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Comparative studies of the levels of mercury in foodstuffs from Artisanal gold mining communities in the Wassa west district of Ghana

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ABSTRACT

The main chemical used for the gold mining is Mercury. It is widely considered to be among the highest priority environmental pollutants of great concern to the world. Concerns about mercury are based on its effect both on ecosystems and human health. Mercury levels in various foodstuffs were determined by instrumental neutron activation analysis (INAA). High level of Hg was found in all the foodstuffs collected from mining areas. Generally, Hg concentration in foodstuffs ranged from *Capsicum sp* <0.01 to 69 µg/kg > *Xanthosoma sagittifolium* <0.01 to 67µg/kg, *Nbelmoschus esculentus* <0.01 to 67 µg/kg > *Colocasia esculentus* <0.01 to 66 µg/kg > Manihot *esculentus* <0.01 to 65 µg/kg , *Musa paradisiacal* <0.01 to 65 µg/kg , leaves of *Xanthosoma sagittifolium*, <0.01 to 65 µg/kg > *Solanum melongena* <0.01 to 63 µg/kg, > *Lycopersicum esculentus* <0.01 to 54 µg/kg. Most of the values far exceed the WHO recommended values of Hg in foodstuffs, 20ngHg per gram fresh weight. This is not surprising because of the large amount of mercury the illegal miners add in order to be sure that they have all amalgamated available gold. Hg levels should be carefully monitored in the Wassa west district in Ghana.

Introduction

Gold mining, the largest mining industry, contributes a large proportion of the foreign exchange earned in Ghana. Extensive large scale and small scale gold mining play important economic role by providing taxes, royalty payments and a major employer. The Gold mining industry contributes to the development of the rural communities by adding to the infrastructure by building schools, hospitals, and roads .Total revenue from gold exports in 2005 amounted to US $ 903,899,619. Total gold revenue for the first quarter of 2006 was US $ 288,154,738[1].

Mercury is the main chemical used in the gold mining. It is widely considered be among the highest priority environmental pollutants of continuing concern to the world. Concerns about mercury are based on its effect both on ecosystems and human health [2]. However gold mining activities can generate a lot of chemical wastes and cause various degrees of environmental damage and a threat to plants, animals as well as human life. Gold mining can generate large concentrations of highly soluble inorganic matter, some of which are considered toxic [3]. The physical properties of mercury have given this toxic element and its compounds industrial utility throughout recorded history. Current uses of mercury include the extraction of gold from ore and the manufacture of vapor lamps, barometers, switches, medical devices. Most of the mercury released from human activities is released into air, through fossil fuel combustion, mining, smelting and solid waste combustion. Some forms of human activity release mercury directly into soil or water, for instance the application of agricultural fertilizers and industrial waste water disposal as well as the use of mercury to process gold by some galamseys. All mercury that is released in the environment will eventually end up in soil surface waters. The health effects of mercury and its components will depend upon the chemical form of mercury concerned. The health effects of mercury vapour have been reviewed recently [4]. Damage is mainly to the nervous system, but effects are also seen, depending on dose, in the oral mucosa and the kidneys. Effects on the nervous system are manifested as tremor and a syndrome of psychological abnormalities labeled erethism, which includes deficits in short-term memory, irritability and social withdrawal. Limited information is available on the effects of mercury vapour on the early stages of the human life cycle. Effects on pregnancy and birth in women occupationally exposed dose-response relationships. These are corrosive poisons an acute single oral dose can induce severe gastrointestinal toxicity, acrodyin ("pink disease") in susceptible children and systematic shock. Subsequent death due to kidney failure may occur. Information on the chronic effects of inorganic mercury compounds in humans or animals indicates that the kidney is the target organ. However, report of health effects due to chronic exposure to compounds of inorganic mercury are rate. Occupational exposure to mercuric oxide has been shown to damage the peripheral nervous system; the effects appear to be reversible [5]. Cases of industrial poisoning were first described in the 16th and 18th centuries. At times mercury poisoning was widely spread among goldsmiths and mirror workers. Recently, outbreaks of methylmercury intoxication were observed in Iraq, as consequence of consumption of bread made from seed grain treated with mercurial fungicides, and in Japan (Minamata disease), following the dumping of mercury-containing

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industrial wastes in the Miniamata bay and consumption of fish caught in the bay.

