Environmental Lead Levels in African Cities

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Introduction

Lead is a common industrial metal that has become widespread in air, water, soil, and food. It is a naturally occurring element that has been used almost since the beginning of civilization. As a result of the many industrial activities that have brought about its wide distribution, lead is ubiquitous in the environment today. Wallace and Cooper (1986) have compiled a list of 120 occupations (e.g., auto-mechanic, painting, printing, and welding) that may involve exposure to lead. All humans have lead in their bodies primarily as a result of exposure to man-made sources (ATSDR, 1992). Studies have shown that the body lead levels of modern humans are about 500 times higher than those of pre-industrial times. Organic lead compounds (Tetraethyl lead and Tetra methyl lead) are extensively used as additives in petrol. It has been pointed out that Africa's contribution to global lead pollution has increased from just 5% in 1980s to 20% in 1996 (Nriagu, 1978, 1979, 1989, Anon, 1996). Some of the lead in the ambient air around urban centers is in the form of sub-micron sized particulate.

More than two-thirds of the Nations in Africa have maximum lead levels above the world median value. In Egypt progressive industrial activity has resulted in increased environmental pollution and attendant health problems. South Africa, however, has introduced unleaded petrol in 1996. In Nigeria, the levels of lead in petrol are estimated at 0.7g/litre. The national consumption of petrol in the country is estimated at 20 million litres per day with about 150 people per car. It is therefore predicted that at least 15,000 Kg of lead is emitted into the environment through burning (Agbo, 1997). For children, the most important pathways of lead exposure are ingestion of chips from lead-painted surfaces, inhalation of lead from automobile emissions, food from lead soldered, plumbing, and medications in the form of folk remedies. Most people in nigeria are ignorant of lead and its toxicity. The main source of adult human exposure is food, which is believed to account for over 60% of blood levels; air inhalation accounts for approximately 30% and water of 10% (John et al, 1991). This paper presents the present status of lead levels in the environment in Nigeria in particular and other African countries in general.

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Lead in Foods and Vegetation

Several studies indicated that plants have the ability to concentrate lead (Sridhar, 1988). Leaf and root contain more lead than stem, and the contents of lead in different plant organs were positively correlated to the lead content in soils. Commonly the Pb does not concentrate in the edible fruited part of the plant . Urban trees also concentrate lead. In a study carried out by Ademoroti (1986) on Levels of Heavy Metals on Bark and fruits of trees in Benin city, Nigeria. Levels of lead deposits in all cases were found to vary according to traffic volume; high levels (58.3-143.5(g/g) were recorded for areas of very high traffic volume and low levels (15.2-15.8(g/g) for areas of low traffic volume. Ketiku and Adeyinka (1999) reported that imported glazed ceramics (drinking mugs, soup bowls, and cooking pots) in Nigeria released lead up to 0.4 ppm as compared to those manufactured locally which leached only up to 0.1 ppm. Okoye (1994) reported high lead levels in dried fish from Nigerian markets. A study carried out by Sridhar and his associates revealed that the lead levels in food varied among the communities whether they are living in high, medium or low density areas. The levels are (mg/Kg): smoked fish 0 to 9.7, 'Gari' a popular native cassava dish, 0 to 8.6, dried meat, 0 to 15.1, Suya (a meat preparation), 6.5, and ;Elubo' (a local preparation), 0 to 12.5. The foods sold in high density areas contained higher levels.

Yet, in another study by Sridhar and Ifeanyi (1998 unpublished data), lead levels were measured in Lagos metropolis. A total of 72 various prepared ready to eat food samples were collected and analyzed for lead from the high (29), medium (18) and low (25) density areas. Varying ranges of results were obtained for all the three areas but high values were recorded for mixed food varieties consumed locally, like soup, 'Jollof' Rice and 'Gari', and Eba (Cassava based) and 'Amala' (Yam based).

Lead in Air

Automobile exhausts are believed to account for more than 80% of the air pollution in some urban centres in Nigeria. The level of lead in Nigeria's super grade gasoline is 600-800mg per litre (Onianwa, 1985; Osibanjo and Ajayi, 1989, Shy, 1990) which is much higher than permissible levels in some pollution conscious countries. In a 1975-76 survey of the level of some automobile related pollutants (excluding lead) in the atmosphere within the urban city of Ibadan, Oluwande (1979) found that the levels of sulphur dioxide, carbon-monoxide and particulate matter were close to the WHO long-term limits. In that study the levels of lead were not measured. But now data are available which agreed with that prediction. In another study from Ile-Ife, among Nigerian traffic wardens, it was found that the mean blood lead level in Lagos wardens was 18.1± 6.4 µg/dl, which was significantly higher than the level of 10.2 ± 2.7 µg/dl in Ife wardens (Ogunsola et al, 1994). Nriagu (1992) reported dust lead levels in Lagos about 5µg/m^3. He further estimated that about 10 to 30% of the children in Africa might be suffering from lead poisoning.

