British Journal of Applied Science & Technology
16(4): 1-7, 2016, Article no.BJAST.26255
ISSN: 2231-0843, NLM ID: 101664541

SCIENCEDOMAIN *international*
www.sciencedomain.org

Evaluation of Arsenic and Lead Soil Contamination by Wooden Electric and Telephone Poles in Two Urban Cities

Lovell Agwaramgbo[1*], Jude Alinnor[2], Sha'Kayla Nunez[1] and Peter Uhuegbue[2]

[1]Department of Chemistry, Dillard University, New Orleans, Louisiana, USA.
[2]Department of Chemistry, Federal University of Technology, Owerri, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author LA designed the study, performed the data analysis, and wrote the first draft of the manuscript. Author JA in collaboration with author PU conducted the Owerri study and wrote the experimental section for the study. Author SKN carried out the sample collection and preparation for the New Orleans study. Author PU in collaboration with authors LA and JA carried out the sample collection, preparation, and digestion for the Owerri study as well as literature review. All authors participated in the revision of the manuscript and read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2016/26255
Editor(s):
(1) Abida Farooqi, Department of Environmental Sciences, Quiad-i-Azam University, Pakistan.
Reviewers:
(1) Fábio Henrique Portella Corrêa de Oliveira, Faculdade de Saúde de Paulista, Brazil.
(2) Md. Safiuddin, George Brown College, Ontario, Canada.
(3) Ewuzie, Ugochukwu, Abia State University Uturu, Nigeria.
(4) Tulay Aşkin Çelik, Adnan Menderes University, Turkey.
Complete Peer review History: http://sciencedomain.org/review-history/14879

Original Research Article

Received 7th April 2016
Accepted 23rd May 2016
Published 2nd June 2016

ABSTRACT

Arsenic and lead have been reported to have toxic effect on human and animal health. Wooden electric and telephone poles have been known to be treated with chromated copper arsenate (CCA) in an effort to preserve them from decay, termites, insects, and rot. Thus, those who work or live on or near lead and arsenic-containing soil or ingest products contaminated by these two heavy metals are at risk of serious health dangers. Thus, the project reported here investigates whether wooden telephone and electric poles contribute to arsenic and lead soil contamination in two urban cities:- New Orleans in Louisiana, USA and Owerri in Imo State, Nigeria. Three wards or neighborhoods were selected in each city for the study and three streets were selected from each

**Corresponding author: E-mail: lagwaramgbo@dillard.edu;*

ward. Three samples were obtained from each street. Soil samples were collected from Owerri Girls Secondary School (OG) in Owerri and at Dillard University in New Orleans where the utility poles were made of concrete rather than wood. The soil samples were dried, sieved, and analyzed for arsenic and lead. The data suggest that the 4.8 mg/Kg mean arsenic level found in New Orleans soil samples is thirteen times higher than the United States Environmental Protection Agency (USEPA) Region VI RECAP level of 0.36 mg/Kg and ten times higher than Federal Environmental Protection Agency of Nigeria (FEPAN) permissible level (0.5 mg/Kg) in soil while the mean lead level of 156 mg/Kg is below the USEPA RECAP level of 400 mg/Kg but more than 3000 times above FEPAN permissible level of 0.05 mg/Kg. The data for the samples from Owerri, Nigeria had arsenic levels below method detection limit but showed a 2.3 mg/Kg mean lead level which is well below the USEPA 400 mg/Kg recap level but forty six times above FEPAN permissible level of 0.05 mg/Kg.

Keywords: Arsenic; chromium; heavy metals; New Orleans; Owerri; utility poles.

