water have been observed together with changes in the content of metals namely cobalt, manganese, and copper. Discharge of domestic wastewater in the River is proven by the presence of matter in suspension and nitrogen as well as the lower dissolved oxygen content observed in samples subjected to analyses. These findings confirm the fact that the pollution undergone by the water that has become an environment more conducive to the proliferation of pathogenic microorganisms of all kinds [20] as it has been concluded based on the results from ancient researches [2, 3]. Based on the newly obtained results, it can be stated that the water from the Kafubu River knows the organic and mineral pollution and therefore, is composed of contaminated water.

As for metals of which the presence has been noticed in the water samples of our interest, their average concentrations can be classified as follows: Co (0.097 mg/L) > Mn (0.068 mg/L) > Cu (0.029 mg/L) > Pb (0.027 mg/L) > Zn (0.026 mg/L) > Ni (0.011 mg/L) > Cd (0.001 mg/L). Unlike the concentrations observed for other metals in the water from the Kafubu River, it is

evident that only the concentration of cobalt exceeds the limit defined by the quality standards for water intended for agricultural use [19, 21-23]. However, in spite of the fact that heavy metals are present in water under consideration, even in concentrations that are smaller than the limits set by the quality standards defined by the FAO [19, 24], the use for watering of vegetables could result in the build-up of metals in the soil and consequently, in their absorption by edible plants [10] grown (see Figure 1).

The average pH of the water under consideration is equal to 7.46, a value that complies with the quality standards for water intended for agricultural use. As for the dissolved oxygen and nitrogen contents, their average values are equal to 16.09 mg/L [25] and 1.97 mg/L, respectively. As for the electrical conductivity and the amount of the matter in suspension, their average values are equal to 384.3 μ S/cm and 246.2 mg/L, respectively. These values surpass the quality standards defined for water intended for agriculture. Considering the high electrical conductivity that corresponds to the presence of chemical species in the water under study, it can be assumed that this mineral load can perturb the growth of vegetables [25]. Indeed, according to [10], the presence of heavy metals in a given plant induces oxidative stress and the displacement of essential chemical species by others and this phenomenon results in perturbation on the functioning of metabolic processes bringing about a decrease in crop yield [26]. This is the reason why Emurotu and Onianwa [27] have stated that a contaminated soil affects the rapid growth of crops and quality yield of agricultural products and thus, poses a threat to human health via the introduction of heavy metals in the food chain [8, 26].

3.2. Physicochemical Quality of Soil Used for Vegetable Cultivation

Due to the presence of metals in the water used for the watering of vegetables of our interest and considering the possibility of their build-up in the soil, samples have been collected and subjected to analyses. The results from these analyses are given in Table 2 below

The reading of the obtained results reveals that the samples are composed of soils of which the pH ranges between 5 and 8. Their average pH is 6.6 so that all samples can be considered as composed of slightly acidic soils. It can be assumed that these soils will weakly transfer their heavy metals to the plants grown

