
LEAD POISONING: A REVIEW OF SOURCES AND ADVERSE EFFECTS

By

Usman Bawa, Ahmad Bukar and Abdullahi Yahaya.

Department of Biology Education,
Federal College of Education (Technical),
Potiskum, Yobe State, Nigeria

Yahaya20@yahoo.com

bawa.usman@yahoo.com

H/P: +2348036083772

ABSTRACT

Lead poisoning is an important environmental disease that can have lifelong adverse health effects. Most susceptible are children, and most commonly exposed are those who are poor and live in developing countries. Studies of children blood lead levels (BLLS) are showing cognitive impairment at increasingly lower BLLS. The sources of lead exposure vary among and within countries depending on past and current uses. Sources of lead may be from historic contamination, recycling old lead products, gold ore processing. In many countries where leaded gasoline is no longer used, average population BLLS have declined rapidly. This article highlights several major sources of lead poisoning, adverse health effects, worldwide. In addition, we recommend three primary prevention strategies for lead poisoning: Identify sources, eliminate or control sources, and monitor environmental exposures and hazards.

Keywords: Lead poisoning, Blood leads level, Lead, Neurodevelopment

INTRODUCTION

Lead is a toxic metal that is not essential for nutrition (Goyer *et al.*, 1995). Lead is one of the most widespread potential chemical contaminants in the environment and may be transferred to man through food (Winder, 1993). The level of lead in the environment increases proportionately with the level of most useful metals in industry, it has no known biological function in both animals and man (Mohmoud, 1997). Lead pollution from uncontrolled human activities has continued to contaminate the environment, posing a serious health concern for humans, plants and animals (Claudio *et al.*, 2003).

Lead is widely used and when ingested or inhaled, is highly toxic to humans of any age. People could be exposed to lead through leaded soils and dusts, water, food, air, traditional medicines, cosmetics, pottery, and formerly used gasoline (Furman and Laleli, 2000). Ingestion of lead from foods is an important and persistent exposure route for both children and adults (Finster *et al.*, 2004). Children are more vulnerable to lead at increased risk for exposure and adverse health effects than adults due to their behavioural and physical characteristics (Finter *et al.*, 2004). Lead exposure leading to excess lead absorption in children is not a unique environmental health problem in the developed countries, but also

exists in the developing countries. Lead poisoning among children can cause damage to brain systems in humans especially among young children (Needlemen, 2004). Lead exposure among children is associated with developmental problems including impaired cognitive function, reduced intelligence, and impaired hearing (Canfield *et al.*, 2003; Jusko *et al.*, 2008).

Despite growing evidence of adverse health effects related to lead, it is still widely used in consumer products and released into the air through combustion of coals and oil, waste incineration, and fugitive emissions during mining and smelting. Many countries have taken steps to control the use of lead, for example lead in house hold paint was banned in Australia in 1920 and by international convention in 1925 (Meyer *et al.*, 2003). However, more must be done to protect people in all nations. World wide a large number of people are exposed to lead, especially those in developing countries. This paper will highlight adverse health effects and several sources of lead exposure reported internationally in the scientific literature. We recommend strategies to prevent people in the world, especially in developing countries like Nigeria.

SOURCES OF LEAD POISONING

Lead in paint

Lead poisoning in paints of residential houses is still one of the main sources of high lead poisoning for children despite the banning of lead paints contents in some countries (DHUD, 1995 cited in Casas and Sardo 2006). Many studies have documented sources of lead poisoning from paint. For example, Laidlaw and Tailor, (2011) showed evidence of soil lead contamination in the older suburb from paint lead contents in Australia. This is also same with the findings of Lin *et al.* (2012) in China, they found lead in

paints as one of the major sources of lead poisoning, their study indicated high lead contents in 16 out of 28 paint samples for residential paints, these lead levels were equal or exceeding the US 600ppm limit and 21% equal to or exceeding the 5000ppm which is the safest level in residential housing in US (Mayan *et al.*, 2001). Lead poisoning cases in children, resulting from lead in paints sources were also reported in earlier studies by Mayan *et al.* (2001). They found high blood lead levels in children aged 1-5 years in Oporto Historical Centre resulting from lead contents in their residential old buildings, 85.8% of the children had blood lead levels of greater than 10µg/dl threshold. Lead based paint is also a major source of poisoning in South Africa, this is showed from the results of 60 randomly chosen houses in both old and new suburbs area in which 17% of the chosen samples were lead contain paints with weight up to 29% (Montgomery and Mathee, 2005). In India, China and Malaysia, 60% of new paints sample were found to contain lead greater than or equal 5000 ppm, the US lead paint contains in residents and 78% contained lead greater than 600ppm which is the limit for new homes (Clark *et al.*, 2006). All these studies have showed evidenced of continued lead poisoning from house hold paints, despite the banning of lead in paint. However, more efforts should be made to completely eliminate lead paint from markets especially in developing countries where such ban is not enforced.