1. INTRODUCTION

Lumber industries, especially, those in the United States treat their woods with preservatives such as chromated copper arsenate (CCA). Treatment of woods with these preservatives prevent decay, rot, or attack of the wood by bacteria, fungi, and insects thereby promoting the longevity of the woods [1-3]. For decades, CCA containing 18.5% CuO, 47.5% CrO_3, and 34% As_2O_5] was mostly used in wood pressure-treatment [4-5]. The copper and arsenic prevent fungi, bacterial and insect attack of the wood while the chromium promotes the fixation of the CCA to the wood which reduces leaching of the chemicals [1,6]. Unfortunately, arsenic and lead are two well known soil and water contaminants with reported toxic and detrimental risks to our environment, human health, aquatic and terrestrial animals, and plants [7-8]. Lead pollution has resulted from several human activities such as paint production [9], mining activities [10], and the manufacture and use of agricultural fertilizers, insecticides and pesticides [10-12], and combustion of coal [13-14]. Similarly, arsenic pollution is also a consequence of both natural phenomena like volcanic eruption and human activities such as the manufacture, use, and disposal of agricultural insecticides and herbicides as well as other various mining, industrial and manufacturing operations. Chronic exposure to lead and arsenic can pose a major human health risks [15-18]. Similarly, chronic exposure to arsenic has been reported damage the neurological, reproductive, central nervous, renal, immune and liver systems as well as skin, bladder, and lung cancer in humans [7,19-24]. Arsenic concentrations as high as 500 mg/kg have been reported in soils having a history of arsenic pesticide or herbicide applications. Duble warned that although the manufacture, sell, and use of the most toxic inorganic forms of arsenic have been banned and replaced with less toxic organic forms, yet, arsenic contamination burden persists [25]. For instance, while residential use of this toxic inorganic form of arsenic has been restricted, its use by lumber industries have not abated. Furthermore, the industries claim that the less harmful alternative options that exist for protecting pressure-treated wood from termites and other pests are more expensive and not widely available. Unfortunately, the EPA insists that there is no conclusive evidence that CCA poses unreasonable risks to the public, therefore sees no reason to remove or replace existing CCA-treated structures or surrounding soils. Currently, over 80% of the lumber sold for outdoor use in the U.S. is pressure-treated with CCA or other toxins that act as preservatives and pesticides. Thus, continued use and presence of these toxins pose ongoing environmental and human arsenic exposure and poisoning. Although a body of research has examined the possible dispersal of CCA chemicals from treated wood into the soil through leaching, erosion, weathering, decay, and flaking [26-30], however, some of the conclusions conflict on the level of leaching of these heavy metals onto the soil surrounding CCA treated utility poles showed high levels of these metals, especially, arsenic. [4,31-34]. Thus, the project reported here investigates if electric and telephone wooden poles are potential sources of arsenic and lead soil contamination in two cities from two countries (Owerri, Nigeria and New Orleans, USA).

1.1 Place and Duration of Study

Dillard University in New Orleans, Louisiana, USA and Federal University of, Technology, Owerri, Imo State, Nigeria, August 2013-August 2014.

2. SOIL SAMPLES AND TEST METHODS

Triplicate soil samples from a depth of 0-1 inch were collected from sites a meter away from telephone and electric wooden poles from each of the three streets from each of the three wards or neighborhoods in New Orleans in Louisiana, USA and Owerri in Imo State, Nigeria. Control samples were from sites with concrete utility poles. Each sample was air dried at room temperature for 48 hr, sieved with a 250 µm sieve, placed in 50 ml labeled sample containers. The New Orleans samples were sent to a commercial Lab, PACE Analytical for lead and arsenic analysis using EPA Method 6010 (Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)). The Owerri samples were air dried, homogenized using mortar and pestle and sieved with a 2 mm sieve. Into each of the respective set of triplicate, 250 ml beaker was put 2.0 g of each sieved soil sample. To each sample was added 10 ml of concentrated hydrochloric acid (HCl) and 10 ml of concentrated nitric acid (HNO_3) respectively. Each resulting mixture was heated until only about 1ml of residue remains. Each residue was allowed to cool to laboratory room temperature and 5ml of nitric acid (20%) was added. The mixture was filtered and the volume was made up to 50 ml with deionized water, and filtered into clean and labeled plastic containers. The samples were then sent to the Federal Ministry of Science and Technology, Uyo, Akwa-Ibom State, Nigeria for lead and arsenic determination using UNICAM 969 Solar Atomic Absorption Spectrophotometer (AAS) in which authentic standard solution of each metal under investigation was run to obtain a calibration curve followed by the aspiration of the digested samples.

