1.9 Growing Health Hazard from Toxic Metals in the African Environment

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Introduction

Any concern for environmental quality is subservient to job creation and the provision of food and shelter in most African communities. By necessity, most of the limited medical resources are devoted to preventive primary health care aimed at combating high rates of infant and maternal mortality, endemic communicable diseases and malnutrition. Environmental health is generally associated with affluence and misguided industrial operations in the developed countries and as such is believed to be a non-issue in Africa. In a recent review paper, I have shown that the ambient concentrations of trace metals and metalloids in some environmental compartments of Africa are comparable to, and often exceed, the levels being found in the developed countries (1). As the metal contamination continues to rise sharply, environmental metal poisoning will likely become another major public health burden on the African population.

Contamination of the African Environment with Toxic Metals

Practically every metal known to mankind is being discharged in one form or the other somewhere in Africa. The continent is richly endowed with mineral resources (Table 1), the mining and smelting of which have become the principle anthropogenic sources of toxic metals. To derive foreign currency, the metal deposits are exploited for short-term economic benefits with little regard for long-term environmental consequences. Regulations on emissions are lax and rarely enforced and the pollution control devices are often not repaired or replaced when they break down. With few exceptions, the mining and smelting centres of Africa are marked by severe environmental contamination with toxic metals and serious impairments of health in non-occupationally exposed people have been reported (1).

In addition to mining and smelting of ore minerals, other important sources of metal pollution include (a) transportation vehicles especially automobiles; (b) fossil fuel combustion to generate energy; (c) burning of fuel wood, agricultural waste and forest/savanna biomass; (d) litter which seems to be everywhere in the urban areas; (e) fertilisers with high Cd content; (f) municipal and industrial sewage and wastewaters; (g) manure derived from household wastes; (h) the spray of metallic fungicides and mulluscicides (see Nriagu, 1991 for details). With emissions from so many sources, the concentrations of trace metals in many ecosystems of the continent have reached unprecedented levels.

Table 1. Mineral Resources of the African Countries

Country	Mineral Resource
Algeria	Lead, zinc, mercury, iron ore, uranium, oil
Angola	Gold, iron ore, oil
Botswana	Copper, nickel, coal
Burkina Faso	Manganese, gold, copper, bauxite, uranium
Burundi	Nickel, gold, copper, platinum
Ethiopia	Gold, platinum, copper
Gabon	Manganese, iron ore, uranium
Ghana	Gold, bauxite, manganese
Guinea	Gold, bauxite, iron ore
Madagascar	Manganese
Mali	Bauxite, iron ore, gold, manganese
Mauritania	Copper, iron ore
Morocco	Lead, manganese, phosphate
Namibia	Copper, lead, zinc, uranium
Nigeria	Tin, columbite, iron ore, coal, oil
Rwanda	Tin
Somalia	Uranium
South Africa	Gold, platinium, coal, iron ore, chromium, manganese
Sudan	Copper, chromium, industrial metals
Tunisia	Lead, zinc, iron ore, oil, phosphate
Uganda	Copper, cobalt
Zaire	Copper, cobalt, zinc, manganese, tin, gold, silver, bauxite, coal, oil
Zambia	Copper, zinc, lead, cobalt, coal
Zimbabwe	Gold, copper, chromium, nickel, tin

The airborne concentrations of Pb in the congested central districts of Cairo average 4.9 $\mu g\ m^{-3}$ in summer and about 3.0 $\mu g\ m^{-3}$ year round (2); these ambient values exceed the 1.5 $\mu g\ m^{-3}$ threshold recommended for the protection of public health (3). From the monthly average dust concentrations at street level in Ibadan (Nigeria) reported to be 48-76 mg m^{-3} (4), the airborne Pb concentrations are estimated to be well over 4.5 $\mu g\ m^{-3}$ The high atmospheric Pb levels in Cairo, Ibadan, Lagos and many other cities of Africa can be attributed to traffic congestion, high dust loads in the air, narrow streets, arrested air flows, lack of rainfall and helter-skelter development and siting of industries.

