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Status of Environmental Contamination in Ghana, the Perspective of a Research Scientist

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Abstract—The production and use of chemicals is an important source of economic welfare in Ghana. However, many chemicals also enter the environment and chemical pollution remains a major environmental issue in Ghana. In Ghana, mining and agriculture remain the major contributors to chemical pollution. For mining; mercury, cyanide and arsenic are normally the reported cases of contamination. Studies have revealed high levels of urinary arsenic in Ghana comparable to other arsenic-endemic areas of the world, while arsenic contamination has been reported in groundwater. Mercury has also been reported in human blood, human urine and fish in southwestern Ghana. Generally, agriculture in Ghana, particularly vegetable farming is fraught with misuse and overuse of pesticides. Pests and diseases pose big problems in vegetable production and these have led many farmers to use chemical pesticides even if they have received no training in application techniques. The results on pesticides residue analysis by several authors indicated water pollution, food contamination and accumulation of toxic compounds in human fluids of farmers. Most examples of contamination reported in literature point to isolated cases. Thus, the status of contamination in Ghana as evidenced from a review of literature is localized and not nationwide.

Keywords: environmental contamination, agriculture, pesticides, mining, arsenic, Ghana

INTRODUCTION

In Ghana, agriculture and mining remain the major contributors to chemical pollution. Agriculture is a major economic sector with about 40% share in the Gross Domestic Productivity (GDP). The livelihood of the average Ghanaian depends either on agriculture or agriculture related business. However, high pre- and post-harvest losses due to pests are a major problem for the productivity in the agricultural sector. Generally, agriculture, particularly vegetable farming, is fraught with abuse, misuse and overuse of pesticides. Pesticides have become an integral part of Ghanaian agriculture, being used on cocoa and cotton plantations, vegetable farms, rice fields, etc. It is estimated that 87% of farmers in Ghana use chemical pesticides to control pests and diseases on vegetables (Dinham, 2003).

Of the pesticides used, 44% are herbicides, 33% are insecticides and 23% are fungicides (Ntow *et al.*, 2006). Organochlorine pesticides have been used in Ghana for more than 40 years, for agriculture and public health purposes with their residues having been found in water, sediments and crops and in humans (Ntow, 2001). Lindane was phased out in the year 2002 and endosulphan, restricted for cotton pest control is now misused for the control of capsids on cocoa and maize, as well as pests on coffee.

Pesticide usage in Ghana, therefore, continues to increase as agricultural production intensifies. However, associated with the increased use of pesticides are environmental and health problems which have arisen due to indiscriminate use and inappropriate handling of the chemicals. Workers exposed to pesticides are often illiterate, and lack training, equipment, and the necessary safety information. Lack of effective legislative controls, and an especially susceptible population coupled with the availability of highly toxic pesticides which are often badly labeled, poorly packaged and irresponsibly promoted are some of the factors which add to the hazards involved in pesticide use in Ghana.

Farmers often spray hazardous insecticides like organophosphates and organochlorines up to five or more times in a cropping season when perhaps two or three applications may be sufficient. Runoff of pesticides from the agricultural fields may contaminate water sources. The toxic, persistent pesticides may spread within the watershed. Consequently, the quality of such water bodies gradually deteriorates to a level, which may jeopardize their use for drinking by humans and livestock. Non-target flora and fauna concentrate these chemicals in their tissues and pass them on along the food chain. The accumulation of such pollutants in the food chain may restrict the consumption of valuable food resource like fish.

Mining also makes a large portion of the GDP and plays a significant role in the economic recovery programme of the country. However, the gains are achieved at a great environmental cost as the exploitation of gold puts stress on water, soil, vegetation and poses human health hazards (Amonoo-Neizer and Amekor, 1993). The main prospects in Ghana occur at Obuasi, Tarkwa, Prestea, Bibiani, Bogoso and Kenyasi, with the gold occurring in close association with sulphide minerals, especially arsenopyrite (Smedley, 1996). For gold mining, mercury, arsenic and cyanide are normally the reported cases of contamination. Studies have revealed high levels of arsenic comparable to other arsenic-endemic areas of the world in urine of inhabitants of Tarkwa (Asante *et al.*, 2007), and some villages near Obuasi (Smedley *et al.*, 1996) in Ghana, while arsenic contamination has been reported in groundwater in Obuasi and Bolgatanga (Smedley, 1996). Mercury has also been reported in surface soil and cassava (*Manihot esculenta*) in Dunkwa (Golow and Adzei, 2002), and in human blood, human urine and fish (Adimado and Baah, 2002) in southwestern Ghana.