A total of 35 'Harmattan' dust samples were collected over an 8-week period (Adogame and Sridhar, 1997 unpublished data). The mean lead values showed a range of 57.5 to 143.2 mg/Kg. The amount of dust is dependent on the density of the area. The trend followed a decrease from the high to medium to low density area. This phenomenon could be accounted for by the volume of traffic and human population with its attendant activities in such areas and dust particles could be more easily raised by moving vehicles and human activity when the soil is dry (Tables 1 and 2).

In another study by Sridhar and Ifeanyi (1998, unpublished data) 52 indoor dust samples from high (18), medium (18) and low (17) density area showed varying lead levels. Nature of the building, wall paintings, degree of ventilation, elevation, nearness to heavy traffic and most especially contamination of dust samples with paint peelings off the wall influenced the values. The lead levels were: 0.19 - 388.80 mg/kg, 18.5 - 398.15 mg/kg, and 10.25 - 215 mg/Kg for high, medium and low density areas, respectively. These values were high in a few cases when considering the fact that outdoor urban road dust lead level was about 100 - 5,000mg/Kg . The type of house has significant influence as evident from the results of dust analysis (mg/Kg): Bungalow, 94.06, Ground floor, 73.15, and First floor, 125.14.

Lead in Water

Samples of 36 surface and ground waters in Ibadan indicated varying lead levels. The surface waters intended for domestic needs showed lead levels in the range of (mg/l) 0.41±0.5, 1.25±0.2, and 0.39±0.5 for high, medium and low density areas. Similarly, most wells showed concentrations for Pb to be slightly but considerably higher specifically in high-density communities: 1.50±0.4, 0.5±0.5, and 0.7±0.6 in high, medium, and low density areas.

A study in Lagos involving 33 surface water samples and 13 ground water samples revealed similar increased lead levels: for surface waters, 0.324±0.089, 0.030±0.046, and 0.346±0.389 mg/l for high, medium and low density areas. For ground waters, 0.022±0.09, and 0.363±0.028 were recorded in high and medium density areas.

The source of lead in water is mostly from the drainage and surface runoffs. Areas where lead based activities are high contribute to the lead levels in the final recipients such as river, stream or wells. A study by Ayodele et al (1996) while working in Kano reported that industries contribute a large quantities of lead through the discharge of effluents (Table 3).

Lead in Soil

Lead levels in soils vary depending on the location and nearness to lead based activities and vehicular density. A study in Ibadan (Sridhar and Adogame, 1997 unpublished data) showed that in residential areas, the levels ranged from (mg/Kg): 364.0 ± 85.2 in high density area, 269.0±133.9 in medium density area and 307.0±161.3 in low density area. In mechanic's villages the values ranged between 292.3 and 491.2. Near petrol stations, the values ranged between 190.0 to 1029 mg/Kg on the top 10-cm level and 237.5 to 3,862.8 mg/Kg in 11to 20-cm layer. Near a lead acid battery industry, the soils showed values of 7,339 in the top 10 cm layer and 6263mg/Kg in the 11 to 20 cm layer. The type of soil, composition and cation exchange capacity and pH will govern the fate of contaminated lead whether to bind or to leach down.

A process was developed to decontaminate soil with lead levels of about seven grams per Kg using physico-chemical and phytoremediation (Sridhar and Johnson, 2000, unpublished data)

Blood lead levels and poisoning

In developing nations limited reports suggest the existence of serious problems of occupational lead exposure. Nasaralla and Ali (1983, 1985) observed that Pb accumulates in crops near Egyptian highways. In an earlier study they had expressed concern about the lack of data on Pb pollution in Egypt to enable estimation of Pb intake in the country. This is probably also true of Nigeria.

There are also reports from Malaysia that progressive industrial activity has resulted in increased environmental pollution and attendant health problem. Lim et al (1983 not cited here) attributed this to the high alkyl Pb content of Malaysian petrol with associated automobile emission. The Pb content of Malaysian petrol is 0.84 g/l and one of the highest in the world. This may be comparable to the situation in Nigeria where high gasoline Pb content has also been reported (Osibanjo and Ajayi, 1989). Other reports have come from Jamaica, Northern Sudan, Zimbabwe and Korea.