Sources from Smelters and Battery Factory

Metal smelters are also a major source of lead poisoning in many countries in the world. The activities of smelting factories release lead into air in high dosage and which contaminate soil, water and food of the nearby residents and subsequently effects children and adults (Tandon *et al.*, 2001). Lead poisoning from smelter, battery factory and gold ore processing has been reported in many papers. In

Torren Mexico, lead emissions from a smelter factory have caused significant increase in blood lead levels of 5.0-25.8 μ dl in children residing near the factory (Soto-Jimenez *et al.*, 2011). Olovero *et al.* (2007) also indicated lead poisoning from a metal smelters Cartagena Colombia in which 7.4% of 184 Children living around the factory had blood lead level above 10 μ g/dl. This is also same in India, where lead poisoning from smelting factories of new jewellery, were showed to increase blood lead level with mean value of 32.84 \pm 1.78 μ g/dl in 31 of the 50 workers investigated (Tandon *et al.*, 2001). Lead poisoning in all these cases was usually associated with traces of lead from these sources that have contaminated the soils, and children living near such sources are at higher risk of lead poisoning.

Battery recycling has also been showed to be a major source of lead poisoning particularly in children residing near battery recycling factory or shops. This was reported by the studies of Kaul and Mukherjee (1999). Their findings showed lead poisoning with increase blood lead level in 116 children with a mean blood value of 71 μ g/dl and a range of 9-234 μ around a close Battery recycling factory in Haina Dominican Republic. However, a follow up survey in August in the same surrounding still shows lead poisoning case, the result indicated that in 146 children examined with high mean blood lead levels of 32 μ g/dl and 23% had between 18 to 19 μ g/dl and 40% had 20 to 39 μ g/dl, 27% between 40 to 99 μ g/dl while the rest had more than 100 μ g/dl (Kaul *et al.*, 1999). Safi *et al.* (2006) also reported lead poisoning near a Battery factory in Gaza, their findings revealed 17.2% of Gaza children had blood lead level greater than < 10 μ g/dl. In Zamfara state Nigeria, a wide spread lead poisoning and lead contamination resulting from gold ore processing was revealed. The result found that majority of the ore processing villages surveyed had at least one child < 5 years of age with a blood lead

level (BLL) \geq 10 μ g/dl and children < 5 years with convulsions and death (Lo *et al.*, 2012).

Sources of lead from leaded gasoline

Leaded gasoline was a major source of atmospheric pollution in many countries before it was first eliminated out in the Mid 1970s in United States, and several other countries have also followed the initiative to ban leaded gasoline (Meyer *et al.*, 2003). Studies in many countries have showed decrease in lead level after elimination of leaded gasoline. For instance studies in India by Singh and Singh (2006) compared the lead levels during the leaded petrol regime prior to 1999, the transitional phase and the unleaded phase from 2000. The results indicated decline in children blood lead level from 18.1 μ g/dl to 12 μ g/dl, decrease was also observed in Ganga River water from 18.0 μ g/l in 1998 to 3.1 in 2001.

Sources of lead from Gunshot and Traditional medicine

Another important source of lead in human diet have been identified in Greenland, from lead gun shot in birds, studies by Bjerregaard *et al.* (2004) found people in Greenland who reported eating gunshot sea birds many times a week have blood lead levels > 50% higher in contrast to those who confessed to eating sea birds from lead gunshot just small times per month or less than that amount. This finding is also consistent with the findings of Johansen *et al.* (2004; 2006) which showed a significantly higher blood lead levels in people who always take gunshot birds meals in Greenland and the blood lead levels increase with high frequency of uptake. Green and Plain (2012) also indicated game birds shot with lead gun as one of the main sources of dietary lead levels in UK, using data from UK food consumption data and

