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Mercury in Surface Soil and Cassava Crop Near an Alluvial Goldmine at Dunkwa-on-Offin, Ghana

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Gold, precious metal, occurs in the soil in various regions of Ghana. Some of the metal occur as the metal in alluvial sand, others as oxides, pyrites and arsenopyrites. It was the metal in the alluvial sand washed down to the coast by rivers which gave the former name Gold Coast.

Those who engage in mining for gold include big companies like Ashanti Goldfields Corporation, Continental Goldfields, Obenema Goldfields, many other companies and small scale native gem winners in all the regions in the country. The only industrial concern which uses mercury in the extraction of gold by amalgamation is Continental Goldfields. All the small scale native miners employ mercury for the extraction of the metal. They evaporate off the mercury and have no good retorting facilities. They are also not aware of the dangers to which they are exposed. Mercury has high vapour pressure and vaporizes easily into the air. The mercury may condense and become attached to particulate matter in the atmosphere. The condensed mercury may fall back to earth in rainfall or some other process. The Ashanti Goldfields Corporation on the other hand uses zinc dust instead of mercury for the extraction of gold.

Mercury is toxic and has been responsible for a number of poisoning calamities in a number of countries (Klein et al 1970, Hammond 1970, Abelson 1970, Croome 1969, Goldwater 1971, Shakman 1974). Since mercury is used in Dunkwa-on-Offin area for extracting gold and is toxic to life processes, it will be of interest to measure how this metal is distributed in the environs of this alluvial goldmine and since air pollutants may not have a defined boundry its dispersal in the country is being studied. The report presented here is part of such studies.

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MATERIALS AND METHODS

Twenty-three farms located wihin the vicinity of Dunkwa-on-Offin in various directions, Fig 1, were selected. At each sampling site three subsites were located randomly. Soil samples were collected by removing the top litter first and a teflon-coated soil auger was used to collect the samples. The samples were collected at depths of 0-5, 5-15 and 15-30 cm to cover the plough zone. The samples were put into already well washed plastic containers and sealed. Nine soil samples were collected from each farm. The auger was washed with distilled water after sampling at each site to avoid cross contamination. Identification numbers and labels were made in each plastic container and conveyed into laboratory.

Cassava tubers were uprooted by first scaping off the top soil with a steel cutlass from three different plants selected randomly at each site. The tuber was cut off from the stem and the adherent soil removed and put into separate poly ethylene bags and sealed. Cassava leaves were clipped with the fingers from the plants at more than 1m above the ground. These were also put into separate poly ethylene bags and sealed. They were accurately labelled and conveyed to the laboratory.

In the laboratory the soil samples were freed of pieces of roots, leaves, pebbles and other foreign objects. They were next dried in an oven at 60°C to constant weight. The dried samples were ground and homogenized in a porcelain mortar, sieved with a 200µm mesh and made into composite samples. They were transfered into plastic containers with lids, labelled and stored at room temperature.

The fresh cassava tubers were each washed gently and rinsed with distilled water and peeled. The fresh peels were removed with stainless steel knife and separated into the periderm (outer skin) and cortex with the fingers. The flesh and the peels were chopped up into smaller pieces and dried at 60°C to constant weight.

The leaves were also chopped into smaller pieces and dried at 60°C to constant weight. These samples were then ground up and homogenized in a porcelain mortar and then sieved with 200 µm mesh, put into plastic containers, labelled and stored to await analysis. The periderm, cortex, fleshy core and leaves were separtely stored and analysed.