Many chemicals including those from less known e-wastes also enter the environment and chemical pollution remains a major environmental issue in Ghana.

REVIEW OF SOME PAST STUDIES

Various studies have been conducted on the agricultural and mining environment of Ghana to elucidate the environmental contamination status in Ghana.

A current study conducted by Ntow *et al.* (2008), assessed the accumulation of persistent organochlorine contaminants in milk and serum of farmers in Ghana. Concentrations of persistent organochlorine (OC) pesticides such as dichlorodiphenyltrichloroethane and its metabolites (DDTs), hexachlorocyclohexane isomers (HCHs), hexachlorobenzene (HCB) and dieldrin in samples of human breast milk and serum collected from vegetable farmers in Ghana during 2005 were determined. The levels of DDTs, HCHs and dieldrin in the breast milk samples were found to correlate positively with age of the milk sample donors. DDTs and dieldrin residues were significantly higher ($p < 0.005$) in males than females and there was association between breast milk and serum residues. When the daily intakes of DDTs and HCHs to infants through human breast milk were estimated, some individual farmers (in the case of DDTs) and all farmers (in the case of HCHs) accumulated OCs in breast milk above the threshold (tolerable daily intake guidelines proposed by Health Canada) for adverse effects, which may raise concern on children health.

The present study which is the most recent and comprehensive study on OC pesticides contamination in farmers from Ghana revealed the presence of persistent, bioaccumulative, and toxic DDTs, HCHs, dieldrin, and HCB in human fluids at levels that raise public health concerns. Although epidemiological studies have not confirmed these chemicals as likely causes of diseases like cancer, the fact that almost all samples tested to date have shown detectable levels of residues of pesticides provides enough reason for concern about possible health effects of these compounds.

Another study by Amoah *et al.* in 2006 also analysed pesticide and pathogen contamination of vegetables in Ghana's urban markets. A total of 180 vegetable samples were randomly purchased from 9 major markets and 12 specialized selling points in 3 major Ghanaian cities: Accra, Kumasi and Tamale. Chlopyrifos (Dursban) was detected on 78% of the lettuce, lindane on 31%, endosulfan on 36%, lambdacyhalothrin (Karate) on 11%, and DDT on 36%. Most of the residues measured exceeded the maximum residue limit for consumption. Vegetables from all the 3 cities were faecally contaminated and carried faecal coliform populations with geometric mean values ranging from 4.0×10^3 to 9.3×10^8 g^{-1}, wet weight and exceeded recommended standards. Lettuce, cabbage and spring onion also carried an average of 1.1, 0.4 and 2.7 helminth eggs g^{-1}, respectively. Because many vegetables are consumed fresh or only slightly cooked, the study showed that intensive vegetable production, common in Ghana and its neighbouring countries, threatens public health from the microbiologic and pesticide dimensions.

Pesticide residues in the Volta Lake, arguably the largest man-made lake in Ghana, were also analysed by Ntow in 2005. Lindane and endosulfan were identified in concentrations ≤0.008 ppb and 0.036 ppb, respectively in water and

≤2.3 ppb and 0.36 ppb, respectively in sediment. DDT and DDE were also found in sediment samples (in concentrations ≤9.0 ppb and 52.3 ppb, respectively). No significant contamination was noted in the lake however. The pesticide levels found in the present study were comparable to a study by Osafo and Frempong in 1998. Although DDT is banned for agricultural use in Ghana, it was detected in sediment samples, along with its metabolite, DDE and the study demonstrated the well-known environmental persistence of this substance, even in tropical environments (Kidd *et al.*, 2001), justifying its prohibition from agricultural use in Ghana. The DDT concentration in the sediment, however, was lower than the DDE level indicating a high degradation rate under hot, dry climatic conditions (Jiries *et al.*, 2002), typically of a tropical lake. Because most OC pesticides, including those detected in the study have the ability to accumulate in biological tissues, and are very toxic to fish and many aquatic invertebrate species, they pose a potential threat to sediment-dwelling organisms.