One of the possible nerve tracts of pollutants from the environment to human organisms is the consumption of foodstuffs polluted by gold mines activities. Contamination of the environment by gold mines activities presents a significant health risk to man. A great deal of data exists on the response to incident acute exposure, but there is little or no information on the effects of chronic exposure to low amounts mercury in foodstuffs. The environmental pollution poses a serious threat to all countries, even more so in developing countries where precipitation is high because the consumption of foodstuffs is greater. The problem is more acute in a region like Wassa west district where the population is growing, and more urbanization and industrialization are taking place. Sources of foodstuffs, both surface and roots crops, are increasingly polluted. Human actions often cause pollution of much greater magnitude than natural contributors. The major source of high heavy metal concentrations in the soils can be metal rich source rock, atmospheric pollution from motor vehicles, combustion of fossil fuels, agricultural fertilizers and pesticides, organic manures, disposal of urban and industrial wastes, as well as mining and smelting processes [6]. Industrial wastes, geochemical structure and mining create potential sources of heavy metal pollution in the aquatic environment [7]. Under certain environmental conditions metals may accumulate to toxic concentration and they cause ecological damage [8]. Metal contamination in environments has received huge concern due to its toxicity, abundance and persistence in the environment, and subsequent accumulation in aquatic habitats. Heavy metal residues in contaminated habitats may accumulate in microorganisms, aquatic flora and fauna, which, in turn, may enter into the human food chain and result in health problems [9]. Widespread contamination caused by gold mining makes it desirable to have a reliable picture of the present and future background of the environment, especially the extent of specific pollutant, such as mercury. Environmental problems related to the presence of mercury in biosphere, whether in liquid, ionic or vapour form in Brazil are already well documented [10]. All mercury that is released in the environment will eventually end up in soil surface waters.

Materials and methods

Sampling and sample preparation

Foodstuffs were obtained from local farms in eight different towns in the Wassa West district of southwestern of Ghana. The towns were Iduapreim, Dumasi, Himan, Wassa Asikuma, Ayanfuri, Huni Valley and Damang. Krofofrom, a town in the Wassa West district with no history of mining activities, was chosen as the control site. The foodstuffs collected were plantain (Musa paradisiacal), cassava (Manihot esculentus), cocoyam (Xanthosoma sagittifolium), kontomire (leaves of Xanthosoma sagittifolium), tomato (Lycopersicum esculentus), pepper (Capsicum sp), garden egg (Solanum melongena), okro (Nbelmoschus esculentus), and Taro (Colocasia esculentus). They were bagged in polyethylene and transported to the Ghana Atomic Energy Commission, laboratories in Accra. They were then cut into smaller pieces with stainless steel knives into clean petri-dishes, frozen and lyophilized. Lyophilized samples were pulverized and stored in polyethylene and placed in hermetically closed polyethylene bags, and stored in a refrigerator at + 40C till analysis. About 150-200 mg of each sample was weighed into pre-cleaned irradiation vials. The analytical methods were validated by analyses of certified reference materials (CRMs) obtained from the National Institute of Standards and Technology ((NIST), USA,). Two standard reference materials obtained from National Institute of Standards and Technology, USA, namely NIST 1566b oyster tissue, 1547 peach leaves, certified reference materials (CRMS) were weighed. The mass of the samples ranged between 150 and 200mg depending on the density of the sample.

Sample irradiation, counting and analysis

Irradiation of the samples and the standards was done using the Ghana Research Reactor-1(GHARR-1) facility operating at half full power 15.0 kW and at a thermal neutron flux of 5.0x1011cm-2s. The Medium-lived radionuclide irradiation scheme was chosen because of my element of interest that is Hg. The samples and the standards were sent into the reactor by means of a pneumatic transfer system operating at a pressure of 0.4 to 0.6 Ba. At the end of irradiation, the capsules were allowed 24h to reach the allow activity before counting.

The samples were then put on the top of the detector and counts were accumulated for 10min (600s) to obtain the spectra intensities.