Mercury contents: Accurately weighed 1g of soil

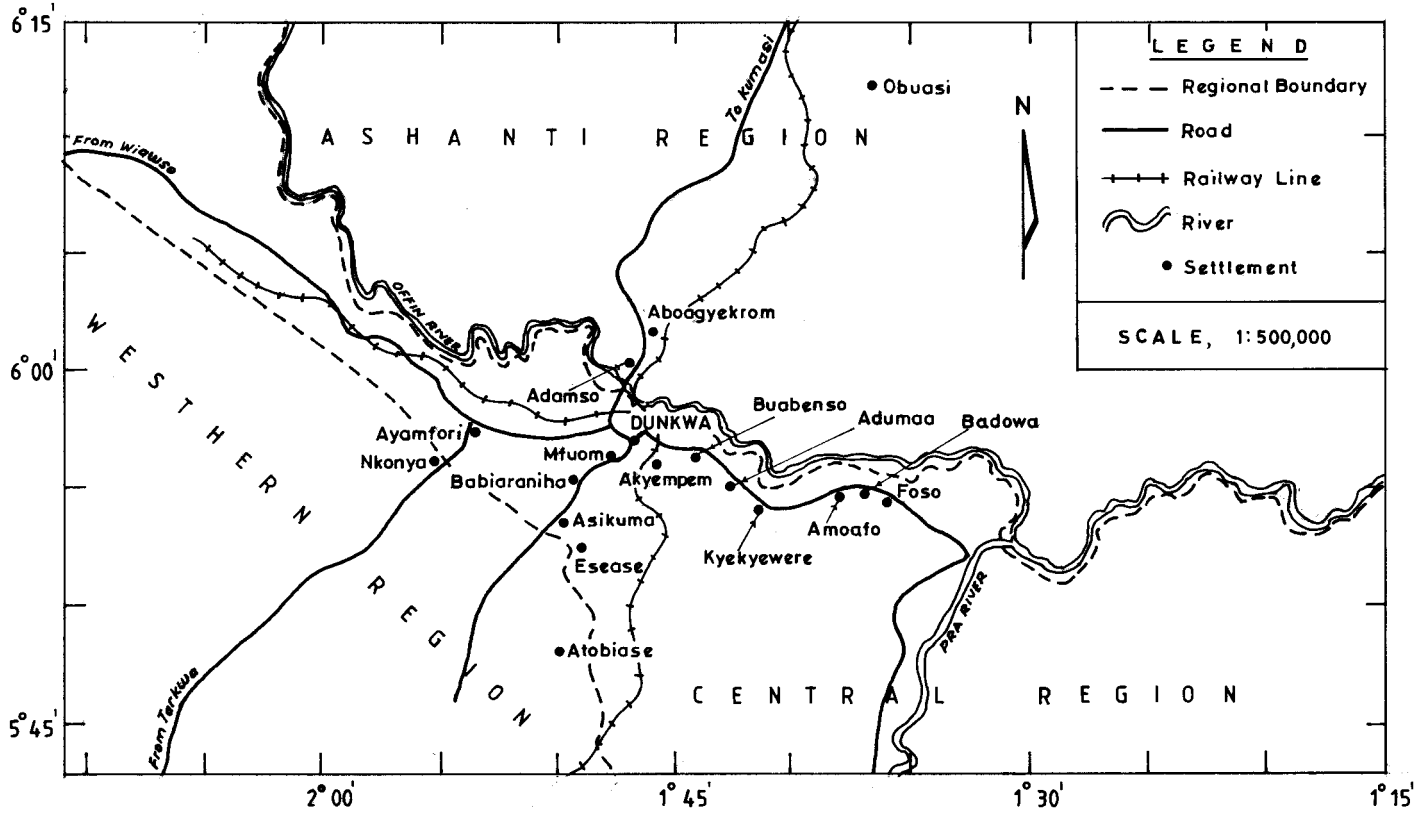

Figure 1: Map Showing Dunkwa and Some of it Surrounding Towns

sample was put into a 100 ml beaker, 5 ml of double distilled water and 5 ml aqua regia were added. Each was mixed thoroughly and placed in water bath for 2 minutes at 95°C. The beaker was removed and allowed to cool. Fifty milliliters of double distillled water were added followed by 15 ml of 5% potassium permanganate solution. It was mixed thoroughly and then placed in a water bath at 95°C for 30 minutes for complete oxidation of mercury in the soil sample. The sample was removed, allowed to cool to room temperature and 6 ml of 12% w/v hydroxylamine hydrochloride diluted to 1000 ml with distilled water was used to zero the Perkin-Elmer 5100 pC. equipped with mercury hollow cathode lamp. The soil digest, a carrier solution of 3% v/v, HCl and 1.1% w/v SnCl in 3% HCl were automatically sucked into a mixing chamber. The mercury was reduced to elemental state. The mercury atoms were aerated with argon gas in the cold vapour cell in the AAS and measured automatically. During the analysis blank solution was analysed intermitently after every 20 samples to zero the instrument. The cell was alligned in the path of the mercury hollow cathode lamp operating at 6 mA and monitored at the 257.7 nm resonance line. Analyses were done in triplicate by sucking 5 µl volume of the digest into the mixing chamber, aerating the elemental mercury into the path of the mercury lamp and the absorption measured by the instrument which was proportional to the mercury atoms in the path, hence the mercury concentration. The results were presented in µg/L and later converted µg/kg.

One gram of cassava tissue samples were accurately weighed into 100 ml beakers, 4 ml of concentrated H_2SO_4 and 1 ml of concentrated HNO_3 were added to each sample and then placed in water bath at 95°C for 30 minutes for the samples to dissolve completely. The samples were then cooled to 40°C in an ice bath and 15 ml of potassium permanganate and 8 ml of 5% w/v potassium persulphate solution were added. The samples were again returned to the water bath and digested for an additional 30 minutes at 95°C. The samples were removed, allowed to cool to room temperature and 6 ml hydroxylamine hydrochloride added to reduce the excess permanganate solution. The mixtures were filtered through a pre-washed filter paper into 50 ml graduated flask and made up to the mark with double distilled water. The filtered solutions were transferred into 50 ml sample bottles for analysis. As indicated earlier, blank solutions were analysed intermittently during the analysis to zero the instrument. Two drops of actan-2-ol were added