Similar to the study done in 2008, a study was conducted by Ntow in 2001 on organochlorine pesticide levels in a farming community in Ghana. A total of 208 samples of water, sediment, tomato, and mothers' breast milk were collected from the environs of Akomadan, a prominent vegetable-farming community in Ghana. Endosulfan sulfate was the most frequently occurring (78%) OC in water with a mean of 30.8 ng/L. Lindane was detected in 38 samples (76% of analysed samples). Sediment samples showed the most number of OC compounds. The concentration was highest in sediment for lindane (mean 3.2 μg/kg) and least for β-endosulfan (mean 0.13 μg/kg). Heptachlor epoxide was present at a quantifiable level in tomato (mean 1.65 μg/kg fresh weight) and in sediment (mean 0.63 μg/kg dry weight).

HCB was detected in 55% and DDE in 85% of all blood samples analyzed. For milk samples, 95% indicated quantifiable amounts of HCB, whereas 80% showed DDE. The mean values of HCB and *p,p′*-DDE in blood were 30 μg/kg and 380 μg/kg, respectively. The mean values of HCB and *p,p′*-DDE in milk were 40 μg/kg fat (1.75 μg/kg whole milk) and 490 μg/kg fat (17.15 μg/kg whole milk), respectively.

The study showed that residues of OC pesticides are present in environmental samples at Akomadan and in human fluids of its inhabitants. The residues have originated from agricultural activities in the area and it is expected that an appreciable build-up of residues with time will occur because of the continuous use of pesticides in the area. Because these compounds are toxic and not environmentally friendly, increased contamination in human fluids could pose serious public health problems.

The first study on multi-elemental contamination in drinking water and human urine from a mining town in Ghana was published by Asante *et al.* (2007). The study was conducted to assess the contamination status of 22 trace elements, especially arsenic in water and residents of Tarkwa, a historic mining town in Ghana. Drinking water and human urine samples were collected in addition to control samples. The study showed that 33.3% of the river water samples exceeded the WHO drinking water guideline of 10 μg/L, whereas 58% of the river waters and 33.3% of the boreholes exceeded the WHO drinking water guideline value of 400 μg/L, posing a potential health risk for the people. No significant difference of arsenic (As) concentrations in human urine between Tarkwa and control site Accra was observed and although As concentrations in drinking water in Tarkwa were low, urinary total As levels (mean of 260 μg/L) were comparable to those in residents of Kofikrom (median of 224 μg/L) and Wumase (median of 297 μg/L) villages, which are gold mining areas in Obuasi, Ghana (Smedley *et al.*, 1996). Both Ghanaian studies were comparable to those reported in highly As-affected areas in the world. This suggests the presence of other sources of As contamination in Ghana, possibly food. In terms of sex, no significant difference in As concentrations was observed between males and females. Also, there was no correlation between urinary As concentration and age of males and females (Asante *et al.*, 2007).

Smedley *et al.* (1996) also reported that concentrations of As in human urine did not vary significantly with age, sex and occupation. In their study conducted in Obuasi, the largest gold-mining area in Ghana, arsenic in drinking water from stream, shallow wells and boreholes ranged from <2 to 175 μg/L and attributed the main sources to mine pollution and natural oxidation of sulphide minerals, predominantly arsenopyrite. Concentrations of As in groundwaters reached up to 64 μg/L being highest in deeper boreholes and is thought to build up as a result of longer residence times undergone by groundwaters in the aquifers. Median concentrations of inorganic urinary As from sample populations in two villages, one a rural streamwater-drinking community and the other a surburb of Obuasi using groundwater for potable supply, were 42 μg/L and 18 μg/L. The slightly higher value for the streamwater-drinking community was suggested to reflect different provenance of foodstuffs and higher As levels of water sources local to the village.

In an attempt to assess the level of As in food, Amonoo-Neizer and Amekor in 1993, determined total arsenic of some Ghanaian food and cash crops from Kumasi and Obuasi farms and markets. Quantitative analysis of As was also conducted on vegetation, cooked food obtained from some homes, local fish and meat, as well as soil and water samples. In all 266 samples examined, values for Kumasi samples ranged from 0.07 to 7.20 mg/kg As, whereas those for Obuasi ranged from 0.12 to 70.50 mg/kg, confirming that As levels for Obuasi (gold mining town) are much higher than those from Kumasi.