Table 1: Physicochemical Quality of Water from the Kafubu River

Parameter	Sampling Time	Water Sample					Mean Value	Quality Standard [19]
		W ₁	W ₂	W ₃	W ₄	W ₅		
pH	8 AM	6.62	7.60	7.15	7.29	6.75	7.08	6.5-8.4
	12 AM	7.20	7.70	8.00	7.97	8.10	7.79	
	18 PM	7.61	7.60	7.30	7.14	7.90	7.51	
	Mean value	7.14	7.63	7.48	7.47	7.58	7.46	
Dissolved O ₂ (mg/L)	8 AM	16.20	19.20	16.50	16.30	16.90	17.02	ND
	12 AM	14.20	12.30	15.20	16.20	15.90	14.76	
	18 PM	15.21	16.00	17.20	17.50	19.20	16.48	
	Mean value	15.20	15.83	16.30	16.67	17.33	16.09	
Total nitrogen (mg/L)	8 AM	1.72	1.80	1.92	1.91	2.02	1.87	ND
	12 AM	2.05	2.03	2.05	1.98	1.97	2.02	
	18 PM	1.82	1.97	2.05	2.12	2.20	2.03	
	Mean value	1.86	1.93	2.01	2.00	2.06	1.97	
Co (mg/L)	8 AM	0.037	0.046	0.340	0.037	0.036	0.099	0.05
	12 AM	0.099	0.120	0.121	0.124	0.127	0.118	
	18 PM	0.058	0.075	0.081	0.065	0.095	0.075	
	Mean value	0.065	0.080	0.181	0.075	0.086	0.097	
Cu (mg/L)	8 AM	0.011	0.009	0.112	0.012	0.011	0.031	0.2
	12 AM	0.023	0.024	0.027	0.032	0.033	0.028	
	18 PM	0.021	0.029	0.035	0.023	0.037	0.029	
	Mean value	0.018	0.021	0.058	0.022	0.027	0.029	
Zinc (mg/L)	8 AM	0.018	0.015	0.018	0.017	0.020	0.018	2.0
	12 AM	0.025	0.028	0.034	0.027	0.032	0.029	
	18 PM	0.027	0.034	0.038	0.031	0.042	0.034	
	Mean value	0.023	0.026	0.030	0.025	0.031	0.026	
Mn (mg/L)	8 AM	0.079	0.077	0.076	0.069	0.073	0.075	0.2
	12 AM	0.071	0.068	0.060	0.058	0.067	0.065	
	18 PM	0.051	0.062	0.070	0.055	0.082	0.064	
	Mean value	0.067	0.069	0.069	0.061	0.074	0.068	
Ni (mg/L)	8 AM	0.014	0.014	0.013	0.015	0.012	0.014	0.2
	12 AM	0.009	0.011	0.014	0.008	0.007	0.010	
	18 PM	0.007	0.008	0.010	0.008	0.015	0.010	
	Mean value	0.010	0.011	0.012	0.010	0.011	0.011	
Pb (mg/L)	8 AM	0.029	0.027	0.028	0.030	0.026	0.028	5.0
	12 AM	0.027	0.026	0.022	0.027	0.025	0.025	
	18 PM	0.029	0.025	0.027	0.029	0.030	0.028	
	Mean value	0.028	0.026	0.026	0.027	0.027	0.027	
Cd (mg/L)	8 AM	0.001	0.000	0.000	0.002	0.001	0.001	0.01
	12 AM	0.001	0.000	0.002	0.000	0.000	0.001	
	18 PM	0.000	0.000	0.002	0.001	0.002	0.001	
	Mean value	0.001	0.000	0.002	0.001	0.001	0.001	

Table 1 (Contd....)

Parameter	Sampling Time	Water Sample					Mean Value	Quality Standard [19]
		W ₁	W ₂	W ₃	W ₄	W ₅		
Electric conductivity (µS/cm)	8 AM	374.0	374.0	380.0	385.0	360.0	374.6	> 300
	12 AM	378.0	380.0	374.0	400.0	420.0	390.4	
	18 PM	374.0	382.0	379.0	400.0	405.0	388.0	
	Mean value	375.3	378.7	377.7	395.0	395	384.3	
Suspended matters (mg/L)	8 AM	247.0	245.0	250.0	248.0	245.0	247.0	< 15
	12 AM	245.0	270.0	255.0	230.0	220.0	244.0	
	18 PM	249.0	277.0	247.0	230.0	235.0	247.6	
	Mean value	247.0	264.0	250.7	236.0	233.3	246.2	

