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# Assessment of heavy metals in irrigation water and vegetables in selected farms at Loumbila and Paspanga, Burkina Faso

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***Abstract:*** *This study was conducted to investigate the concentrations of heavy metals in water and vegetable. Water and vegetable samples were collected in Loumbila and Ouagadougou, central region Burkina, and analyzed for Co, Cr, Fe, Mn, Zn, Pb, Ni, Cd, As and Hg using flame atomic absorption spectrometry (FAAS). The concentrations of some heavy metals exceeded their respective permissible limits in water samples. The average concentrations of Cr (0.116 ±0.028 mg/l), Mn (0.462 ±0.01 mg/l), Ni (0.451 ±0.006 mg/l) and Hg (0.034 ±0.002 mg/l) observed in Loumbila water was higher than the Recommended Maximum Concentration for irrigation. In Paspanga water, only Co (0.264 ±0.008 mg/l) and Mn (0.442±0.06 mg/l) concentration exceeded the Recommended Maximum Concentration for irrigation. The average concentrations of heavy metals in Goudrin irrigation water were less than FAO recommended limit. The vegetable data indicate that the average concentration of Chromium (4.5±0.04 mg/kg) in tomato exceeded the WHO/FAO limit for vegetable. This study reveals that the leaves accumulate more Fe, Mn and Zn than the fruit, and cabbage accumulate more Co, Fe, Zn and As than lettuce. In general the vegetable from the study region can be considered safe for consumption because the average concentrations of heavy metals accumulated were below WHO/FAO recommended limits for vegetable.*

***Keywords:*** *heavy metal, concentration, contamination, irrigation water, vegetables.*

## I. Introduction

The heavy metals contamination is becoming more and more important in urban areas soils. People are using waste water in agriculture fields which is no clean water source. The accumulation of heavy metals in the soil can be cause by waste water irrigation. The use of waste water can increase the crop productivity, but also increases the contamination of heavy metals (Pb, Ni, Cd, Cu, Zn, Mn, Cr…) in the plants. The plants (Amaranthus, Fenugreek and Spinach) heavy metals concentrations depend on the soil concentration [1][2]. The vegetable from the contaminated soil can accumulate some high concentration of heavy metal and cause some serious risk to human health [3]. As an example, John et al [4] show that the vegetable and the soil from Kaduna city are polluted by Pb, Cd and Cr. The rice grain accumulated the heavy metals (Cu, Pb, Mn, Co, Cd, Cr and Fe) smaller than their concentration in growth soil and their transfer factor are very small [5].

The accumulation of heavy metals in soil can be due to the irrigation water and thereafter contaminate the vegetable and fruit. Heavy metal concentrations in vegetable are different to those of the fruits that reveal the difference between their capacities of accumulation [6]. Muamar et al [7] noticed in his study that the main source of contamination of shallow wells is waste water canal, and the distribution of metals in wells is affected by the location of the wells. There is relation between the use of sludge and contaminated water on buildup of heavy metals in soil. The use of pesticide and chemical fertilizer alongside sludge in the farms is an additional reason for transferring Cr, Ni and Pb from soil to edible parts of the crops.

Burkina is a landlocked country with weak waters resources. The development of agriculture is becoming very important with the used of wastewater, dam water, drilling water and well water. The used of water in agriculture without knowing the quality of the water can be the cause of environment and vegetable pollution.

The present work, deals with the determination of heavy metal concentrations in irrigated water and some of the vegetables grown in Ouagadougou and Loumbila area.

## II. Materials and methods

### II.1 Study Area

In this study, the water samples were collected in three different agricultural areas: market garden of Loumbila, Paspanga and Goudrin. Distance of 18 kilometers from Ouagadougou capital city of Burkina, the market garden of Loumbila is expanding around the dam. The dam of Loumbila is located at a longitude of

01°24'07.4 West and a latitude of 12°29'35.8 North with the water capacity of 42.2 million cubic meter. It is used by market gardeners to irrigate the plants [8]. The market garden of Paspanga is located in Ouagadougou behind the Yalgado Ouedraogo Teaching Hospital with the surface of 1ha. It is irrigated with the water well located two meters from the hospital waste water pipe. The market garden of Goudrin is located in Ouagadougou, district 28, located at a longitude of 01°27'25.39 West and a latitude of 12°22'56.44 North and the drilling water was used to irrigate the vegetable. The vegetable samples were collected in Loumbila and Paspanga. 14 samples of different vegetables and 10 samples from water sources were collected randomly from Loumbila, Paspanga and Goudrin during January 2013 to February 2014.