lead concentration from gunshot birds meals up- take weekly. Other unusual sources of lead are from the use of traditional medicines or herbals containing high lead contents. A case study of a 51 year old in New Zealand, reported to be severely poisoned in Christchurch Hospital, investigation revealed uptake of an Indian traditional medicine Ayurvedic with high lead content (Roche *et al.*/2005). Another case study in New Hampshire involving a 37 year woman who was lead poisoned with 81µg/dl blood lead levels, and sources were traced from taking five traditional medicines obtained from Ayurvedic physician in India. They were both analysed to contain 17,000-12,000ppm lead contents and the other having 60-100ppm (Aroujo *et al.*/2004). Lin *et al.* (2012) also reported a lead poisoning in a 3 year old boy with blood lead level of 303µg/dl and his 6 month sister with blood lead level of 385µg/l from a Chinese family in Guangzhou, the sources of poisoning was traced to use of a traditional Chinese medicine instead of baby powder. Further analysis revealed the powder to have contained 817,000mg/kg of lead tetroxide.

EFFECTS OF LEAD ON HUMAN AND THE ENVIRONMENT

Lead consumption has detrimental effects in all parts of the body systems, and children are more susceptible to lead poisoning because of their high rate of hand to mouth exposure. Lead has several adverse effects on human including effects on hematopoietic system, nervous and kidney (Casas and Sordo, 2006). Several studies have showed effects of lead on human health from various sources. For example study by Tandon *et al.* (2001) in India has reported lead poisoning from occupational silver refiners' factory workers in which a significant numbers of the workers showed several symptoms of anaemia, abdominal colic, and blue lining of gum due to high lead blood levels. Lead poisoning death associated

cases of 200 people was also recorded in the USA ,between 1997-1998 due to blood lead levels higher than 100 micrograms per decilitre (Kaufmann *et al.*2003). High lead on the cognitive development of the central nervous system has adverse effects especially on children and infants even at blood lead levels of less <10µg/dl (CDS,2002). The identified effects of lead on the Central nervous system are encephalopathy, and symptoms include headache, loss of memory, dullness. However Kordas *et al.* (2006) studied the relationship between blood lead levels and children neurodevelopment in Mexico and found that blood lead levels of children even at less than < 10µg/dl concentrations has adverse effects on children neurodevelopment at the age of 12 and 24 months. This finding is consistent with the results of Lanphear *et al.* (2000) using analyses of data from the Third National and Nutrition Examination survey (NHANESS 3) in the US from 1988 to 1994, found cognitive deficits associated with children blood lead level less than 5pg/dl. Apparently more evidence of low IQ and intellectual deficits were found to be associated with children's with blood lead levels concentrations below 5- 10µg/dl were also showed by previous studies (Surkan *et al.* 2007; Lanphear, 2005; Chiodo *et al.* 2004). More so Canfield *et al.* (2003) further revealed that decline in IQ due lower blood lead levels less than <10µg/dl concentrations are even greater than the decrease in IQ at higher blood lead levels. These findings indicate that children exposure even at lower concentrations which prior do not pose a serious health concerns, has the greatest effect on children intelligent and neurodevelopment. Because of the evidences listed, the threshold of 10µg/dl of the Disease Control and Prevention Standard for children blood lead levels should not be explained as the safe blood lead levels where significant effects do not occur. However, lead exposure at 28 weeks of gestation, has showed to be the most detrimental child

exposure stage with permanent deficits in intellectual development.

Other Adverse effects of high lead blood levels have also shown to decrease fertility in men (Gennart *et al*/1992; Ghaffari *et al*/2011). Lerda (1992) also found low sperm concentration associated with 38 male workers in a battery factory at 48.6µg/dl. However several case studies of lead poisoning have been reported with children blood lead levels above the 10µg/dl recommended threshold. For example in China Anhui province 23 children with blood levels higher than 250µg/l had to be admitted in hospital due to severe lead poisoning from a battery factory (Wang *et al*/2011). Shen *et al.* (1996) in China showed children living in industrial and busy traffic areas had blood lead levels above 10µg/dl with average levels of 21.8-67.9µg/dl which falls within the range of lead poisoning and shows decreases in neurodevelopment.