A PC-based gamma ray spectrometry system. The spectrometry system consists of high purity germanium (HPGe) N-type coaxial detector, an Ortec Multi-Channel Analyzer (MCA) emulation software card and a Pentium II computer for spectrum and data evaluation and analysis. Samples and standards were placed at a distance of 7.2 cm from the surface of the detector. The areas under the photopeaks of the identified element were integrated and converted into concentration. The PC-based gamma-ray spectroscopy system was used for the measurement. The accumulated spectral intensities were analyzed both quantitatively and qualitatively. The quantitative involves the conversion of the area under the photo peaks of the identified element into concentration whilst the qualitative involves the identification of the photo peaks of the element of interest.

Validation of the analytical methods

The analytical methods were validated by analyses of certified reference materials (CRMs) obtained from the National Institute of Standards and Technology ((NIST), USA,)

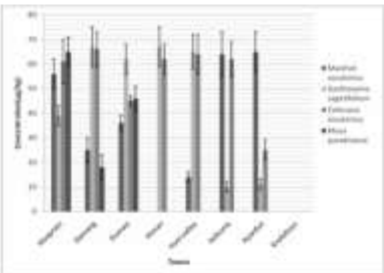
Analysis of certified reference materials

Two standard reference materials obtained from National Institute of Standards and Technology, USA, namely NIST 1566b oyster tissue, 1547 peach leaves, certified reference materials (CRMS) were weighed. The mass of the samples ranged between 150 and 200mg depending on the density of the sample

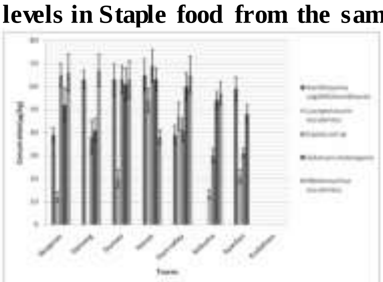
Results and discussions

In Table1, analytical results obtained at our laboratory for the certified reference materials, namely NIST 1547 Peach Leaves and 1566b Oyster Tissue, are compared with recommended values. The accuracy of the method can be deduced by good agreement obtained between the two sets of results. Precision of the counting was found to be less than 10%. The detection limit obtained for analysed element was 0.01 ppm. The results of INAA measurements of Hg in staple foods are presented in Table 2. The results of the INAA for the measurements of Hg in vegetable foods are presented in Table 3. For the staple foodstuffs (Table 2) concentrations of mercury varied among foodstuffs, in Manihot esculentus levels of Hg ranged from <0.01 to 65 µg/kg. The highest was found in Ayanfuri, which is a mining town, whiles the lowest was detected in Krofofrom which is non-mining area used as control area. The concentrations of mercury in Xanthosoma sagittifolium varied from< 0.01 to 67μg/kg, with the highest from Damang and Himan. They are all mining towns. The lowest concentration obtained from Krofofrom, which is used as the control area. The concentrations of mercury in Colocasia esculentus ranged from <0.01 to 66 μg/kg with the highest from Ayanfuri, which is a mining town, and the lowest from Krofofrom which is non-mining area as used as control area. The concentrations of mercury in Musa paradisiacal varied from <0.01 to 65 μg/kg with the highest from Himan. The lowest concentration obtained from Krofofrom, which was used as the control area.

For the vegetable foods (Table 3) concentrations of mercury varied among foodstuffs. The concentrations of mercury in Lycopersicum esculentus ranged from <0.01 to 54 μg/kg with the highest from Himan, which is a mining town, and the lowest from Krofofrom which is non-mining area, used as control area. The concentrations of mercury in Capsicum sp, ranged from <0.01 to 69 μg/kg with the highest from Himan, which is a mining town, and the lowest from Krofofrom which is non-mining area, used as control area. The concentrations of mercury in Solanum melongena ranged from <0.01 to 63 μg/kg with the highest from Himan which is a mining town, and the lowest from Krofofrom which is non-mining area, used as control area. The concentrations of mercury in Nbelmoschus esculentus ranged from <0.01 to 67 μg/kg with the highest from Damang, which is a mining town, and the lowest from Krofofrom which is non-mining area used as control area. The concentrations of mercury in leaves of Xanthosoma sagittifolium ranged from <0.01 to 65 μg/kg with the highest from Himan, which is a mining town, and the lowest from Krofofrom which is non-mining area used as control area.