3. RESULTS AND DISCUSSION

Figs. 1 and 2 show the average lead levels in the triplicate soil samples collected near wooden utility poles from the streets of New Orleans and Owerri, respectively. The data on Fig. 1 show that all but one sample from New Orleans had lead level well below the exposure limit of 400 mg/kg for both United States Environmental Protection Agency (USEPA) Region VI and Louisiana Department of Environmental Quality (LADEQ). However, 66% of 7^{th} Ward, 100% of 8^{th} Ward, and 25% of 9^{th} Ward samples had lead levels above the USEPA cancer screening level of 100 mg/kg. Although research prior to Hurricane Katrina by Mielke [35-36] showed elevated lead levels and wide distributions across New Orleans neighborhoods, no similar studies exist for the levels of lead near utility poles pre and post Hurricane Katrina in New Orleans. All the samples from Owerri neighborhoods had lead levels ranging from less than 0.0025 mg/kg, the method limit of detection (MLD) to 6.6 mg/kg, all of which are well below the USEPA recap or permissible level of 400 mg/kg but equal or higher than the Federal Environmental Protection Agency of Nigeria (FEPAN) regulatory level of 0.05 mg/kg and the control samples respectively. The data on Fig. 3 show the respective average arsenic level ranging from 3.2 to 9.4 mg/kg found in the triplicate soil samples near utility poles from the selected streets in New Orleans. The data clearly demonstrate that soil samples were contaminated above USEPA Region VI exposure limit of 0.36 mg/kg but were all below the LADEQ RECAP level of 12 mg/kg. On the contrary, soil samples from Owerri had arsenic levels below 0.0025 mg/kg (MLD). Rotkin-Ellman et al. reported in 2010 that the average arsenic levels in all New Orleans' hot spots pre-hurricane Katrina flooding (pre-2005), post Katrina flooding (2005) and post Katrina recovery were 3.69, 23.36, 3.26 mg/kg respectively suggesting temporal changes in the arsenic levels throughout New Orleans [37]. However, in this study being reported here, the average arsenic level around wooden utility poles is 4.9 mg/kg, two years after Rotkin-Ellman's report. These results demonstrate that the arsenic levels around wooden utility poles are not following the reduction trend seen with the arsenic levels in the New Orleans neighborhoods. Furthermore, there is no existing background data on arsenic levels near wooden utility poles in New Orleans and the data from this study may represent such. Lastly, the control samples collected around concrete poles had arsenic levels below the method detection limit which suggests that (a) the concrete utility poles had no CCA and could not have leached arsenic around the soil or (b) post Katrina recovery activities attenuated or remediated any level of arsenic or lead contamination around the soil (very unlikely). Thus, the finding in this study demonstrating that wooden utility poles, in part, contribute to arsenic contamination is in agreement with the findings by Coles [1], Zagury [30], Cao [31], Stilwell [32], Shiralipour [33], and Mortimer [34] in which soil or plant samples near CCA treated wooden poles, deck or fence had higher levels of arsenic. More important is the finding by Dubey [38] in which high levels of arsenic were found in treated wood debris in New Orleans after hurricane Katrina. The data for the soil samples from Owerri suggest that either the wooden utility poles were not treated with CCA or any arsenic leachable preservatives or were not treated at all.

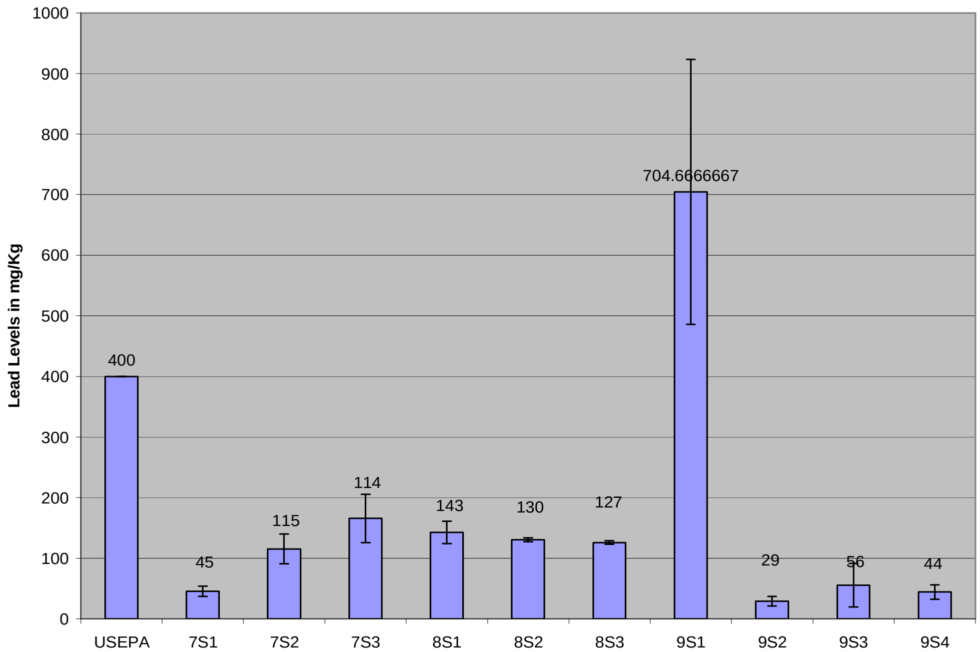

Fig. 1. Average lead levels (mg/Kg) in soil samples from near wooden utility poles in New Orleans, LA, USA; 7, 8, 9 = 7th, 8th, and 9th wards, respectively, S1, S2, S3 = Street #1, Street #2 and street #3, respectively. Control samples had no detectable levels