### II.2 Samples and Sampling Techniques

The irrigation water was collected in polyethylene bottles. At the sampling site, the bottles were rinsed twice with the water to be sampled prior to filling. The water samples were acidified on site, with nitric acid. The choice of the vegetable samples was mainly based on their availability and their frequency in the daily consumption: lettuce, cabbages, pepper. The vegetable samples were deducted by the hand, and set in sterile polyethylene bottles. The vegetable samples were washed with clean tap water to remove the soil particles adhered to the surface. The samples were brought back to the laboratory and kept in a refrigerator before digestion.

### II.3 Laboratory Analysis

The heavy metals such as cobalt (Co), chromium (Cr), iron (Fe), manganese (Mn), zinc (Zn), lead (Pb), nickel (Ni), cadmium (Cd), arsenic (As) and Mercury (Hg) were analyzed in the vegetable and water sample by Atomic Absorption Spectrometer.

The water sample(5.0g) were weighed into a 100ml polytetrafluo-roethylene (PTFE) Teflon tube and concentrated acids of 6mL of concentrated nitric acid (HNO3, 65%), 3mL of concentrated hydrochloric acid (HCl,35%) and 0.25mL of Hydrogen peroxide (H2O2,30%) were added to each sample. The samples were then loaded on the microwave carousel. The vessel caps were secured tightly using a wrench. The complete assembly was microwave irradiated for 26 minutes using milestone microwave Labstation ETHOS 900, INSTR: MLS-1200 MEGA.

The vegetable sample(0.5g) were weighed into a 100ml polytetrafluo-roethylene (PTFE) Teflon tube and concentrated acids of 6.0 mL of concentrated nitric acid (HNO3, 65%) and 1.0 mL of Hydrogen peroxide (H2O2,30%) were added to each sample. The samples were then loaded on the microwave carousel. The vessel caps were secured tightly using a wrench. The complete assembly was microwave irradiated for 25 minutes using milestone microwave Labstation ETHOS 900, INSTR: MLS-1200 MEGA.

After digestion the Teflon tube mounted on the microwave carousel were cooled in a water bath to reduce internal pressure and allow volatilized material to re-stabilize. The solution was then diluted to 20 ml with distilled water and assayed for the presence of elements (Zn, Pb, Mn...) using VARIAN AA 240FS-Atomic Absorption Spectrometer in an acetylene- air flame.

The metal final concentration was calculated using the following formulas:

$$\text{Final concentration} = \frac{C_{metal} * D_{factor} * V_{nominal}}{\text{Sample weight (g)}}$$

Where $C_{metal}$ is the concentration of the metal, $D_{factor}$ is the dilution factor and $V_{nominal}$ is the nominal volume.
For water samples: nominal volume=20ml and sample weight=5g.
For vegetable samples: nominal volume=20ml and sample weight=0.5g.

## III. Results and discussions

### III.1 Heavy metal in irrigation water:

**Table 1:** Average concentration (mg/l) of heavy metals in irrigation water

| Sample description | [Co] | [Cr] | [Fe] | [Mn] | [Zn] | [Pb] | [Ni] | [As] | [Hg] |
|---|---|---|---|---|---|---|---|---|---|
| Loumbila Water | ND | 0.116 ±0.028 | 1.286 ±0.006 | 0.462 ±0.01 | 0.036 ±0.006 | 0.272 ±0.004 | 0.451 ±0.006 | 0.016 ±0.004 | 0.034 ±0.002 |
| Paspanga Water | 0.264 ±0.008 | 0.016 ±0.004 | 1.052 ±0.023 | 0.442 ±0.06 | 0.048 ±0.008 | 0.092 ±0.001 | ND | ND | ND |
| Goudrin Water | ND | ND | 1.048 ±0.004 | 0.043 ±0.001 | 0.406 ±0.002 | 0.086 ±0.006 | ND | 0.008 | ND |
| Maximum Limit (mg/l) | 0.05 | 0.1 | 5 | 0.2 | 2 | 5 | 0.2 | 0.1 | 0.001 |