Table 2: Agricultural Soil Samples Physicochemical Characteristics

Soil Sample	pH	Co (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Cd (mg/kg)
S ₂	5.8	828.1	188.8	100.0	628.1	65.0
S ₃	5.7	687.5	125.0	106.3	662.5	60.3
S ₄	6.8	656.3	109.4	81.3	656.3	62.5
S ₅	6.9	625.0	107.9	81.3	562.5	56.3
S ₆	7.1	562.5	103.1	79.7	468.8	53.1
S ₇	7.2	718.8	93.8	78.1	375.0	50.0
S ₈	6.9	718.8	140.0	84.4	437.5	62.5
S ₉	6.2	815.6	112.5	87.5	659.4	59.4
S ₁₀	5.2	1093.8	131.3	112.5	781.3	56.3
S ₁₁	5.5	1062.5	128.1	109.4	734.4	65.6
S ₁₂	7.4	546.9	118.8	71.9	625.0	68.8
S ₁₃	6.8	781.3	100.0	75.0	593.8	78.1
S ₁₄	7.7	531.3	75.0	62.5	500.0	46.9
S ₁₅	7.6	556.3	81.3	78.1	531.3	59.4
Mean value	6.6	630.2	115.4	86.4	591.5	56.1
QS - European Union	ND	ND	140	75	300	3.0
QS - Canada	ND	40	150	150	375	3.0
QS - France	ND	ND	100	50	100	2.0
QS - United Kingdom	ND	ND	135	75	300	3.0
QS - Netherlands	ND	20	36	35	85	0.8
QS - Sweden	ND	ND	40	30	40	0.4
QS - Switzerland	ND	25	50	50	50	0.8
QS - WHO	ND	ND	ND	107	84	4.0

QS: quality standard; ND: not defined.

on them. However, considering the individual pH of each sample, the soils under study can be divided in three categories composed of acidic soils (S₁₀ and S₁₁), slightly

acidic soils (S₁, S₂, S₃, S₄ and S₉) and neutral soils (S₅, S₆, S₇, S₈, S₁₂ and S₁₃). More than half (54 %) of the samples subjected to analyses consist of neutral soils.

Consequently, the remaining samples are composed either of the acidic or weakly acidic soils that account for only 46 % of all samples. It is clear that the soils under consideration contain heavy metals of which the average concentration exceedingly surpasses the limit set by the standards in force in different countries around the world [28]. Indeed, cobalt, copper, nickel, lead and cadmium were observed in the soil samples to an average concentration that is greater than the limit set by the quality standards [28]. The content of heavy metals in soil is looked at as the main indicator of its degree of contamination [8].

Given the increased presence in the soil samples of the metals already identified in the water used for the watering of vegetables, it can be assumed that metals have accumulated in the soil and consequently, have a greater chance of ending up in the edible plants to be grown on those soil [26, 29]. This finding supports the argument related to a possible accumulation of metals in the soils brought about by the watering of vegetables using water abstracted from the Kafubu River [4, 10, 29]. Consequently, the possibility of seeing the vegetables cultivated along the Kafubu River (broccolis

and amaranths) undergoing a contamination brought about by heavy metals of which the toxicity to humans cannot be excluded [10, 29, 30]. The concerned toxic metals are present in high concentrations in soil samples taken approximately 20 cm from the surface.

3.3. Chemical Composition of Vegetables Grown along the Kafubu River

The samples of the vegetables (amaranths and broccolis) have been subjected to analyses in view of establishing a relationship between their chemical composition and the mineral pollution that they may undergo because of being grown on polluted soils. This pollution is in relationship with their watering using the water wherein heavy metals are present. The results from analyses of the vegetables are given in Tables 3 and 4.

The obtained results reveal that amaranths grown along the Kafubu River are not contaminated by toxic pollutants such as lead and cadmium considering that their average concentrations (Cd: 0.06 mg/kg and 0.04 mg/kg) are below the quality standards defined for

Table 3: Mineral Composition of Amaranth

Chemical Element	Average Content (mg/kg)	Phytotoxicity Range (mg/kg)	WHO Quality Standard for Edible Plants (mg/kg)
Co	9.37	15 – 30	50
Cu	9.0	30 – 100	73.3
Zn	23.88	ND	99.4
Mn	15.66	300 – 500	500
Ni	0.37	10 – 100	67.9
Pb	0.04	30 – 300	0.3
Cd	0.06	5 – 30	0.2

Table 4: Mineral Composition of Broccoli

Chemical Element	Average Content (mg/kg)	Phytotoxicity Range (mg/kg)	Content for Edible Plants (mg/kg)
Co	1.50	15 – 30	50
Cu	9.09	30 – 100	73.3
Zn	21.03	ND	99.4
Mn	3.88	300 – 500	500
Ni	0.15	10 – 100	67.9
Pb	10.72	30 – 300	0.3
Cd	0.10	5 – 30	0.2

edible plants [19, 28]. The same finding applies to other metals such as copper, cobalt, manganese, nickel and zinc. In addition, the concentrations of different metals analysed are well below levels considered hazardous to the vegetable kingdom, usually observed in tissues of plants insensitive toward heavy metals. From the above, it can be assumed that the metals observed in the soil to concentrations above quality standards are not present in the soil water in the form of bioavailable species easily absorbable by the plants via their roots. In fact, the absorption of the metals by plants from soils depends on many factors such as metal forms, plant species and parts and soil properties such as the pH and the redox potential [31].