Asogwa (1979) studied 43 battery workers and 50 control subjects. Forty-nine of his exposed subjects had BLL below 40 μg/dl while only one had a value between 40 and 50 µg/dl out of the battery workers, 15 had BLL below 40 µg/dl, 25 had BLL of between 40 and 80 µg/dl and 3 had values of between 80 and 120 µg/dl. Ayoola (1979) reported on 10 cases of Pb poisoning. He drew attention to the difficulty of the diagnosis of Pb toxicity and cautioned that with the rapid industrialization of Nigeria, doctors and other health workers should be aware of the possible increase in the incidence of plumbism. Ayoola (1979) also noted the long term consequences of Pb even after quitting a Pb-based occupation.

Osibanjo and Ajayi (1989) reported that the highest level of Pb occurs in Aviation gas (915 µg/ml) and super grade gasoline, 600-800 µg/ml (with a mean of 700 µg/ml). The comparable maximum levels in United States and Britain (UK) being 200 µg/ml and 500 µg/ml, respectively (Osibanjo and Ajaiyi, 1989). The authors however reported that trace amounts of Pb (2-7 µg/ml) are present in diesel oil, kerosene and lubricating oil. Ndiokwere (1984) studied heavy metal pollution and its effect on soil, vegetation and crops. Okoye (1994) in a survey of Pb and other metal contents of dried fish from Nigerian markets remarks that the Pb content is high. He observes that the high Pb content in fish from Nigerian markets indicates serious Pb contamination in Nigeria. He attributes this mainly to heavy automobile traffic and the high lead content of the local automobile fuels.

Anetor et al (1999) studied 137 subjects in Ibadan comprising of 86 Pb workers and 51 control subjects. They were matched for age, sex, socio-economic status and dietary intake. The Pb workers were classified into 3 exposure categories according to severity of exposure as low, moderate and severe. Blood and urine samples were collected from all subjects. In this study 95% of Pb workers had BLL >40 µg/dl (1.93 µmol/dl, the upper limit currently acceptable in occupational exposure), 60% of the Pb workers had BLL >55 µg/dl (2.70 µmol/l, a level indicative of severe poisoning), 38% of Pb workers had BLL 60 µg/dl (2.90 µmol/l) a level considered indicative of the need to exclude the worker from further exposure), only 4% of Pb workers had BLL below 40 µg/dl (1.93 µ mol/l). In another study involving 880 occupationally unexposed subjects from Iseyin, Shaki, Ogbomoso, and Sokoto, indicated that occupationally exposed workers had higher blood lead levels. The levels correlated well with smoking, alcohol and salt intake (Adeniyi and Anetor, 1999).

Omokhodion (1994) studied blood samples from 90 males and 47 females attending a general outpatient clinic over a period of 1 month in association with 24 tap water samples from 8 locations around Ibadan, Nigeria. Blood lead levels ranged from 3.0 - 27.6 µg/dl. The mean blood lead level for females and males were 11.40 ± 6.16 and 12.33 ± 5.68 (µg/dl, respectively. The water samples in all eight locations show lead levels <5 µg/l. Omokhodion and Osungbade (1996) made a questionnaire-based survey of automobile mechanics and allied technicians in Ibadan. A total of 300 people were interviewed. The questionnaire sought information on health problems associated with work, the presence of chronic illness and where workers seek help when they fall ill. The interview was followed by hand examination for dermatitis. Musculoskeletal disorders were the commonest work-related health problems reported. Of the 50 respondents who recorded Musculoskeletal disorders, 27 (54%) had low back pain, 75 (25%) of them had signs of hand dermatitis, which was most common among panel beaters and welders.

Conclusions and Recommendations

From the available data, it could be concluded that the lead concentration in various environmental samples: surface and ground waters, dust, soils and foods are relatively high as compared to other developed countries. Levels of lead in soils from risky environments such as battery industry, mechanic villages, petrol stations are much higher as compared to those soils from the residential environment. Residents near heavy traffic highways are at high-risk for Lead pollution. 'Harmattan' dust which is characteristic of most sub-Saharan cities carry considerable amounts of lead due to lead from moving vehicles.

