DETERMINATION OF TOTAL ARSENIC OF SOME FOOD AND CASH CROPS, VEGETATION, COOKED FOOD, FISH, MEAT, SOIL AND WATER FROM KUMASI, OBUASI AND THEIR ENVIRONS

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ABSTRACT

The total arsenic of some Ghana food and cash crops, vegetation, cooked food obtained from some horues, locll fish, and rneal, as well as some soil and water samples from Kumasi and Obuasi were determined. In all, 266 samples were examined. Sanlpling depended on whlch samples were available and obtainable at the different locations. Vegetation was as far as possible collected from sources of water utilized for domestic purposes. Absorption Spectrophotometry was employed.

Arsenic concentration values for Kumasi ranged between 0.07 and 7.20 mg/kg whilst in Obuasi a range of 0.12 to 70.50 mg/kg was obtained.

The data showed that arsenic levels for Obuasi Samples were much higher than those from Kumasi.

Keywords: Arsenic, Food, Cash-Crops, Vegetation, Soil, Water

INTRODUCTION

The mining sector contributes a very large portion to the Gross National Product of Ghana and is playing a very significant role in her Economic Recovery Programme. Gold mining, the largest sub-sector, accounts for the largest proportion of Foreign Exchange which Ghana earns from the mining industry. Gold has recently superseded cocoa as the highest Foreign Exchange earner for the country. The economic gains for Ghana are however achieved at a great environmental cost and exploitation of Gold in Ghana puts an immense stress on the air, water, soil, and vegetation which constitute the life support systems, and also frequently poses a potential as well as real hazard to human health.

The most serious problems are in Obuasi and Prestea due to the nature of the ore and the method of processing. The gold occurs in these two locations largely lock-d in mineralized dyke and schist (pyrite and arsenopyrite) associated with arsenic and sulphur. The extraction of the gold involves roasting which lets out amongst other airborne particles, large quantities of arsenic; 14 - 19 tons daily at Obuasi.

The dangers of the oxides of arsenic, too numerous to catalogue, impair human life right from its very basis to the end. They damage chromosomes, induce spontaneous abortions, cause congenital malformations due to placental transfer of the elements, reduce birth weights, disturb functions of the liver and of the Central Nervous System and contribute to lung cancer etc.

Studies [1, 2, 3, 4] have established large amounts of arsenic in soils, water, plants, some food items, and human hair. Arsenic in the soils was found to be largely labile [3] The purpose of this study is to extend work already done to cover;

(1) determination of arsenic in other food items, cash crops, and waters;
(2) analyses of cooked foods for arsenic, and
(3) compilation of similar data iln Kumasi as a baseline since Kumasi is too remote from Obuasi for the concentrations of arsenic in these substances to be affected by the flue gases from the Obuasi mine chimney.

EXPERIMENTAL

Sampling depended on what was available and obtainable at the various locations which are indicated on Figs 1, 2 and 3.

Two hundred and sixty six (266) samples were analysed as follows:

KUMASI - Food crops, 84; Cash Crops, 8; Cooked foods, 6; Vegetation 6; Fish and Meat, 2;

OBUASI - Food crops, 104; Cash crops, 11; Cooked foods, 9; Vegetation, 20; Fish and meat, 2; Soil, 7; Water, 7. Vegetation was as far as possible collected

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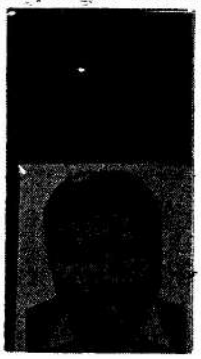