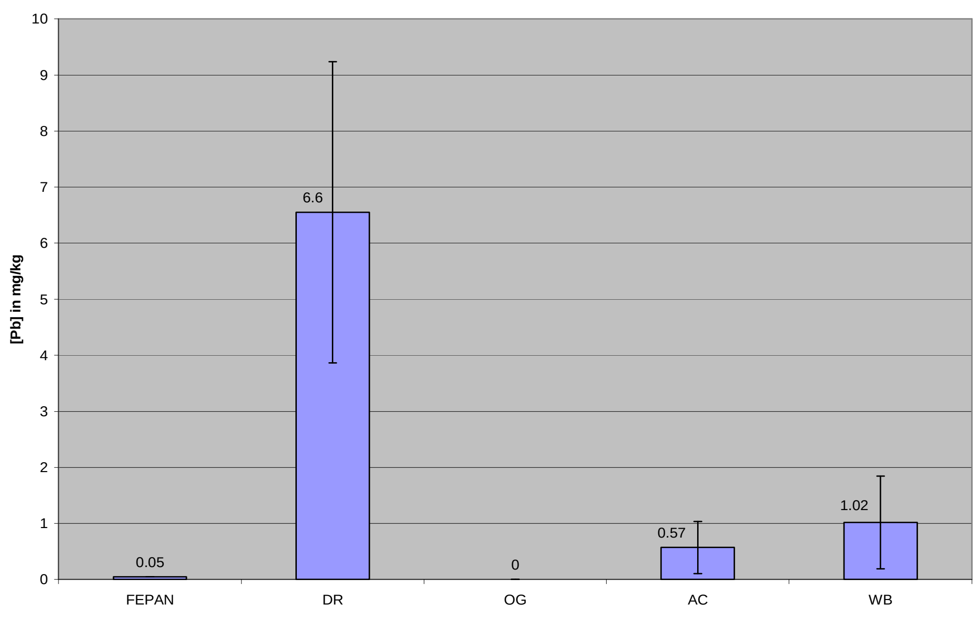

Fig. 2. Average lead levels in soil samples near wooden utility poles from Neighborhoods in Owerri, Imo State, Nigeria; FEPAN = Federal Environmental Protection Agency, Nigeria; DR = Douglass Road; OG = Owerri Girls Secondary School; AC = Assumpta Cathedral; WB = World bank