The following measures are therefore recommended:

- Phasing out of lead from petroleum production and formulation of policies at National level to reduce the lead use and emissions,
- Monitoring and evaluation of lead levels in the environment at regular intervals and maintaining data base,
- Strengthening of laboratories in the region with adequate and up to date equipment to handle the environmental samples and to ensure quality assurance,

- Monitoring of blood lead levels among populations particularly children in risk environments,
- Educational programs for various population groups on the health and ecological effects of lead,
- Exchange of information from West African region through networking and other modern media,
- Periodic review of lead levels in the environment through regional conferences and roundtable conferences, and
- Involvement of Non Governmental Organizations and Activist Groups in campaigning against lead emissions.

References

Agbo, S. (1997), Effects of lead poisoning in children, in Proceedings At a Workshop on Vehicular Emission and Lead Poisoning in Nigeria, Edited by A. A. Falomo and C. C. Chikwendu, Organized by Friends of the Environment (FOTE), Lagos, pp. 20-28

Adeniyi, F. A. A. and Anetor, J. I. (1999), Lead-poisoning in two distant states of Nigeria: an indication of the real size of the problem, *African Journal of Medicine and Medical Sciences*, 28, pp. 107-112

Anetor, J. I., Adeniyi, F. A. A. and Taylor, G. O. L. (1999), Biochemical indicators of metabolic poisoning associated with lead based occupations in nutritionally disadvantaged communities, *African Journal of Medicine and Medical Sciences*., 28, pp. 9-12

Anon (1996), Lead pollution: A blight on the future, *Africa Health*, 18, p. 7

Asogwa, S.E (1979). The risk of lead poisoning in battery chargers and the possible hazards of their occupation on the environment. *Nigerian Medical Journal*. 9: 189-193.

ATSDR, (1992). Case studies in Environmental Medicine - Lead toxicity. U.S. Department of Health and Human Services (September), pp.1-21.

Ayodele, J. T., Momoh, R. U., and Amin, M. (1996), Determination of heavy metals in Sharada Industrial effluents, in Water Quality Monitoring and Environmental Status in Nigeria, Proceedings of the National Seminar on Water Quality Monitoring and Status in Nigeria, Organized by Federal Environmental Protection Agency and National Water Resources Institute, Published by Federal Environmental Protection Agency, October 16-18, 1991, pp. 158-166

Ayoola, E.A. (1979). Lead Poisoning in Adults. *Nigerian Medical Journal*. 9: 185-188.

John, H, Cheryl, H, Richard, S and Christine, S. (1991). Toxics A to Z - A guide to everyday pollution Hazards. University of California Press. Berkley. Los Angeles. Oxford pp.47-104

Ketiku, A. O., Adeyinka, O. (1999), Leaching of lead from imported and Nigerian earthenware pottery and ceramic household utensils into food and drink, West *African Journal of Biological and Applied Chemistry*, 44, pp. 18-20

Nasralla, M. M. and Ali, E. A. (1985), Lead accumultion in edible portions of crops grown near Egyptian traffic roads, *Agriculture, Ecosystem and Environment*, 13, 73-82

Ndiokwerre, C.C (1984). A study of heavy metal pollution from motor vehicle emissions and its effect on roadside soil, vegetation and crops in Nigeria. *Enviromental*. *Pollution Ser*. *B*. 7, pp 35-42

Nriagu, J.O, Blackson, M.I and Ocram, K (1996) Childhood lead poisoning in Africa- a growing Public Health Problem, *Science of The total Environment* 181 (2): 93-101.

Nriagu, J.O (1978) Lead in the atmosphere in the Biogeo-chemistry of lead in the environment. Amsterdam, Elsevier-North, Holland; part A, Pp.138-164.

Nriagu, J.O (1979) Global inventory of natural and anthropogenic emissions of trace metals to the atmosphere. *Nature* (London), 279, pp 408 - 411.

Nriagu, J.O (1989) A global assessment of natural sources of atmospheric trace metals. *Nature* (London) 338, pp.48-49.

Onianwa, P.C and Egunyomi, J.K (1983). "Trace metal levels in some Nigeria Mosses used as indicators of atmospheric pollution", *Environmental Pollution Series B* 5, pp.71-81.

Onianwa, P.C. (1985), Accumulation, exchange and retention of trace heavy metals in some mosses from S. W. Nigeria. A Ph. D. Thesis, Chemistry Department, University of Ibadan, Nigeria.

Onianwa, P.C (1993). Environmental pollution studies in an underdeveloped country: Heavy metal pollution in Ibadan, Nigeria. Int. J. Env. Educ. And Inf. (Published by Environmental Resources Unit, University of Salford, U.K

Osibanjo, O. and Ajayi, S.O (1980). Trace metal levels in tree barks as indicators of Atmospheric Pollution", *Environment International*. Vol.4, pp. 239-244

Osibanjo .O; Ajayi S. O ; Mombeshora C. (1981) Pollution studies on Nigerian rivers, Toxic heavy metals statute on surface waters in Ibadan city. *Environmental International*, Vol. 5 pp 45- 53.