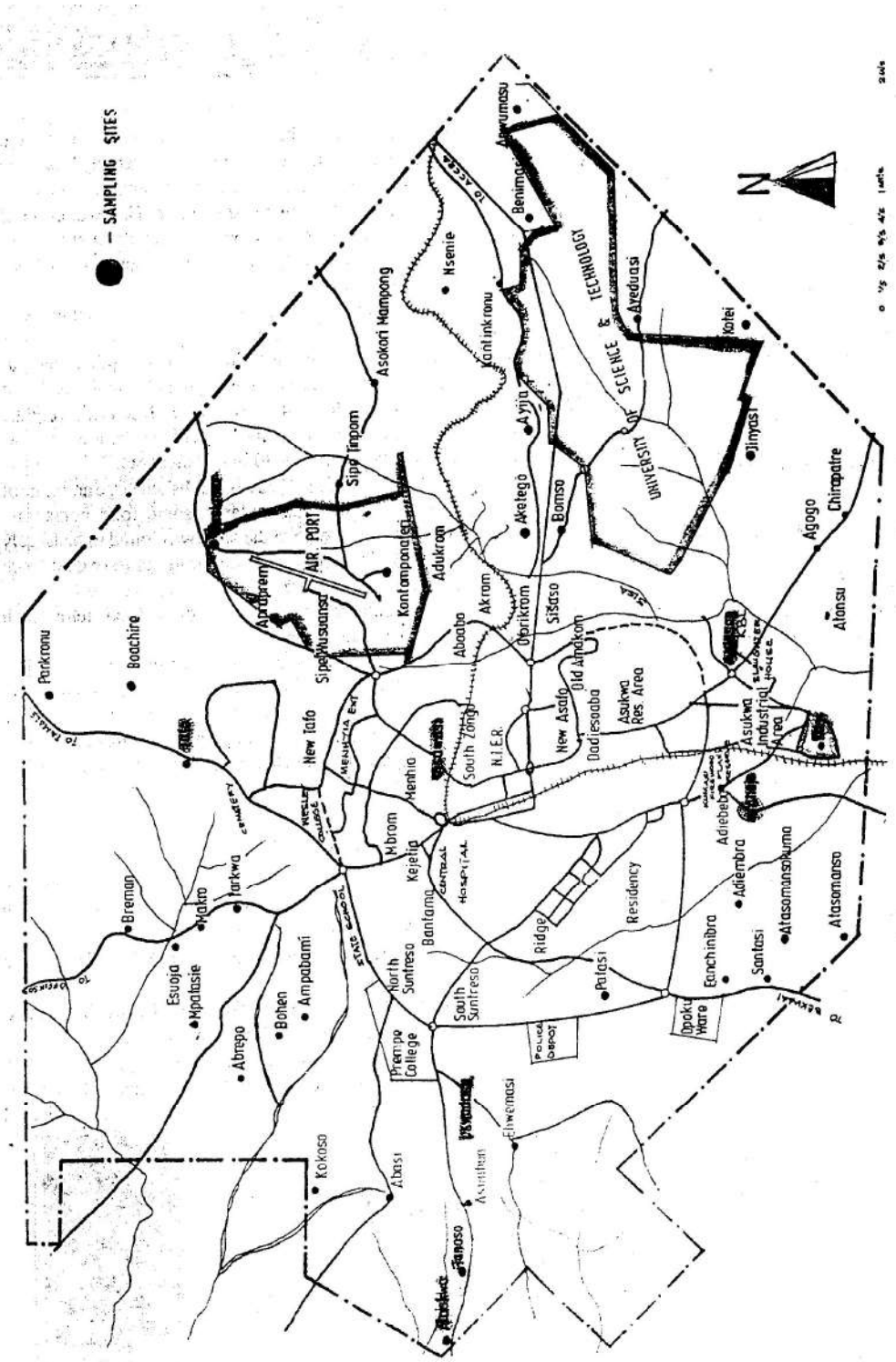


Fig.1: Map of Kumasi indicating Sampling Sites of Environmental Monitoring

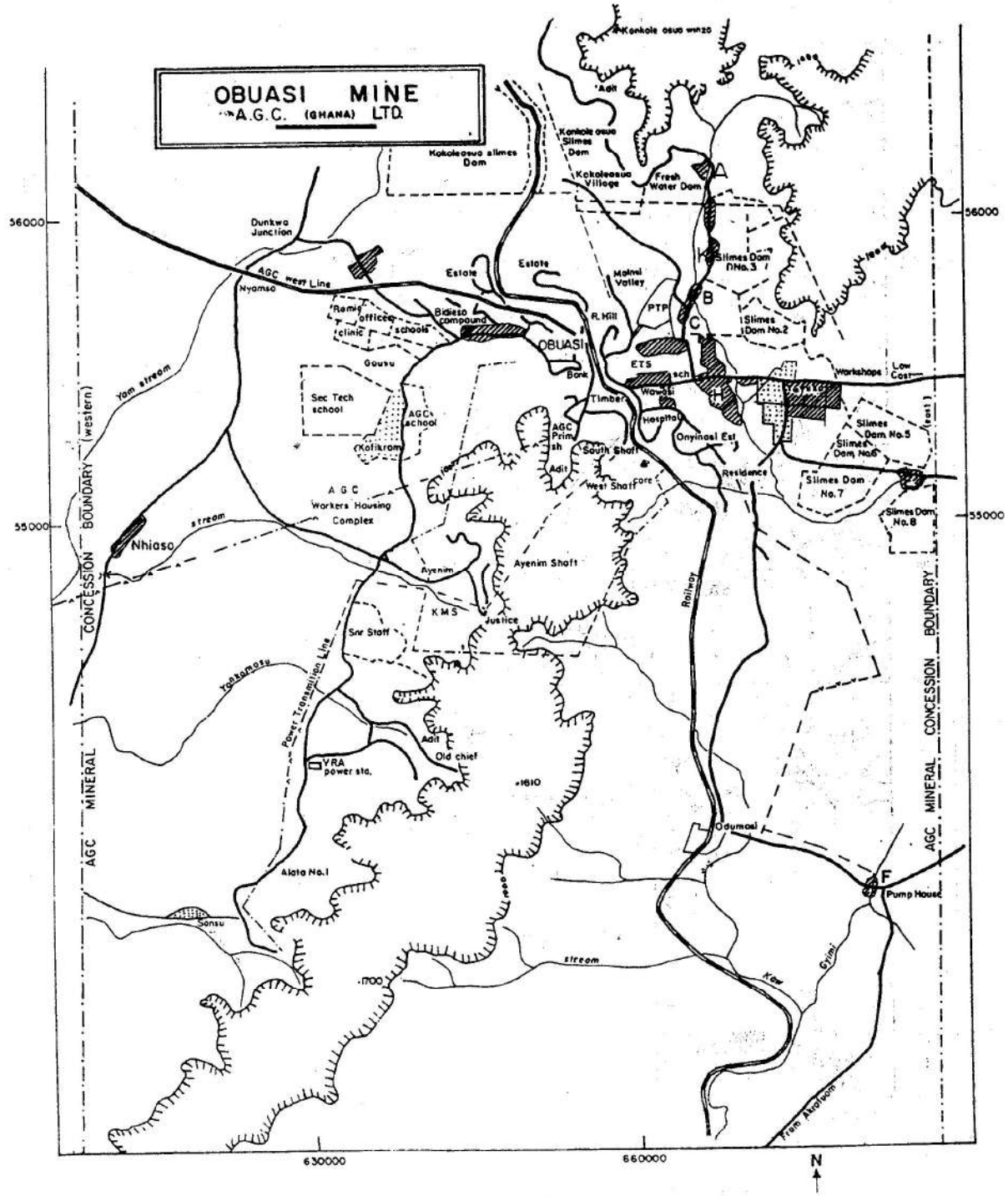


Fig. 2: Map of Obuasi Gold Mine showing Sampling Sites

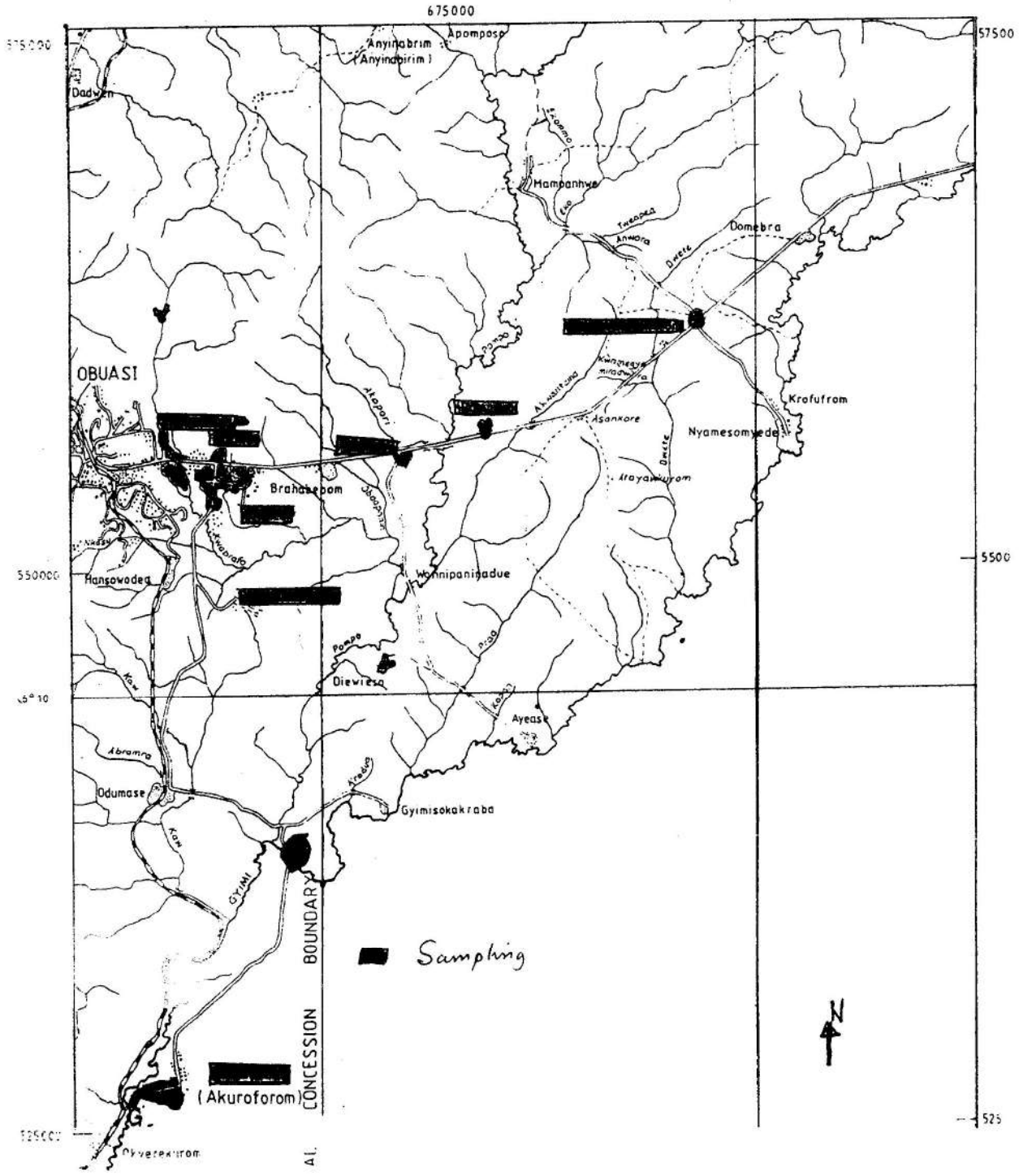


Fig. 3: AGC (Ghana) Ltd.,Gyimi-Pompo River Catchment Area

from sites where waters were utilized domestically. All reagents were of analar grade. Food and Cash crops, vegetation, and soil samples were air dried for about three weeks. Cooked food, fish, and meat were cut into small pieces and oven dried at 50° C for at least 7 days. The dried