Studies using biomonitors such as mosses, lichens and tree barks generally find levels of trace metal pollution in urban areas of Africa that are similar to those in cities of the developed countries (5-8). The reported high flux of Pb into the Gulf of Guinea of over 1000 $\mu g\ m^{-2} yr^{-1}$ (9) provides a dramatic illustration of the high intensity of Pb emissions from natural and anthropogenic sources in West Africa. Indeed, elevated levels of Pb in roadside ecosystems have been documented in many rural and urban areas of Africa (1). The Pb contents of roadside dusts exceed 7000 $\mu g\ g^{-1}$ and average 770-1820 $\mu g\ g^{-1}$ in many parts of the city of Lagos, Nigeria (10). In Nairobi, Kenya, the soil Pb concentrations exceed 4000 $\mu g\ g^{-1}$ in the industrial areas and 2000 $\mu g\ g^{-1}$ in the city centre (11). The traffic density may be lower but the African cities are much more dusty, dirty and congested, resulting in the accelerated build-up of lead in urban ecosystems.

The high concentrations of trace metals that may have been reported in surface waters of Africa are most likely due to sample contamination. The sediments however provide strong evidence of toxic metal pollution in many aquatic ecosystems. The trace metal concentrations in the River Niger delta sediments (12) are often much higher than the values observed upstream (13). The Hg, Zn and Pb concentrations in Ebrie Lagoon sediments, Ivory Coast, reach values which are 30-, 6- and 20-fold higher than those of uncontaminated sediments in the same region (14). The Cd, Cu, Ni, Pb and Zn contents of Lagos Lagoon sediments of 6.2, 7.5, 113, 178 and 46 $\mu g\ g^{-1}$ (15) are several times higher than those of uncontaminated sediments in the country. Downstream from Cairo, the Cd, Cu, Cr, Zn and Pb concentrations in finegrained (<2μm) sediments of River Nile have been shown to be 18, 13, 8, 8 and 5 times higher than those in sediments upstream of the city (16).

The synoptic review above points to the fact that African ecosystems are far from being free of toxic metal pollution. In fact, the levels of pollution in the cities are comparable to, and sometimes exceed, those of urban areas of developed nations. Marked increases in the release of toxic metals into the environment can be expected in future. The exploding population in the continent will entail larger demand for metallic goods and products. The rapid and unplanned urban growth will be accompanied by increased traffic, energy consumption, and industries in undesirable locations. With limited financial resources, pollution-prone cottage industries are encouraged while lax or ineffectual environmental controls entice the multinational companies to locate their polluting industries in these countries. The expected net result will likely be a sharp rise in the flow of toxic metals into the African environment.

Human Exposure

The exposure of African populations to increasing levels of pollutant metals in their environment represents a hitherto unrecognised health hazard. The narrow streets and overcrowding in urban areas, the helter-skelter location of pollution-prone industries, the open type of home designs, the vibrant outdoor lifestyle, the endemic dusty environment, the prevalence of contaminated dusts, both indoor and outdoor, poor nutrition and health, poor hygienic practices and the preponderance of children and pregnant women (the two groups at most risk) can combine to increase the level of exposure and susceptibility to lead and other metal poisoning. In addition to living conditions and lifestyle, cultural practices can also influence the exposure to toxic metals in terms of religious beliefs, medical treatment, food habits and beauty practices. Heavy metals for instance are featured in the *materia medica* of traditional African medicine. Preparations of lead sulfide in various organic bases are used in most parts of the continent as an eye salve or cosmetic under such names as kohl, tiro, tanjere, etc. (17). Elevated blood lead levels and even chronic lead poisoning have been associated with such an exposure route. Even some of the medicinal plants are known to be bioaccumulators of toxic metals (18).