ND= Not detected

The table 1 shows average concentration (mg/l) of heavy metals in the irrigation water from Loumbila, Paspanga and Goudrin sites. The average concentration of heavy metals in the irrigation water in Loumbila site were 0.116±0.028 for Cr, 1.286±0.006 for Fe, 0.462±0.01for Mn, 0.036±0.006 for Zn, 0.272±0.004 for Pb, 0.451±0.006 for Ni, 0.016±0.004 for As and 0.034±0.002 for Hg from January 2013 to February 2014 whereas Co and Cd concentration were below the detectable limits. Among the detected heavy metals in Loumbila water, Cr, Mn, Ni and Hg concentration exceeded the permissible limit set by FAO (1989). The irrigation water in Loumbila can lead to soil or/and plants pollution in Cr, Mn, Ni and Hg. The average concentration of heavy in Paspanga irrigation water were 0.264±0.008 for Co, 0.016±0.004 for Cr, 1.052±0.023 for Fe, 0.442±0.06 for Mn, 0.048±0.008 for Zn and 0.092±0.001 for Pb whereas the concentration of Ni, Cd, As and Hg were very low. Co and Mn average concentration were higher than FAO (1989) permissible limit, and this can lead to soil or/and plants pollution. In Goudrin irrigation water, only Fe, Mn, Zn and Pb were detected with the concentration of 1.048±0.004, 0.043±0.001, 0.406±0.002 and 0.086±0.006 respectively. In all irrigation water of the sites, the average concentration was maximum for Fe but smaller than the permissible limit. Cd concentration was below the detectable limits in the irrigation water at the three sites. Irrigation water at Loumbila was more polluted in Cr, Fe, Mn, Pb, Ni, As and Hg than irrigation water at Paspanga and Goudrin, this can be justified by type of water. Loumbila site used the dam water, Paspanga used the well water and Goudrin used the drilling water. The concentration of Co was higher in irrigation water at Paspanga and the maximum concentration of Zn was in Goudrin water. The dam water was more concentrated in heavy metal than well and drilling water.

### III.2 Heavy metal in vegetable:

**Table 2:** Concentration of heavy metal in vegetable from Loumbila and Paspanga

| Site | Vegetables | [Co] | [Cr] | [Fe] | [Mn] | [Zn] | [As] |
|---|---|---|---|---|---|---|---|
| Loumbila | Cabbage | 0.50±0.06 | <0.04 | 2.532±0.016 | 0.4±0.04 | 0.34±0.02 | 0.08±0.02 |
| | Pepper Leaves | <0.2 | <0.04 | 1.176±0.048 | 6.96±0.08 | 0.36±0.04 | <0.04 |
| | Pepper Fruit | <0.2 | <0.04 | 0.204±0.008 | <0.08 | 0.26±0.06 | 0.120±0.001 |
| | Tomato | <0.2 | 4.5±0.04 | 28.98±0.09 | 2.8±0.092 | 4.52±0.05 | 0.06±0.02 |
| Paspanga | Spinach | 1.26±0.1 | <0.04 | 0.646±0.02 | 0.38±0.06 | 0.40±0.01 | <0.04 |
| | Lettuce | 1.28±0.08 | <0.04 | 3.47±0.004 | 0.28±0.04 | 0.40±0.04 | <0.04 |
| | Cabbage | 2.10±0.02 | <0.04 | 6.208±0.024 | <0.08 | 0.82±0.06 | 0.120±0.001 |
| Permissible Limits in Vegetables | | - | 2.3 | 425.5 | 500 | 99.4 | 0.43 |

The average concentration (mg/kg) of heavy metals in vegetables (cabbage, pepper (Capsicum annuum), tomato, spinach and lettuce) from both study sites (Loumbila and Paspanga) are shown in Table 2. The concentration of Pb, Ni, Cd and Hg were below the detection limit in all the vegetable deducted in the two study sites.

**Cobalt (Co):** The higher concentration of Co was detected in Cabbage, 2.10±0.02 at Paspanga and 0.50±0.06 at Loumbila. The average concentration of Co in spinach was 1.26±0.1, lettuce 1.28±0.08. Co was not detected in pepper leaves, pepper fruit and Tomato. The vegetable from Paspanga were more contaminated than those from Loumbila, this can due to the high concentration of Co in Paspanga irrigation water. The Co concentrations of all vegetable were between the normal concentration ranges 0.1 – 10 mg/kg [9].

**Chromium:** The tomato is the only vegetable where the chromium was detected and the average concentration was 4.5±0.04mg/kg. In cabbage, pepper, spinach and lettuce, the concentration were below detectable limits. The mean concentration of chromium in the tomato was the permissible limit recommended by FAO in vegetables (2.3mg/kg) [10][11][12].

**Iron:** The highest concentration of iron was found in Tomato 28.98ppm, followed by cabbage 6.21ppm, lettuce 3.47ppm, pepper leaves 1.176ppm, spinach 0.646ppm and pepper fruit 0.204ppm. The average concentration of Iron in the vegetable was very low than the permissible limit recommended by FAO in vegetables (425,5mg/kg) [13][14].