(a) Mercury levels in Staple food from the sampling areas



(b) Mercury levels in Vegetable foodstuffs from the sampling areas

According to 1997 US EPA Report, the concentration of Hg in most foodstuffs is often below the detection limit (usually 20 ng Hg per gram fresh weight) but in this present study, a high concentration of Hg was observed in the foodstuffs. This might be due the uncontrolled usage of Hg by illegal miners for gold extraction in these areas. Descending order of Hg levels in foodstuffs; Capsicum sp > Xanthosoma sagittifolium, Nbelmoschus esculentus > Colocasia esculentus > Manihot esculentus, Musa paradisiacal, leaves of Xanthosoma sagittifolium, > Solanum melongena, > Lycopersicum esculentus. Compared with our results, most of the towns recorded concentrations higher than the proposed recommended levels of mercury. Studies have showed extensive mercury contaminations in intensive illegal mining towns. This could explain the high values of mercury concentration in this study; since this work was carried out in an intensive illegal mining town 'galamsey'. Himan recorded high mercury level in four foodstuffs; this means people living in that area are in real danger. There are high concentrations of mercury in at least two foodstuffs from each town.

Conclusions

The purpose of this study was to estimate the Hg concentrations in some of the most consumed foodstuffs grown in Wassa west district of Ghana. The results obtained from this study clearly indicate that foodstuffs grown in Wassa west district of Ghana are polluted with Hg due to the activities of the illegal miners. Elevated values of Hg observed in almost all the foodstuffs. The impact of small scale gold mining on the environment and human health in the Wassa west district in Ghana at the present largely localized and affects mainly the population of the small scale mining communities. If not contained and improved, however, the impacts of small scale mining activities will be long lasting and threaten economic development, essential ecological processes and human health of future generations. At the present the main concern is that of human health, especially for those who consumed the foodstuffs grown in those areas. Hg levels should be carefully monitored in the Wassa west district in Ghana. As in many countries, a plan to decrease inputs of Hg to the environment and to mitigate potential consequences of Hg accumulation in the environment is also urgently needed.

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Table1: Analytical results and recommended values of NIST- 1547 peach leaves and NIST-1566b oyster tissue certified reference material (CRM) (mg/kg)

ELEMENT	NIST- 1547 PEACH LEAVES		NIST-1566B OYSTER TISSUE	
	RECOMMENDED VALUE	THIS WORK	RECOMMENDED VALUE	THIS WORK
Hg	0.031 ± 0.007	0.033±0.009	0.0371 ± 0.0013	0.0384±0.0021

TABLE 2: The concentration (µg/kg) of mercury in staple foods is shown in table below for all the towns

Food crops	Iduaprien	Damang	Dumasi	Himan	Huni valley	Asikuma	Ayanfuri	Krofofrom
Manihot esculentus	56±6	25±5	36±3	<0.01	14±2	64±9	65±8	<0.01
Xanthosoma sagittifolium	39±4	67±8	62±6	67±8	65±7	10±2	11±2	<0.01
Colocasia esculentus	61±9	66±7	45±2	62±6	64±8	62±7	25±4	<0.01
Musa paradisiacal	65±6	18±5	46±5	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 3: The concentration (µg/kg) of mercury in vegetable foodstuffs is shown in table below for all the towns

Food crops	Iduaprien	Damang	Dumasi	Himan	Huni valley	Asikuma	Ayanfuri	Krofofrom
Xanthosoma sagittifolium(leaves	39±3	63±4	63±7	65±7	39±4	<0.01	59±5	<0.01
Lycopersicum esculentus	12±2	<0.01	20±4	54±5	47±6	13±2	21±3	<0.01
Capsicum sp	65±5	38±7	63±6	69±7	41±5	30±3	31±2	<0.01
Solanum melongena	52±7	41±5	61±7	63±5	60±6	54±4	48±4	<0.01
Nbelmoschus esculentus	66±8	67±7	63±8	38±3	65±8	57±5	<0.01	<0.01