One of the important sources of environmental mercury pollution in Africa is the widespread use of medicated soaps and skin-bleaching creams and potions that typically contain 5-15% of an amino mercuric halide as the active ingredient (1). These products have also been implicated as a major cause of nephrotic syndrome among the sophisticated young African women. One study at the Kenyatta National Hospital, Nairobi found that about 70% of student nurses used the mercurial skin toner and that the levels of Hg in urine and several tissues were correlated with the use of these products (Table 2). Since the absorption of Hg through intact skin is very slow, most of the Hg is probably transferred into the body by food handling and hand to mouth activity. Since personal hygiene is often limited by the scarcity of water, food handling and hand to mouth activity (and a lot of people eat with their fingers) must be regarded as a particularly important route of exposure for many contaminants. Other notable adventitious routes of metal exposure in African communities include earthenware vessels improperly glazed in primitive potteries and the ubiquitous cottage industries which sometimes result in severe contamination of the home environment.

Contaminated dusts and soils represent a major source of lead exposure in African children, especially in crowed urban areas. Soil Pb intake by infants (1-4 years old) has been estimated to be 0.5-7.5 µg per kg body weight per day (1). When the daily intakes from air inhalation (0.02-1.0 µg Pb kg^{-1} body weight) and foods (0.3-1.8 µg Pb kg^{-1} are also taken into account, it is clear that many children in African cites are being exposed to Pb levels that may exceed the WHO recommended Pb intake tolerance of 7µg kg^{-1} day^{-1} from all sources (21). In fact, it has been suggested that 10-30% of the children in some urban areas of Africa may already be suffering from lead poisoning (1). Chronic lead poisoning which induces depression, behavioral and neurological disorders in children, hypertension in adult males and negative pregnancy outcomes in females, remains one of the unrecognised public health issues in contemporary Africa.

Table 2. Effects of Skin Bleaching Creams on Mercury Levels in Urine and Body Tissues*

Tissue or body fluid	Group A	Group B	Group C
Urine	109 μg/l	6 μg/l	2 μg/l
Scalp hair	2108 μg/g	137 μg/g	11 μg/g
Pubic hair	335 μg/g	25 μg/g	18 μg/g
Fingernails	165 μg/g	62 μg/g	9.7 μg/g

* Group A subjects were using mercurial skin bleaching creams at the time of the study; Group B subjects had used such creams but had stopped using them at the time of the study; Group C subjects had never used any mercury-containing skin toners. Urine samples were from healthy female nurses while the tissue samples were obtained from patients with nephrotic syndrome (19, 20).

The Pb concentrations in body fluids and tissues point to a silent epidemic of environmental lead poisoning in Africa. The blood lead (Pb-B) concentrations in urban and rural residents of Egypt of 170-360 and 140-250 μg l^{-1} respectively (22) suggest that a large number of people have Pb-B above the CDC recommended medical intervention threshold value of 250 μg l^{-1}. The Pb content in hair of adult males in Khartoum, Sudan have been showed to be significantly higher than those of Britons, Germans and Saudi Arabians (23). A recent study of trace metal concentrations in human milk from six countries found the highest values for As, Cd, Cr and Hg in Nigeria or Zaire (24). Unfortunately, few systematic studies of the Pb-B distribution in African children has actually been reported. It is hoped that the present report on a silent epidemic of childhood lead poisoning will stimulate such an overdue investigation.

References

1. Nriagu J O, 1992. Toxic Metal Pollution in Africa. *Sci. Total Environ.*, 121: 1-37.

2. Ali E A, Narsalla M M and Shakour A A, 1986. Spatial and Seasonal Variation of Lead in Cairo Atmosphere. *Environ. Pollut. (Series B),* 11: 205-210.

3. NAS, 1980. Lead in the Human Environment. Environmental Studies Board, National Academy of Sciences, Washington, DC.

4. Oluwande P A, 1977. Automobile Traffic and Air Pollution in a Developing Country. *Intern. J. Environ. Studies,* 11: 197-203.

5. Nyangababo, J T, 1987. Lichens as Monitors of Aerial Heavy Metal Pollution in and Around Kampala. *Bull. Environ. Contam. Toxicol.*, 38: 91-95.