samples were then ground and screened to pass 2mm openings. Arsenic content of all the samples was determined by Atomic Absorption Spectrophotometry. All determinations were conducted in triplicate.

RESULTS AND DISCUSSION

Arsenic content of food crops in Kumasi, Tables 1 and 2, where arsenic is not directly let out into the atmosphere as a result of industrial activity, ranged from 0.07 (Farm orange) to 0.97 (Market peppper) mg/kg wet weight. The total arsenic in Obuasi food crops, Tables 3 and 4 ranged from 0.14 (Farm cocoyam leaves) to 1.86 (Farm plantain) mg/kg wet weight. Arsenic content was highest in plantain with a mean value of 1.13 mg/kg wet weight and a standard deviation of 0.13. This may be accounted for by the fact that plantain has a high iron content and high sorption of arsenate ions by iron is a well known phenomenon. Amasa [4] for; orange from Obuasi, 2.29 ppm dry weight, is lower than our 2.94 to 4.10 mg/kg dry weight; cassava from Obuasi market, 2.65 ppm dry weight, is higher than ours from the market, 1.28 mg/kg dry weight; cassava from Obuasi farm, 1.83 ppm dry weight, lies within our range of the same farm produce of 1.45 to 3.50 with a mean value of 2.55 mg/kg