In animals Lead poisoning cases have been evident particularly in birds, where lead shot accumulated in birds resulted in severe poisoning and even death (Casas and Sordo, 2006). Studies by Clark and Scheuhammer (2003) found high lead bone concentrations of 58µg dry weight in a Turkey vulture and some Bald eagles were found dead away from their aquatic habitat due to lead poisoning in Canada. Evidence suggest source of lead from feeding on preys shot with lead gun which accumulates and ingested by the predators through feeding. More so, Secondary lead poisoning from swallowing of gunshot lead fragments of their prey were also detected in the livers of 16 raptor species with concentration greater than 20ppm dry weight (Plain *et al.*, 1995). Prior Kim *et al.* (1999) in Hokkaido Japan found high concentrations of lead greater than 70µg/g dry in the liver of two Stellers sea eagles and white-tailed sea eagle as a result of secondary lead poisoning through the swallowing of lead shot accumulated in their prey tissue. Gunshot birds tend to have accumulated lead

contents in their bodies which have secondary effects on their predators, leading to lead poisoning cases. Effects of high lead concentration in plants include reduction in rate of photosynthesis by alteration of chloroplast ultrastructure, reducing chlorophyll synthesis and hindering electron transport, and stunted growth (Casas and Sordo 2006).

PREVENTIVE STRATEGIES

The strategies to prevent lead pollution in the environment will involve the following:

1. Identification of pollution sources: identifying the potential sources of a particular lead pollution such as the Battery factory recycle plants, shops and unregulated smelting activities which could contaminate soil, water and food of the nearby residents. These can be minimize or shut down to reduce lead pollution at the source.
2. Removing or Control pollution at sources: Removing lead pollution or controlling lead pollution at source, through adopting and implementing effective lead control guidelines to minimize emissions from sources, use of clean technology to reduce lead pollution and provisions of adequate legislation to prohibit un-necessary use of lead in the environment.
3. Similar programme like the successful elimination of leaded gasoline in many countries in the world could be launched or replicated to control unchecked battery and smelting activities by buyback programmes.
4. Legal banning on the use of leaded ammunition for game birds hunting to reduce the source of lead poisoning from lead gunshot birds.

5. Public Enlightenment: Through enlighten parents on the ways of exposure to lead poisoning, potential sources of lead poisoning, symptoms of lead poisoning in children and its effects on human health.

CONCLUSION

Lead poisoning case has continued to increase despite the ban of leaded gasoline in many countries, due to unregulated activities of smelting, battery factories and use of lead paints in residential houses. These activities result in high blood lead levels mostly in children living near such factories with significant cognitive and developmental health effects even below the 10µg/dl blood lead level threshold. However there is need for complete elimination of non-essential sources of lead poisoning in countries across the world, to protect the future of these vulnerable children.

REFERENCES:

- Aroujo, J., Beelen, A. P., Lewis, D. L., Robinson, G. G., Delaurier, C., Carbajal, M., and Roscoe, R. j. (2004). Lead poisoning Associated with Ayurvedic Medication-Five States, 2000-2003. *MMWR*, and *Mortality Weekly Report* 53(26):582-593.
- Bjerregaard, P., Johansen, P., Mulvad, G., Pedersen, H. S. and Hansen, J. C. (2004). Lead source in human diet in Greenland, *Environmental Health Perspectives*, 112(15):1496- 1499.
- Casas, S. J., and Sordo, J. (2006). Lead chemistry, Analytical Aspects, *Environmental Impact and Health Effects*. Killington, Oxford UK, pp: 56-67.
- Centre for Disease Control and Prevention (2002). Managing elevated blood lead levels among young children, Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention. Available online at http://www.cdc.gov/nceh/lead/casemanagement/casemanage_main.htm [accessed on 26 December, 2013].
- Clark, C. S., Rampal, K. G., Thuppil, V., Chen, C. K., Clark, R., and Roda, S. (2006). The lead content of current currently available new residential paint in several Asian countries, *Environmental Research*, 102(1):9-12.
- Canfield, R. L., Henderson, j. C. R., Cory-Slechta, D. A., Cox, C., Jusko, T. A., and Lanphear, B. P. (2003). Intellectual impairment in children with blood lead concentrations below 10µg per decilitre, *New England Journal of Medicine*, 348(16):1517-1526.
- Chiodo, L. M., Jacobson, S.W., and Jacobson, J. L. (2004). Neurodevelopmental effects of postnatal lead exposure at very low levels, *neurotoxicology and Teratology*, 26(3):359-371.
- Clark, A.J., and Scheuhammer, A.M. (2003). Lead poisoning in upland-foraging birds of prey in in upland-foraging birds of prey in Canada, *Ecotoxicology*, 12:1-4.
- Claudio, E. S., Godwin, H. A, and Magyar, J. S. (2003). Effects of lead poisoning, *Progress Inorganic Chemistry*, 51(1):46-49.
- Finster, M. E, Gray, K. A., and Binns, H. J. (2004). Lead levels of edible grown in contaminated residential soils: a field survey, *Science Total Environment*, 320(2-3):245-257.