As for broccoli samples (Table 4), the average concentrations of most heavy metals analyzed do not result in contamination and remain below the acceptable values for edible plants. On the contrary, broccoli is contaminated with lead observed to an average concentration of 11 mg/kg, a value that is 36 times the maximum allowable level for edible plants. However, this average lead concentration is outside the range of values considered phytotoxic. It is important to recall that lead, together with arsenic and cadmium, are the metals most commonly encountered as contaminants of vegetables. These metals are involved in health problems when their concentrations become great [8, 15, 26, 29, 31, 32]. Indeed, lead is reputed to perturb the intelligence development of children, to accumulate in the blood and is responsible for hypertension, nephropathy together with cardiovascular disease [32, 33]. Besides, it has been demonstrated that the consumption of vegetables contaminated with lead and cadmium results in a significant decrease in the human's life expectancy [15].

Overall, the obtained results reveal a link between the contamination of broccoli with lead and the mineral pollution undergone by the soil and water used in the urban agriculture practiced in Kasungami in view of producing vegetables consumed by the population living in the City of Lubumbashi. Similar researches also pointed out the contamination by cadmium of vegetables consumed in the City of Lubumbashi [2, 3]. Based on the concentrations of the heavy metals analyzed, it can be stated that the consumption of vegetables grown in the Kasungami district can result in poisoning of food mainly due to the presence of lead observed in their tissues. Consequently, possible human health harms related to other heavy metals cannot be excluded or neglected in the long term, as the outcome of their bioaccumulation [26, 29, 33],

although the concentrations to which they have been observed in edible plants did not exceed the toxicity limits defined by the WHO quality standards. Indeed, [4] involved in the achievement of similar researches arrived to the conclusion that long-term irrigation with wastewater can result in a build-up of heavy metals in soils owing to their strong affinity for organic matter and consequently, in foods [5, 7-9, 26, 29, 33]. Besides, the accumulation of heavy metals in edible plants has become nowadays a major international public health issue of concern [26, 33], as it has been recently acknowledged in the case of imported rice [10].

4. CONCLUSION

The present work, being a part of an effort to contribute to the human health protection against food poisoning that can arise due to the consumption of contaminated vegetables from the urban agriculture, what follows can be retained:

- The water from the Kafubu River that is utilized in the urban agriculture of vegetables experiences the pollution of mineral and organic origin owing to the presence of heavy metals (Co>Mn>Cu) ordinarily encountered in wastewaters from the copper industry. The same water contains nitrogen, matters in suspension and small oxygen content so that it is likely to contribute to the contamination of the vegetables;
- The soil used to grow vegetables in Kasungami and consumed by the population living in the City of Lubumbashi has undergone the pollution of mineral origin as evidenced by the high concentrations of heavy metals (Pb: 375 – 781 mg/kg; Cd: 47 – 78 mg/kg; Co: 531 – 1094 mg/kg; Ni: 63 – 113 mg/kg). The use of this soil in urban agriculture can result in the long term in the contamination of edible plants with toxic metals;
- Mineral chemical analysis of samples of vegetables watered with water from the Kafubu River and grown on the surrounding soil showed that amaranths do not contain heavy metals to concentrations that exceed the limits set for edible plants by the WHO. The same is not true for broccoli, of which samples contain lead observed to phytotoxic levels.

Overall, the obtained results reveal a link between the contamination of vegetables grown in Kasungami and the pollution of mineral origin that has affected the

water and soil used, exclusively in the case of broccoli. This finding justifies the banishment of unhealthy practices in urban agriculture of the vegetables consumed in the City of Lubumbashi in view of protecting the health of consumers. Further studies are therefore needed on the addressed problem in view of assessing the health risks associated with the ingestion of heavy metals through the consumption of vegetables by the population.

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