Table 1: Total arsenic in samples from Kumasi market, values throughout the paper are in mg/kg wet weight except those in parenthesis which indicate dry weight

Cassava	Cassava peel	Plantain	Plantain peel	Cocoyam	Pepper	Orange
0.70(1.85)	0.26(0.96)	0.51(1.54)	0.28(1.32)	0.47(1.08)	0.10(0.65)	0.97(2.22)
Beans	Pear	Fish	Meat	Tobacco	Oil palm fruit	
0.54(3.70)	0.20(1.02)	(3.30)	(2.59)	(2.40)	(4.53)	

Table 2: Total arsenic concentration in some food crops from Kumasi farms

Sample	Number of samples	Range	Mean	Standard Deviation	Relative standard deviation (%)
Cassava	9	0.28–0.47(0.73–1.25)	0.38(1.03)	0.07(0.19)	17.89(18.35)
Cassava peel	-do-	0.15–0.31(0.56–1.16)	0.23(0.86)	0.10(0.21)	41.74(24.53)
Plantain	-do-	0.28–0.48(0.84–1.45)	0.36(1.10)	0.08(0.25)	23.33(22.64)
Plantain peel	-do-	0.14–0.27(0.66–1.25)	0.18(0.85)	0.04(0.19)	22.78(22.35)
Cocoyam	8	0.35–0.54(0.81–1.24)	0.42(0.97)	0.07(0.16)	16.43(16.29)
Cocoyam leaves	-do-	0.10–0.14(0.60–0.87)	0.12(0.73)	0.02(0.09)	12.50(12.33)
Pepper	5	0.22–0.32(0.50–0.72)	0.26(0.58)	0.04(0.08)	14.31(14.31)
Orange	6	0.07–0.23(0.46–1.43)	0.13(0.85)	0.07(0.40)	50.00(47.06)
Beans	5	0.18–0.30(0.36–0.60)	0.26(0.52)	0.07(0.10)	26.92(19.62)
Pear	7	0.11–0.19(0.59–0.97)	0.15(0.76)	0.03(0.14)	18.67(18.29)

Table 3: Total arsenic concentration in samples from Obuasi market

Cassava	Cassava peel	Plantain	Plantain peel	Cocoyam	Cocoyam leaves	Pepper	Orange	Beans
0.71(1.88)	0.34(1.28)	0.90(2.71)	0.43(2.02)	0.69(3.26)	0.69(2.26)	0.35(3.09)	0.47(3.73)	0.59(1.81)
Pear	Fish	Meat	Tobacco	Oil palm fruit				
0.41(2.14)	(2.60)	(3.48)	(2.34)	(4.37)				

Table 4: Total arsenic concentration in some food crops from Obuasi farms

Sample	Number of samples	Range	Mean	Standard Deviation	Relative standard deviation (%)
Cassava	9	0.55-1.32 (1.45-3.50)	0.96 (2.55)	0.26 (0.70)	27.29 (27.53)
Cassava peel	-do-	0.29-0.90 (1.10-3.40)	0.59 (2.22)	0.19 (0.81)	32.88 (36.49)
Plantain	12	0.67-18.6 (2.02-5.65)	1.13 (3.43)	0.34 (1.07)	29.73 (31.20)
Plantain peel	-do-	0.23-0.92 (1.09-4.34)	0.53 (2.47)	0.20 (0.94)	37.17 (37.85)
Cocoyam	8	0.52-1.51 (1.20-3.50)	0.98 (2.26)	0.40 (0.92)	40.51 (40.08)
Cocoyam leaveas	-do-	0.14-0.47 (0.89-2.94)	0.30 (1.86)	0.13 (0.85)	44.66 (45.91)
Pepper	-do-	0.19-0.97 (1.97-4.50)	0.67 (2.96)	0.28 (0.91)	42.39 (30.74)
Orange	7	0.46-0.65 (2.94-4.10)	0.55 (3.46)	0.06 (0.45)	11.09 (13.01)
Beans	5	0.38-0.67 (0.76-1.34)	0.49 (0.99)	0.13 (0.22)	25.51 (22.12)
Pear	6	0.18-0.47 (0.93-2.43)	0.31 (1.59)	0.11 (0.62)	36.77 (38.74)