6. Osibanjo P and Ajayi S O, 1980. Trace Metal Levels in Tree Barks as Indicators of Atmospheric Pollution. *Environ. Intern.*, 4: 239-244.

7. Fatoki, O S and Ayodele E T, 1991. Zinc and Copper Levels in Tree Barks as Indicators of Environmental Pollution. *Environ. Intern.,* 17: 455-460.

8. Glooschenko W A, 1986. Monitoring the Atmospheric Deposition of Metals by Use of Bog Vegetation and Peat Profiles. *Adv. Environ. Sci. Technol.*, 17: 507-533.

9. WMO, 1989. The Atmospheric Inputs of Trace Species to the World Ocean. Report and Studies No. 38, Joint Group of Experts on the Scientific Aspects of Marine Pollution. World Meteorological Organisation, Geneva.

10. Ajayi A and Kamson O F, 1983. Determination of Lead in Roadside Dust in Lagos City by Atomic Absorption Spectrophotometry. *Environ. Intern.,* 9: 397-400.

11. Onyari J M, Wandiga S O, Njenga, G K and Nyatebe J O, 1991. Lead Contamination in Street Soils of Nairobi City and Mombasa Island, Kenya. *Bull. Environ. Contam. Toxicol., 46: 782-789.*

12. Ndiokwere C L, 1984. An Investigation of the Heavy Metal Contents of Sediments and Algae from the River Niger and Nigerian Atlantic Coast Waters. *Environ. Pollut. (Series B),* 7: 247-254.

13. Nriagu J O, 1986. Chemistry of River Niger, I. Major Ions; II. Trace Metals. *Sci. Total Environ.*, 58: 81-92.

14. Kouadio I and Trefry J H, 1987. Sediment Trace Metal Contamination in the Ivory Coast, West Africa. *Water, Air and Soil Pollut.*, 32: 145-154.

15. Okoye B C O, Afolabi, O A and Ajao E A, 1991. Heavy Metals in the Lagos Lagoon Sediments. *Intern. J. Environ. Studies,* 37: 35-41.

16. Elsokkary I M and Muller G, 1989. Geochemical Association of Heavy Metals in Sediments of the Nile River, Egypt. Proceedings, International Conference on Heavy Metals in the Environment, Geneva, Vol 1, pp 134-139.

17. Healy M A, Aslam M and Bamgboye O A, 1984. Traditional Medicines and Lead-Containing Preparations in Nigeria. *Publ. Health, London*, 98: 26-32.

18. Ndiokwere C L, 1984. The Determination of Constituent Elements in Some Nigerian Medicinal Plants by Thermal-Neutron Activation Analysis. *J. Radioanal. Nucl. Chem. Letters,* 85: 325-338.

19. Barr R D, Woodger B A and Rees P H , 1973. Levels of Mercury in Urine Correlated with the Use of Skin Lightening Creams. *Am. J. Clin. Path.,* 59: 36-40.

20. Barr R D, Smith H and Cameron H M , 1973. Tissue Mercury Levels in the Mercury-Induced Nephrotic Syndrome. *Am. J. Clin. Path.,* 59: 515-517.

21. WHO, 1977. Environmental Health Criteria, 3: Lead. World Health Organisation, Geneva.

22. Kamal A A M, Eldamaty S E and Faris R, 1991. Blood Lead Level of Cairo Traffic Policemen. *Sci. Total Environ.*, 105: 165-170.

23. Ahmed A F M and Elmubarak A H, 1990. Lead and Cadmium in Human Hair: A Comparison Among Four Countries. *Bull. Environ. Contam. Toxicol.*, 45: 139-148.

24. Paar R M, De Maeyer E M, Iyengar V G, Byrne A R, Kirkbright G F, Schoch G, Niinisto L, Pineda O, Vis H L, Hofvander Y and Omolulu A, 1991. Minor and Trace Elements in Human Milk From Guatamala, Hungary, Nigeria, Phillipines, Sweden and Zaire. Biol. *Trace Element Res.*, 29: 51-75.

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