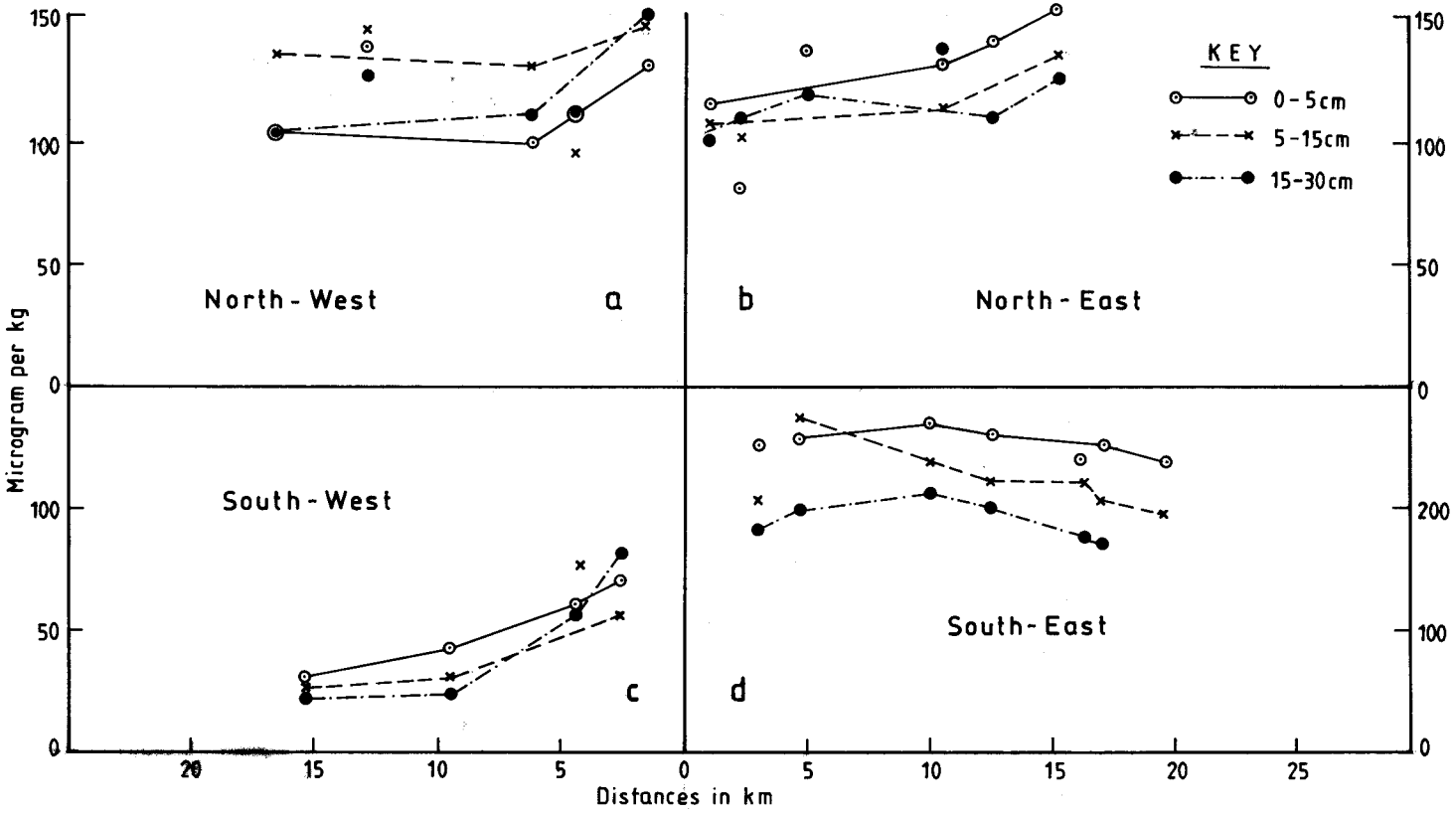

Figure 2: Levels of mercury in various zones of surface soil at various distances from Dunkwa-on-Offin