dry weight and a standard deviation of 0.70. The same author gives 4.80 ppm as the arsenic content of cocoyam leaves whilst we arrive at lower values ranging from 0.89 to 2.94 with a mean value of 1.86 mg/kg dry weight and a standard deviation of 0.85. Cited value [4] for; cocoyam, 150 yard from the mine, of 1.89 ppm dry weight lies within our range of 1.20 to 3.50 with a mean of 2.26 mg/kg dry weight and a standard deviation of 0.92; plantain from the market, 0.615 ppm lies well below the range of 2.02 to 5.65 with a mean of 3.43 mg/kg dry weight and a standard deviation of 1.07 obtained by us. Another source of literature values [5] for some of these food crops gives the normal arsenic content for cassava and pepper as 0.13 and 0.96 ppm respectively. This value for cassava is less than even the least value of 0.73 mg/kg dry weight obtained for a Kumasi farm. The cited result for pepper, however, is higher than the range obtained for Kumasi farms but lower than the 2.22 mg/kg dry weight obtained for pepper from Kumasi market.

Arsenic in cooked foods (Tables 5 and 6) were found to range between 1.26 and 3.24 mg/kg dry weight in uncontaminated Kumasi and 2.04 and 3.81 mg/kg dry weight in Obuasi. Arsenic levels in food, except seafoods have been found to be generally well below 1 mg/kg wet weight[6] however, concentra[illegible] of between 0.6 and 58 mg.kg d[illegible]eight have [illegible]und in some food supplements prepared from kelp [7] Edible seaweed, a common product in Japan, has been reported to contain arsenic levels ranging from 19 to as much as 172 mg/kg dry weight, with a mean concentration of 112 mg/kg [4]

Fish (Tilapia) from Kumasi market contained 3.30 mg/kg dry weight of arsenic, Table 1,whilst that from Obuasi market contained 2.60 mg/kg weight, Table 3. Meat (goat) from the same sources contained 2.59 and 3.48 mg/kg dry weight of arsenic respectively. Fish and fish products are known to contain the highest concentrations of arsenic in the animal kingdom. Concentrations in marine bottom feeding fish range between 2.5-4.9 mg/kg;crustaceans, 1.2 to 10.9 mg/kg; and non bottom feeding fish 0.2 to 4.9 mg/kg [9,10].

Tables 1, 3, 7 and 8 indicate that cash crops (tobacco, oil palm fruit and cocoa) in both Kumasi and Obuasi markets and farms are in the range; tobacco, 2.14 to oil palm fruit, 1.16 to 5.87; Cocoa, 2.23 to 2.46 mg/kg dry weight. It has been reported that the arsenic content of plants grown on soils that had never been treated with arsenic containing pesticides varied from 0.01 to about 5 mg/kg dry weight [11] One may therefore infer that food and cash crops, even those fr[illegible]he environs of Obuasi mines, are not grown on soil[illegible]ch are unduly contaminated with arsenic.

Table [illegible]otal arsenic concentration in cooked food from Kumasi

Sample location	Cooked cassava	Cooked plantain	[illegible]u
Asawasi	(1.94)	(2.86)	(1.53)
University of Science and Technology	(1.81)	(3.24)	(1.26)
Average	(1.91)	(3.03)	(1.40)

Table 6: Total arsenic concentration in some cooked food from Obuasi homes

Sample	Tutuka	Wawasi	Kwabrafofo	Average mean
Cooked Cassava	(2.65)	(2.53)	(2.84)	(2.67)
Cooked plantain	(3.14)	(3.81)	(3.21)	(3.39)
Fufu	(2.43)	(2.04)	(2.65)	(2.37)

Table 7: Total arsenic concentration in some cash crops from Kumasi farms.

