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Arsenic, Cadmium, and Mercury in Cocoyam (*Xanthosoma sagititolium*) and Watercocoyam (*Colocasia esculenta*) in Tarkwa a Mining Community

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Abstract Cocoyam (*Xanthosoma sagititolium*) and Watercocoyam (*Colocasia esculenta*) have gained increased importance in the diets of majority of people in developing countries such as Ghana. The concentration levels of arsenic, cadmium, and mercury in Cocoyam (*X. sagititolium*) and Watercocoyam (*C. esculenta*) in Tarkwa and its surrounding villages a mining community in Ghana were measured in this study. From the results of the study, the levels of arsenic, cadmium and mercury in *X. sagititolium* and *C. esculenta* were higher than the WHO recommended levels. These root tubers absorb or uptake toxic chemicals from the soil as a result of the mining operations. This means that, the consumption of *X. sagititolium* and *C. esculenta* by humans from such environments may pose a serious health risk. There is therefore the need for a concerted effort by all to minimize the negative impact of gold mining in the study area.

Keywords *Colocasia esculenta* · *Xanthosoma sagititolium* · Efuantah · Nsuta and Tamso

Gold has a fascinating history and a special place in the world. It has long been considered as one of the most precious metals and the most used precious metal in a range of everyday applications essential to modern life. Its main uses are jewellery, dentistry, adornments on buildings and artistic expressions. In view of the uses of gold, the mining of gold in Ghana is considered one of the highest foreign exchange earners and contributes greatly to the socio-economic development of the country. Mining of gold is either by using mercury to extract the gold by amalgamation or by use of cyanide (Greenwood and Earnshaw 1997).

Trace metals such as arsenic, cadmium and mercury are either involved in the process or produced as a result of the gold mining. These toxic metals get into the soil or land and contaminate the land. The people within the mining area farm on the contaminated land hence, the root tuber crops such as *Xanthosoma sagititolium* and *Colocasia esculenta* absorb or uptake toxic chemicals from the soil. In this paper, analysis has been conducted on arsenic, cadmium and mercury for samples collected from different areas in a mining community, so as to give clues on how mining operations are contributing to Ghana's fast-increasing pollutional problems (Davies 1980).

Materials and Methods

Samples were collected from three towns viz Efuantah, Nsuta and Tamso which are all mining communities. *Xanthosoma sagititolium* samples were obtained from Efuantah whilst *C. esculenta* samples were also obtained from Nsuta and Tamso. They were uprooted using stainless cutlass and transferred into labelled black polythene bags. They were placed in an ice – chest and then conveyed to the laboratory for further analysis.

In the laboratory, the samples were washed thoroughly with double distilled water. The samples were then chopped into pieces and mashed in bits using mortar and pestle. The mashed samples were stored in a refrigerator for further analysis.

For the digestion of cadmium and arsenic, exactly 2 g of the stored mashed *X. sagititolium* and *C. esculenta* were

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weighed into a 500 mL beaker; 40 mL of concentrated HNO_3 was added and left overnight to allow for complete digestion process. After the initial digestion, 10 mL of 30% v/v hydrogen peroxide (H_2O_2) was added to complete the digestion and oxidation of the trace metals in the samples into their ionic forms. The samples were then filtered through Whatman No. 154 filter paper into a 100 mL volumetric flask. The contents of the 100 mL flask were later adjusted to the 100 mL mark with double distilled water (Fifield and Haines 1997; Garcia et al. 1974).

Similarly, for the digestion of mercury in the samples, 1.0 g of the stored mashed *X. sagititolium* and *C. esculenta* were weighed into a 100 mL beaker and 4 mL of concentrated HNO_3 followed by the addition of 4 mL concentrated H_2SO_4 were added to the weighed samples and then placed in a water bath at 80°C for 30 mins. The samples were then cooled to 4°C in an ice bath and 15 mL of $KMnO_4$ solution were added to the samples followed by 8 mL of $K_2S_2O_3$ and then placed in water bath at 95°C for 30 mins for complete oxidation of the mercury in the samples. The samples were removed, allowed to cool to room temperature; 6 mL of $NH_2OH{\cdot}HCl$ was added to reduce the excess permanganate colour in the mixture. The samples were then filtered through Whatman No. 154 filter paper into a 100 mL volumetric flask. The contents of the 100 mL flask were later adjusted to the 100 mL mark with double distilled water (Fifield and Haines 1997; Garcia et al. 1974).

The flame – atomic absorption spectrophotometer (AAS) was used to determine the concentration of arsenic and cadmium in the digested sample using cadmium and arsenic lamps at 228.8 and 193.7 nm wavelengths, respectively. The cold vapour technique was used to determine the concentration of mercury in the digested sample using a mercury lamp of wavelength 253.7 nm. All reagents used in the analysis were of the analytical grade supplied by BDH UK.

Results and Discussion

For the sake of comparison, the maximum permissible levels of daily oral intake of trace metals such as arsenic, cadmium and mercury in foodstuffs – *X. sagititolium* and *C. esculenta*, set by the World Health Organization (WHO), were used as baseline level to determine the level of pollution with regards to the uptake of arsenic, cadmium and mercury by *C. esculenta* and *X. sagititolium* grown in the study areas and the levels obtained in this study as shown in Table 1 below.

The WHO permissible levels of trace metals in food are threshold limits by which no observable adverse effect will be seen in human beings who consume the foods containing these trace/toxic chemicals.

From Table 1, it could be observed that the level of cadmium absorbed by the *X. sagititolium* from the soil is 0.043 mg/g is actually higher than the WHO permissible levels of daily oral intake for cadmium in *X. sagititolium*. The level of arsenic and mercury in the *X. Sagititolium* obtained are 0.146 and 0.003 mg/g, respectively. These values are also higher than the WHO permissible limits.

It could also be seen from Table 1 below that the concentration of cadmium in *C. esculenta* is far higher than the acceptable standards by the WHO (0.274 mg/g). For arsenic, the level was 0.401 and 0.005 mg/g for mercury in *C. esculenta*. The values are all higher than the WHO acceptable standards.

From Table 1 below, the levels of trace metals in *C. esculenta* from Tamso is as follows, for arsenic; we had, 0.366 mg/g, for cadmium, we have, 0.089 mg/g and for mercury 0.002 mg/g. All the above results obtained were found to be higher than the WHO allowable levels of trace metals in food crops for human consumption.

From the results of the study, the levels of cadmium, arsenic and mercury in *X. sagititolium* and *C. esculenta* from Tarkwa mining area and the surrounding villages are higher than the WHO recommended levels. That the consumption of *X. sagititolium* and *C. esculenta* by human beings may pose serious health risk to them. We find that the levels of arsenic, cadmium and mercury in soil in the study areas are very high and hence their uptake by tuber crops such as *X. sagititolium* and *C. esculenta* (Pacyna 1987; Browing 1969).

This calls for a concerted effort to minimize the negative impacts of gold mining in the study area.

Table 1 Permissible level of the daily intake of trace metals; i.e., arsenic, cadmium and mercury in food (cocoyam and watercocoyam)

Name of metal	Permissible by WHO standards mg/g	Levels obtained from the analysis mg/g		
		Efuanta *Xanthosoma sgititolium*	Nsuta *Colocasia esculenta*	Tamso *Colocasia esculenta*
Cadmium	0.000504	0.043	0.274	0.089
Arsenic	0.0003	0.146	0.401	0.366
Mercury	0.0003	0.003	0.005	0.002

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