- Furman, A., and Laleli, M. (2000). Semi-occupational exposure to lead: a case study of child and adolescent street vendors in Istanbul, *Environmental Resources*, 83(1):41-45.
- Gennart, J. P., Buchet, J. P., Roels, H., Ghyselen, P., Ceulemans, E., and Lauwerys, R. (1992). Fertility of male workers exposed to cadmium, lead or manganness. *American J. Epidemiol*, 135:1208-1219.
- Ghaffari, M. A., and Motlagh, B. (2011). In vitro effect of lead, silver, tin, mercury, indium and bismuth on human sperm creatine kinase activity: a presumable mechanism for men infertility. *Iranian Biomedical Journal*, 15(1):38-43.
- Goyer, R. A., Cheian, M. G., Jones, M. M., and Reigart, J. R. (1995). Role of chelating Agents for prevention and treatment of exposure to toxic metals, *Environmental Health Perspective* 103: 1048-1052.
- Green, R. E., and Plain, D. J. (2012). Potential health risks to adults and children in UK from exposure dietary lead in game birds shot with lead ammunition, *food and chemical Toxicology* 50:4180-4190.
- Johansen, P., Pedersen, H. S., Asmund, G., and Riget, F. (2006). Lead shot from hunting as a source of lead in human blood, *Environmental pollution*, 142(1):93-97.
- Johansen, P., Asmund, G., and Riget, F. (2004). High human exposure to lead through consumption of birds hunted with lead shot. *Environmental pollution*, 127 (1):125-129.
- Jusko, T. A, Henderson, D. A, Parsons, P. J., Cory-Slechta, D. A., Parsons, P. J., and Canfield, R. L. (2008). Blood lead concentrations <10µg/dl and child intelligence at 6 years of age, *Environmental Health Perspective*, 116: 243-248.
- Kaul, B., and Mukerjee, H. (1999). Elevated blood lead and erythrocyte protoporphyrin levels of children near a battery-recycling plant in Haina.Dominician Republic, *international journal of Occupational and Environmental Health*, 5(4):307-312.
- Kaul, B., Sandhu, R. S., Depratt, C., and Reyes, F. (1999). Follow-up screening of lead-poisoned children near an auto battery recycling plant, Haina Dominican Republic. *Environmental Health Perspectives*, 107(11):917.
- Kaufmann, R.B., Staes, C.J., and Matte, T.D. (2003). Deaths related to lead poisoning in the United States, 1979-1998. *Environmental Research*, 91(2):78-84.
- Kim, E. Y., Goto, R., Iwata, H., Masuda, Y., Tanabe, S., and Fujita, S. (1999). Preliminary survey of lead poisoning of Steller's sea eagle (*Haliaeetus pelagius*) and white-tailed sea eagle (*Haliaeetus albicilla*) in Hokkaido, Japan, *Environmental Toxicology and Chemistry*, 18(3):448-451.
- Kordas, K., Canfield, R. L., Lopez, P., Rosado, J. L., Vargas, G. G., Gebrian, M. E., and Stoltzfus, R. J., (2006). Deficits in cognitive function and achievement in Mexican First-graders with low blood lead concentrations. *Environmental Research*, 100(3):371-386.
- Lanphaer, B. P., Dietrich, K., Auinger, P., and Cox, C. (2000). Cognitive deficits associated with blood lead concentrations <10 micro g/dl in US children and adolescents. *Public Health Reports*, (6):115-521.