Sample	Tanoso	Kwadaso	Tafo	Ayeduase	Kaase	Average
Tobacco	(2.14)	-	-	-	-	(2.14)
Oil palm fruit	(3.70)	(3.56)	(3.24)	-	-	(3.50)
Cocoa	-	-	-	(2.42)	(2.46)	(2.44)

Table 8: Total Arsenic Concentration in some Cash Crops from Obuasi Farms

Sample	Akaporiso	Bomposo	Kwabenaakwakrom	Kwameduokrom	Nantrin	Akrofruom	Nhicao	Average
Oil palm fruit	(4.63)	(2.24)	(1.16)	(2.10)	(5.87)	(3.44)	(1.75)	(3.03)

Concentration of arsenic in Cocoa at the Cocobod depot, Obuasi, was 2.23mg/kg dry weight

Table 9: Total arsenic concentration in some vegetation - Kumasi

Sample	U.S.T.	Airport	Ahinsan	Average
Star grass (Eleusine Incica)	(6.00)	(7.20)	(6.80)	(6.67)
Elephant grass(Panicum Maximum)	(4.40)	(5.54)	(4.60)	(4.85)

Table 10: Total arsenic concentration in vegetation, soil, and water from Obuasi asi.

Sample	Fern (Pteris Vitatae)	Palm leaves	Elephant grass	Star grass	Soil	Water/p.p.m.
A	(48.50)	(3.50)	-	(10.17)	(21.50)	4.40
B	(70.50)	(3.70)	-	(39.30)	(26.60)	10.40
C	(59.60)	(3.80)	-	(12.41)	(21.90)	5.60
D	-	-	-	(3.75)	(21.30)	4.70
E	-	-	-	(5.99)	(19.80)	4.90
F	-	-	-	(5.65)	(5.40)	2.80
G	-	-	(2.36)	(2.23)	(16.20)	3.50
H	-	-	(5.10)	-	-	-
I	-	-	(5.50)	-	-	-
J	(58.00)	(2.20)	-	-	-	-
K	(62.40)	(4.20)	-	-	-	-
AVE/MEAN	(59.80)	(3.48)	(4.32)	(11.36)	(19.39)	5.19

Arsenic content of vegetation around Kumasi and Obuasi are given in Tables 9 and 10 respectively. Elephant grass (Panicum Maximum) around Kumasi had values in the range of 4.40 to 5.54 whilst Star grass (Eleusine Indica) ranged between 6.00 and 7.20 mg/kg dry weight. The arsenic content of Elephant grass around Obuasi was in the range 2.36 to 5.50; and of Star grass, 2.23 to 39.30 mg/kg dry weight values for other vegetation in the environs of Obuasi were Palm leaves, 2.20 to 3.80; Fern (Pteris vitatae), 48.00 to 70.50 mg/kg dry weight. With the exception of Palm leaves, abnormally high values were obtained from site B, Fig.2, opposite Slime Dam number 3 and about 450 metres from the Pompora Treatment Plant (PTP). This site is the converging point of effluent from the ore treatment plant, water issuing from Slime Dams numbers 3 and 4, the Kwabrafo stream flowing from the polluted hills towards the north-east, and the fresh water dam overflow which originates from the polluted hills to the north of PTP. Arsenic from all these waters accumulates at site B contributing to increased arsenic concentrations available to vegetation, growing at the edge of the stream at this point. Sites A, B, C, J and K which invariably had high values of arsenic in their vegetation lie within 1 km radius towards north east of PTP which is the prevalent wind direction from the chimney and consequently receive a lot of dust fall from the flue gases. Fern contained arsenic concentrations which were far in excess of the other types of vegetation. This is in conformity with previous findings (4). The values correlated very well with wind direction and distance from ,the chimney, being much lower than recorded before (4) since the sites were much further away from the chimney.

Arsenic values determined for soil 5.40 - 29.60 with a mean value of 19.39 mg/kg; and water 2.80 - 10.40 with a mean value of 5,19 ppm; at the sampling sites of star grass are found in Table 10. These values correlated very well with arsenic content of vegetation found on the sites Arsenic content of soil and water at F were extremely low, 5.40 mg/kg and 2.80 ppm respectively, compared to the other values since F is too far away and to the South-East of the Chimney.