**Manganese:** Results showed that Manganese concentration is high in vegetable from Loumbila site than those from Paspanga Site. The highest concentration of Manganese was found in pepper leaves 6.96 ppm, followed by tomato 2.8 ppm, cabbage 0.4 ppm, spinch 0.38 ppm and lettuce 0.28ppm. The irrigation water at Loumbila and Paspanga were polluted by Manganese but the average concentration of Manganese in the vegetable was very low than the permissible limit recommended by FAO in vegetables (500mg/kg) [13].

**Zinc:** The highest concentration of iron was found in Tomato 4.52 ppm, followed by cabbage 0.82 ppm, lettuce and spinach with the same concentration 0.40ppm, pepper leaves 0.36 ppm and pepper fruit 0.26ppm. The average concentration of Zinc in the vegetable was very low than the permissible limit recommended by FAO in vegetables (99.4mg/kg) [10][14].

**Arsenic:** The higher concentration of arsenic was detected in Cabbage and pepper fruit with the same value 0.12 ppm, followed by tomato 0.06 ppm. The average concentrations were smaller than permissible limits set by FAO (0.43mg/kg) [10]. Arsenic concentration was below the detection limit in pepper leaves, spinach and lettuce.

### III.3 Heavy metal in pepper leaves and fruits:

**Table 3:** Average concentration (ppm) of heavy metal in leaves and fruit

| Sample description | [Fe] | [Mn] | [Zn] | [As] |
|---|---|---|---|---|
| Pepper Leaves | 1.176±0.048 | 6.96±0.08 | 0.36±0.04 | ND |
| Pepper Fruit | 0.204±0.008 | ND | 0.26±0.06 | 0.120±0.001 |

ND= Not detected

The average concentration of iron, manganese, zinc and arsenic in pepper leaves and pepper fruit cultivate from Loumbila soil are shown in table 3. In the leaves, the iron, manganese and zinc concentration were 1.176 ppm, 6.96 ppm and 0.36 ppm respectively. The arsenic concentration in the leaves was less than the detection limit. In the fruit, the average concentration of iron, zinc and arsenic were 0.204 ppm, 0.26 ppm and 0.120 ppm respectively, and the manganese concentration was smaller than the detection limit. The data showed that the iron, manganese and zinc levels of the pepper leaves were higher than the pepper fruits, while the arsenic concentration in the fruit was higher than leaves (Table 3). This study shows that the concentrations of iron and zinc in the pepper were less than those detected in Ghana [15].

### III.4 Heavy metal in Lettuce and Cabbage cultivate on the some soil:

**Table 4:** Concentration of heavy metal in two vegetable cultivate on the same soil

| Sample description | [Co] | [Fe] | [Mn] | [Zn] | [As] |
|---|---|---|---|---|---|
| Lettuce | 1.28±0.08 | 3.47±0.004 | 0.28±0.04 | 0.40±0.04 | ND |
| Cabbage | 2.10±0.02 | 6.208±0.024 | ND | 0.82±0.06 | 0.120±0.001 |

ND= Not detected

The levels of cobalt, iron, manganese, zinc and arsenic detected in lettuce and cabbage cultivate on the same soil at Paspanga are shown in the Table 4. The average concentrations of heavy metals in lettuce were 1.28 ppm for Co, 3.47 ppm for Fe, 0.28 ppm for Mn and 0.40 ppm for Zn. In the Cabbage, the concentrations were 2.10 ppm for Co, 6.208 ppm for Fe, 0.82 ppm for Zn and 0.120 ppm for As. The data in Table 4 shows that the levels of cobalt, iron, zinc and arsenic in cabbage were higher than those detected in lettuce. The data shows that the concentrations of manganese and zinc in the lettuce and cabbage were less than those detected in Ghana, while the iron levels in the lettuce and cabbage were higher than those detected in Ghana [13]. This higher concentration of the iron in lettuce and cabbage can due to the ferruginous character of the soil [16]. The concentrations of iron, zinc and arsenic in cabbage were smaller than the recommended value [17][18].

## IV. Conclusion

The present study revealed that there were high concentration of heavy metal in water and vegetables. This research indicated that Loumbila irrigation water were polluted by chromium, manganese, nickel and mercury and Paspanga irrigation water were only polluted by cobalt and manganese. Also the tomato was polluted by chromium. This study also indicated that leaves were more contaminated than the fruit. In general, the tomato, cabbage, pepper, spinach and lettuce cultivate at the study areas (Loumbila and Paspanga) can be considered safe for consumption because the average concentrations of heavy metals accumulated were below WHO/FAO recommended limits for vegetables.

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