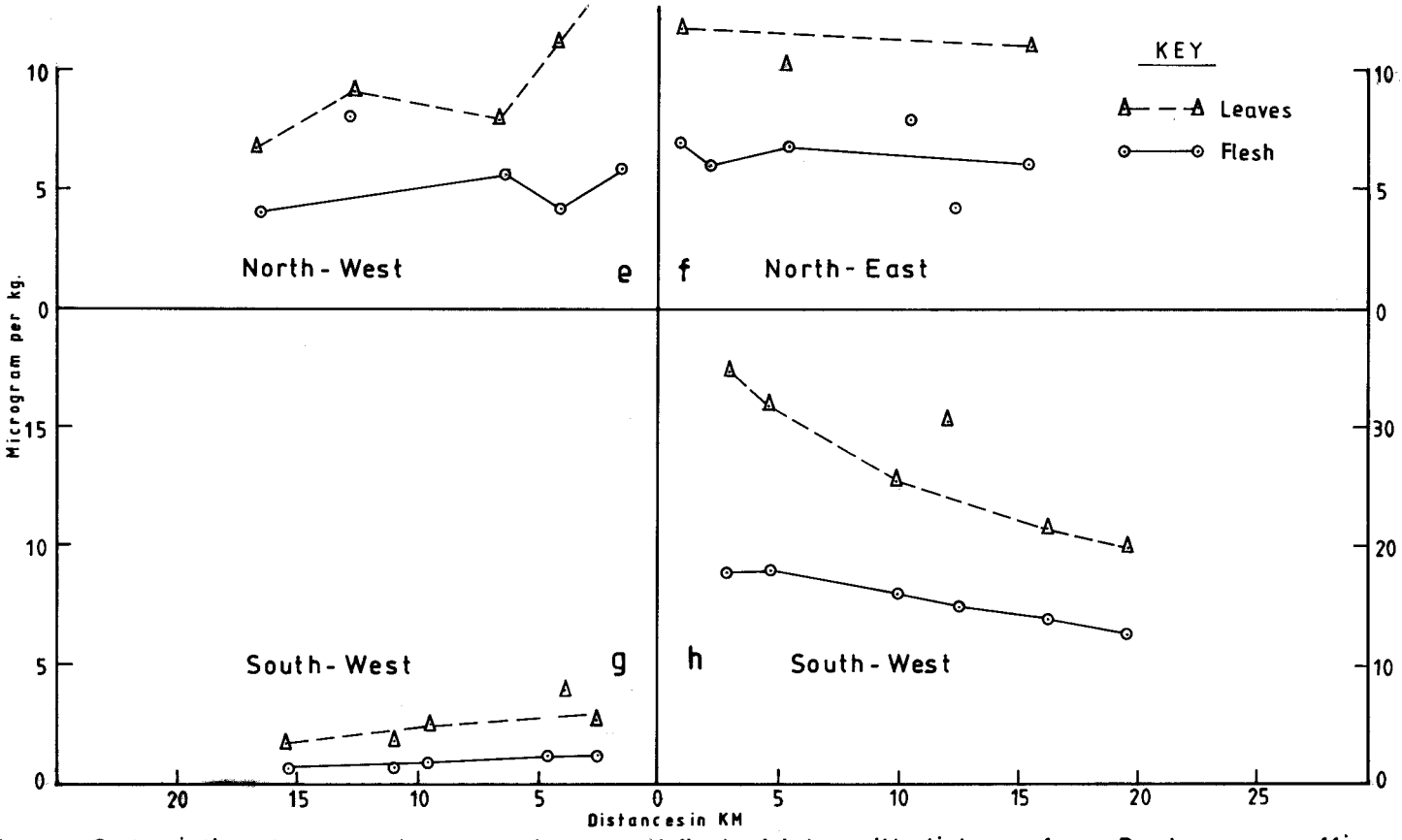

Figure 3: Variation of mercury in cassava leaves and flesh of tuber with distance from Dunkwa - on - offin

to each to prevent foaming and were analysed in the same manner as soil samples described above.

Recovery studies by standard addition method gave recoveries between 92 and 102% for mercury in soil for levels between 0.4 and 2 µg/kg and standard error of 0.01 and co-efficient of variation of 1,.5%. Recovery studies on tissues of cassava gave similar results.

RESULTS AND DISCUSSION

The levels of mercury in the surface soil with the exception of a few Fig 2a tended to decrease with depth from the surface to a depth of 30 cm, Fig 2b-d. This might be due to the fact that the source of mercury was due to precipitation from the air. Thus if not interfered with, the surface layers of the soil contained more mercury. The discrepancy shown by Fig 2a, might be due to the mercury being carried to deeper layers because of its weight to subsoil or that the temperature was high enough to cause most of the surface mercury to vaporize whilst the lower layer was cold enough to retain more of the mercury.

With the exception of Fig 2b, mercury level tended to decrease with distance from Dunkwa-on-Offin (Fig 2a, c-d). This indicates that the aerial source of mercury was Dunkwa-on-Offin where mercury was used in extracting gold industrially. The pattern shown by Fig 2b indicated that more mercury was brought from outside, probably, Obuasi which is in the North-Eastern direction of Dunkwa-on-Offin. The activities of small scale gold digging is most intense in Obuasi and its environs. At the time of the studies industrial extraction of gold with mercury was suspended and hence interference from outside might replace the usual pattern.

The mercury levels in the soil were higher than those recommended for contaminated soils, 0.5 - 50 ppb (McBride 1994). The surface soil in the environs of Dunkwa-on-Offin was contaminated with mercury and the South-Eastern portion was the most contaminated, Fig 2d.

The leaves of cassava had the highest levels of mercury, Fig 3. The leaves might have received aerial sources of mercury more than the soft fleshy portion which was buried under the surface of the soil. The decrease of the levels of mercury with distance from Dunkwa-on-Offin, Fig 3, shows that aerial source is

Dunkwa-on-Offin where it was used for extraction of gold. Thus anybody who uses cassava leaves for preparing soup and stew is more likely to accumulate more mercury and could be easily poisoned with this metal when the toxicity limit is exceeded.

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