Uncontaminated soils were found to contain arsenic levels between 0.2 and 40 mg/kg while arsenic treated soils contained up to 550 mg/kg [12]. Also soil levels in excess of 200 to 300 mg/kg are necessary for plants to absorb sufficient arsenic to reach edible plant levels of 1 mg As per kilogram fresh weight. Water from B contained an abnormally high concentration of arsenic 10.40 ppm. attributable to reasons already stated. None of the waters sampled is fit for irrigation, livestock industry or for the Protection of aquatic life [13].

CONCLUSION

Arsenic content of samples analysed were generally higher for the environs of Obuasi than of Kumasi, Fig.4. Considering the wet weight concentration; cassava, cocoyam, and plantain from Obuasi contained arsenic ranging from above to well below the 1 mg/kg wet weight recorded [6] However, the dry weight concentrations were much lower than the highest [8] but higher than the lowest [7] of other recorded food items.

Fish and meat from Kumasi and Obuasi contained similar arsenic concentrations which were above the concentrations generally obtaining in non bottom-feeding fish, similar to those of bottom-feeding fish, and much lower about a third of the highest value obtained for crustaceans [9, 10]

Since the highest recorded value of arsenic in plants grown on soils which had never been contaminated with arsenic is 5 mg/kg dry weight [11], it may be inferred that both food and cash crops samples around Obuasi, are not grown on soils which are unduly contaminated with arsenic.Their arsenic content must therefore be due to other sources. Star grass and especially fern near to the Chimney and in the direction of the plume are very contaminated with arsenic and correlate very well with arsenic concentrations of corresponding soils agreeing with the evidence that such increased plant residues result from increased soil arsenic content [14]. Arsenic contents of the soils samples, albeit high, are not unsual even for uncontaminated soils and will not induce plants to absorb sufficient arsenic to reach edible plant levels of 1 mg/kg fresh weight [12, 15].

The waters investigated contain too much arsenic to be useful even for the Protection of aquatic life or agricultural purposes and are definitely unfit for drinking [13]

Fig 4a Comparison of mean As. Concentration

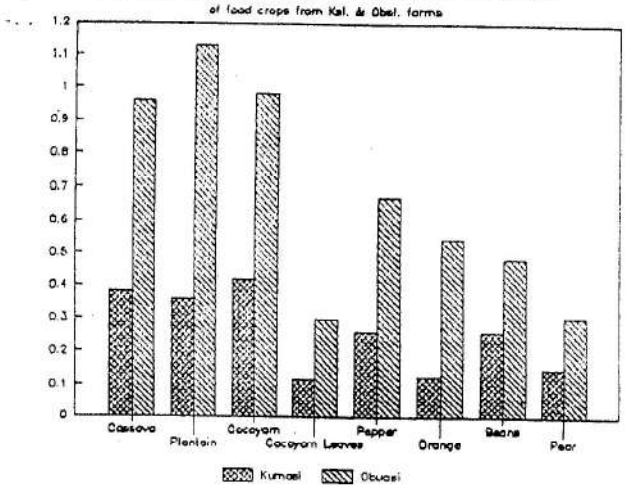
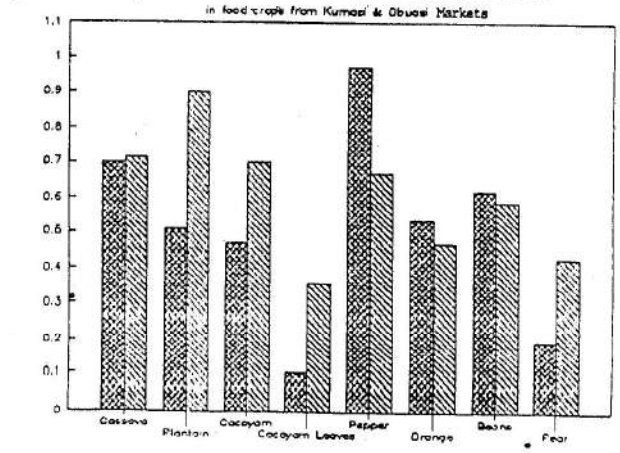


Fig. 4b. Comparison of mean As. Concentration



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