Osibanjo, O. and Ajayi, S.O (1989). Trace metal Analysis of Petroleum Products by Flame atomic absorption spectrometry. *Nigerian Journal of Natural Sciences*. 4: 33-40.

Shy, C. M. (1990), Lead in petrol: The mistake of xxth century, *World Health Statistics Quarterly*, 43, 168-176

Sridhar, M.K.C. (1986). Trace element composition of Pistia Stratiotes L. in a polluted lake in Nigeria, *Hydrobiologia*. 131, pp. 273-276.

Sridhar, M;K.C. and Bammeke, A.O. (1986). Heavy metal contents of some solid wastes in Ibadan, Nigeria. *Water, Air, and Soil Pollution*.29, pp. 51-56.

Sridhar, M.K.C. (1988). Uptake of trace elements by water lettuce (Pistia stratiotes). *Acta Hydrochim. Hydrobiol* 16, pp. 3, 293-297.

Sridhar, M.K.C. and Okekearu, I. R. (1999), Exposure toindoor lead in Lagos Metropolis: ANigerian Experience, *Epidemiology*, USA, Vol. 10, No. 4, 227p

Sridhar Mynepalli, Adogame, L. and Olawuyi, J. (2000), Lead exposure in urban centres: A case study from Ibadan, Nigeria, *Epidemiology*, Vol. 11, No. 4, p. 862

Sridhar, M. K. C., Olawuyi, J. F., Adogame, L. A., Okekearu, Osajie, C. O., and Linda, A. (2000), Lead in the Nigerian environment: problems and prospects, in 11th Annual International Conference on Heavy Metals in the Environment (J. Nriagu, Editor), No. University of Michigan, School of Public Health, Ann Arbor, MI (CD-ROM), Wallace, B. and Cooper, K. (1986). The citizen's guide to lead: Uncovering a hidden health hazard. NC Press Ltd. Toronto

Table 1. Lead Levels in dust samples from various socio-economic groups in Ibadan

(Source: M. K. C. Sridhar, and Leslie Adogame, 1997 Unpublished data)

Source of Sample	Lead, mg/Kg particulates
High Density Area (n=17)	125± 35.7 to 143.2±42.8
Medium Density Area (n=6)	54.6±35.1 to 83.9±29.3
Low Density (n=12)	57.5±88.0 to 89.6±20.9

Table 2. Lead Levels in Commercial Automobile Exhaust in a Selected Area in Lagos Metropolis

(Source: AA. O. Agbalajobi and M. K. C. Sridhar, April 2001 Unpublished data)

Source of Sample	Lead, mg/g particulates	Range Mean ±SD
Commercial Automobile Exhaust (n=20)	0.043 - 11.40	3.01± 2.71
Heavy Duty Automobile Exhaust (n=10)	0.096 - 18.00	5.404±5.63
Private Automobile Exhaust (n=25)	0.038 - 11.20	3.064±3.09

Table 3. Lead Levels in Some Industrial Effluents at Sharada Industrial Estate, Kano
(Source: J. O. Ayodele, R. V. Momoh and M. Amin, 1996)

Source of Effluent	Suspended Lead mg/l Mean±SD	Dissolved Lead mg/l Mean±SD	Total Lead mg/l Mean±SD
Industry 1 (n=10)	184.4±10.23	202.49±2.81	388.20±12.67
Industry 2 (n=10)	75.60±11.54	363.0±21.81	446.4±35.97
Industry 3 (n=10)	1.94±0.55	18.04±8.18	21.70±8.12

Table 4. Blood Lead Levels among Exposed and Unexposed Controls in Nigeria
(Source: F. A. A. Adeniyi and J. I. Anetor, 1999)

Subjects Number n	Mean Age (Years)	Blood lead level µg/dl
Exposed Group (Battery industry, Paint industry, Petroleum Depot, an insecticide Company, Ibadan))	86	56.3±0.95 (26 - 97)
Control Group I (Workers from Offices, Ibadan)	51	30.1±1.47* (10 - 58)
Control Group II (People from Iseyin, Shaki, Ogbomosho and Sokoto)	880	28.8±1.22* (15 - 63)

**Compared to exposed workers, the values are significantly lower (P<0.001)*
**Results in parenthesis are ranges*