- Lanphear, B.P., Hornung, R., Khoury, J., Yolton, K., Baghurst, P., Bellinger, D.C., and Robert, R. (2005) Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. *Environmental Health Perspectives*, 113(7):894-910.
- Laidlaw, M. A. and Taylor, M. P. (2011). Potential for childhood lead poisoning in the inner cities of Australia due to exposure to lead in soil dust. *Environmental Pollution*, 159(1):1-9.
- Lerda, D. (1992). Study of sperm characteristics in persons occupationally exposed to lead. *American Journal of Industrial Medicine*, 22:567-571.
- Lin, G. Z., Wu, F., Yan, C., and Liu, X. (2012). Childhood lead poisoning associated with traditional Chinese Medicine: A case report and subsequent lead source inquiry, *Clinica Chimica Acta*: 115-1159.
- Lo, Y.C., Dooyema, C. A., Neri, A., Durant, J., Jefferies, T., Medina- Marino, A. and Brown, M.J. (2012). Childhood lead poisoning associated with gold ore processing: a village level investigation Zamfara state, Nigeria. *Environmental Health Perspectives*, 120(10):1450-1455.
- Mayan, O. N., Henriques, A. T., and Calheiros, J.M. (2001) Childhood lead exposure in Oporto Portugal *International Journal of Occupational and Environmental Health*, 7(3):209-216.
- Mohmoud, L.A. (1997). Renal effects of environmental and occupational lead exposure, *Environmental Health Perspective*, 105(9):928-938.
- Montgomery, M., and Mathee, A. (2005). A preliminary study of residential paint lead concentrations in Johannesburg. *Environmental Research*, 98(3):279-283.
- Meyer, P. A., McGeehin, M.A., and Falk, H. (2003). A global approach to childhood lead poisoning prevention, *international journal of hygiene and environmental health*, 206(4):363-369.
- Needleman, H. (2004). Lead poisoning, *Annually Review Medicine*, 55(1):209-222
- Olovero-Verbel, J., Duarte, D., Echenique, M., Guette, J., Johnson-Restrepo, B., and Parsons, P.J. (2007). Blood lead levels in children aged 5-9 years living in Cartagena, Colombia, *Science of the Total Environment*, 372(2):707-716.
- Plain, D. J., Sears, J., and Newton, I. (1995). Lead concentrations in birds of prey in Britain, *Environmental Pollution*, 87(2):173-180.
- Roche, A., Florkowski, C., and Walmsley, T. (2005) Lead poisoning due to ingestion of Indian herbal remedies, *Journal of the New Zealand Medical Association*, 118:1219-1228.
- Safi, J., Fischbein, A., El Haj, S., Sansour, R., Jaghabir, M., Hashish, M. A., and Richter, E.D. (2006). Childhood lead exposure in the Palestinian authority, Israel, and Jordan: results from the Middle Eastern regional cooperation project, 1996-2000. *Environmental Health Perspectives*, 114 (6):917.
- Shen, X. M., Rosen, J. F., Guo, D., and Wu, S. M. (1996). Children lead poisoning in China. *Science of the Total Environment*, 181 (2):101-109.
- Singh, A. K., and Singh, M. (2006). Lead decline in the Indian environment resulting from the petro-lead phase-out programme. *Science of the Total Environment*, 368(2):686-694.

- Surkan, P. J., Zhang, A., Trachtenberg, F., Daniel, D. B., Mckinlay, S., and Bellinger, D. C. (2007). Neuropsychological function in children with blood lead levels <10 µg/dl, *Neurotoxicology*, 28(6):1170-1177.
- Soto-Jimenez, M., F., and Flegal, A .R. (2011). Childhood lead poisoning from the smelter in Torreon Mexico, *Environmental Research*, 111(4):590-596.
- Tandon, S. K., Chatterjee, M., Bhargava, A., Shukla, V., and Bihari, V. (2001). Lead poisoning in Indian silver refiners, *Science of the Total Environment*, 281(1):177-182.
- Wang, J. J. A., Luo, W., Yang, R., Chen, J., and Cai, T. (2011). Lead poisoning in china: A nightmare from industrialisation. *The Lancet*, 3777(9776):1474-1476.
- Winder, C. (1993). Lead reproduction and development, *Neurotoxicol*, 14(2-4): 303-317.
- Tandon, S. K., Chatterjee, M., Bhargava, A., Shukla, V., and Bihari, V. (2001). Lead poisoning in Indian