Amasa in 1975 also analyzed human hair samples from mine workers and Obuasi citizens, various food items; drinking and washing water from Obuasi town; vegetation and soils from the countryside bordering the goldmine. The mine workers examined showed abnormally high As levels in the hair, as did most of the town people. The vegetation in the immediate periphery of the mine, about 1 mile to the north of the chimney was also polluted with As. Some food items and water were contaminated with As and soil between the chimney and Akrokerri had unusually high As contents. Arsenic levels as far as 2.5 miles away from the chimney were sufficiently high to cause plant injury and plant growth inhibition (Anastasia and Kender, 1973).

Table 1. Summary of mercury levels in human blood, urine, hair, nail and fish tissues from different locations in the Ankobra and Tano river basins in Southwestern Ghana.

River Basin	Location	Blood Mean (Range)	Urine Mean (Range)	Hair Mean (Range)	Nail Mean (Range)	*n*	Fish Mean (Range)	*n*
Ankobra	Anwiaso	102 (30.2–218)	34.2 (1–183)	1.61 (0.15–5.86)	2.65 (0.57–10.0)	50	0.18 (0.03–0.29)	7
	Sahuma	13.4 (2.1–68.1)	2.6 (0.13–6.96)	0.62 (0.32–2.19)	0.73 (0.18–5.40)	50	0.32 (0.01–2.4)	21
Tano	Tanoso	16.5 (2.1–57.2)	6.4 (2.0–14.3)	4.27 (0.06–28.3)	3.45 (0.13–22.9)	51	0.20 (0.09–0.39)	11
	Elubo	39.5 (1.8–70.4)	7.3 (0.02–42.5)	1.21 (0.07–3.19)	1.05 (0.22–9.68)	66	0.32 (0.05–2.5)	15

Source: Adimado and Baah, 2002.
NB: Blood and urine samples are in μg/L whiles hair, nail and fish tissues (wet wt.) are in μg/g.

Another arsenic study conducted in rural groundwater in Ghana notably Bolgatanga and Obuasi showed levels of arsenic to range from <1 to 64 μg/L for Obuasi and <1 to 141 μg/L for Bolgatanga (Smedley, 1996). Sulfide minerals such as arsenopyrite and pyrite present in the Birimian basement rocks of both areas were the dominant As sources. Thus, the arsenic is considered to derive ultimately by oxidation of sulfide minerals. Concentrations were mostly higher in the Obuasi groundwaters, where arsenopyrite is known to be more concentrated and pyrite is a relatively abundant accessory mineral. In both study areas, dissolved total As levels tended to be higher in deeper groundwaters under conditions of lower electrode potential and higher pH (>6).

Adimado and Baah in 2002 analysed mercury in human blood, urine, hair, nail and fish from the Ankobra and Tano River basins in southwestern Ghana. 217 subjects were involved in the study and the results are summarized in Table 1.

The mean blood and urine mercury concentrations for the 50 subjects of Anwiaso in the Ankobra river basin were significantly higher than those of the other groups. None of the Anwiaso subjects' blood mercury concentration was less than 3 μg/L, the limit for non-exposed person. Possibly, these subjects could have been exposed to some inorganic mercury vapour as a result of the illegal mining operations which involve amalgamation of the gold concentrate and later heating the amalgam to vapourise mercury. The high blood mercury levels may be connected with the heavy accumulation of organic mercury in fish. With the high fish consumption habits of Ghanaians, the possibility of alarming clinical levels of mercury in blood may be likely as stated by the authors.

CONCLUSIONS

Current studies have revealed the presence of persistent, bioaccumulative, and toxic DDTs, HCHs, Dieldrin, and HCB in human fluids and at levels that raise public health concerns. Though epidemiological studies have not confirmed these chemical compounds as likely causes of diseases like cancer, the fact that most samples tested to date have shown detectable levels of pesticides provide ample reason for concern about many possible health effects of these compounds. In terms of mining, studies are required to evaluate toxic effect on humans who are exposed to especially As, Mn and Hg. Furthermore, if the geologic and groundwater conditions that promote high As concentrations are known, they may be helpful to identify high-risk areas. Thus, studies are needed in an attempt to eliminate or reduce sources of contamination, and also to provide information for epidemiological studies that establish a relation between levels of contamination and predominance of diseases.

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