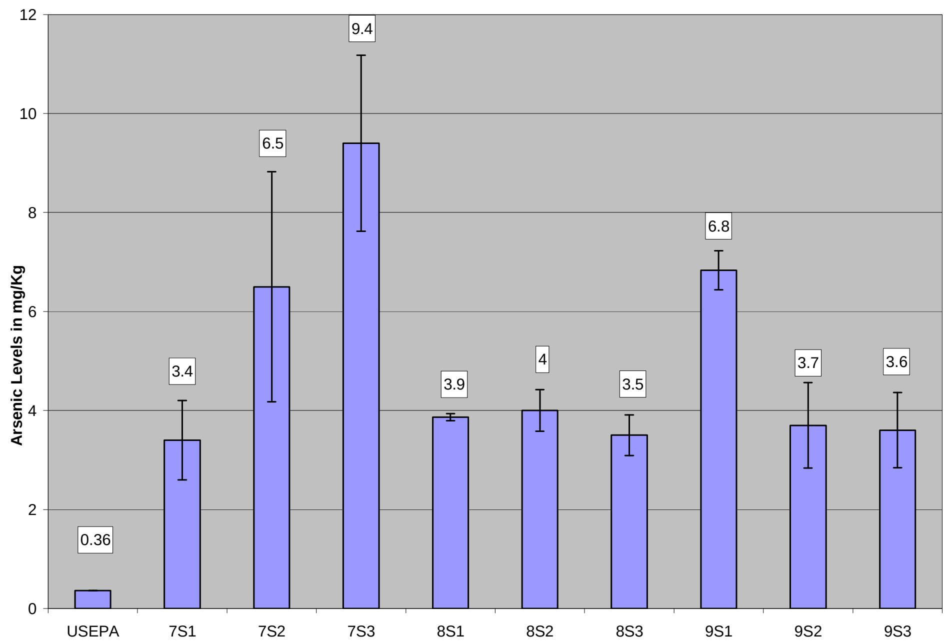

Fig. 3. Average arsenic levels in soil samples near wooden utility poles in New Orleans, Louisiana, USA; 7, 8, 9 = 7th, 8th, and 9th wards, respectively, S1, S2, S3 = Street #1, Street #2 and Street #3

4. CONCLUSIONS

The samples from Owerri city in Imo state, Nigeria were not contaminated with arsenic based on United States USEPA and Nigerian FEPAN permissible levels of 0.36 mg/Kg and 0.5 mg/Kg, respectively. This may suggest that the wooden utility poles in Owerri could have been treated with chemical agent/s other than chromated copper arsenate. Although the lead levels in Owerri soil samples were below USEPA Risk Evaluation Corrective Action Plan (RECAP) level of 400 mg/kg, 60% of those samples had lead levels above FEPAN exposure limit of 0.05 mg/kg which could be attributable to sources and practices other than the chemicals used in treating the utility poles. On the other hand, the data from the soil samples around the wooden utility poles in New Orleans clearly demonstrate that the soil samples were contaminated with arsenic levels 9-20 times above USEPA regulatory values. The only high lead samples were from the 9th Ward and is consistent with its post Katrina high lead levels. The average arsenic level of 4.9 mg/kg in this study not only suggest that the soils were highly contaminated but also bucks the reduction trend found around New Orleans neighborhoods where the average arsenic level dropped from 23.36 mg/kg post Hurricane Katrina 2005 to 3.26 mg/kg in 2010, post Hurricane Katrina recovery. It should be noted that the samples from the control site with concrete utility poles had no arsenic contamination. Thus, these results, in combination, provide the evidence that average arsenic level found in soils near the wooden utility poles is in part, attributable to the CCA used in treating the utility wooden poles. Furthermore, since there are no background data on arsenic levels in soils near wooden utility poles in New Orleans pre or post Hurricane Katrina, this study fills that void.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cynthia A. Coles, Joseph A. Arisi, Marion Organ, Geoff Veinott. Leaching of chromium, copper, and arsenic from CCA-treated utility poles. Applied and Environmental Soil Science; 2014. Article ID 167971, 11 pages.
DOI: 10.1155/2014/167971

2. Hingston JA, Collins CD, Murphy RJ, Lester JN. Leaching of chromated copper arsenate wood preservatives: A review. Environmental Pollution. 2001;111(1):53-66.
3. Lahiry AK. An introduction to environmental aspects of groundwater arsenic and CCA treated wood poles in Bangladesh, Section 5 (Environmental Aspects), Doc. IRG/WP 97 – 50081, Int. Res. Group on Wood Preservation, Stockholm; 1997.
4. Rahman FA, Allan DL, Rosen CJ, Sadowsky MJ. Arsenic availability from chromate copper arsenate. J. Environ Qual. 2004;33(1):173-180.
5. P. A. Cooper. Leaching of CCA from treated wood: pH effects. *Forest Products Journal.* 1991;41(1): 30–32.
6. Lebow S, Foster D, Evans J. Long-term soil accumulation of chromium, copper and arsenic adjacent to preservative-treated wood. Environmental Contamination and Toxicology. 2004;72:225-232.
7. Eisler R. Arsenic hazards to humans, plants, and animals from gold mining. Rev. Environ Contam. Toxicol. 2004;180: 133-165.
8. Brammer H. Threat of arsenic to agriculture in India, Bangladesh and Nepal. Economic and Political Weekly. 2008; 43(47):79-84.
9. Mielke HW. Lead dust contaminated USA communities, comparison of Louisiana and Minnesota. Applied Geochemistry. 1993; 8(Suppl. 2):257-261.
10. Cotter-Howells J, Thornton I. Sources and path- ways of environmental lead to children in a Derbyshire mining village. Environmental Geochemistry and Health. 1991;13(2):127-135.
11. Ma QY, Logan TJ, Traina SJ. Lead immobilization from aqueous solutions and contaminated soils using phosphate rocks. Environmental Science & Technology. 1995;29:1118-1126.
12. Sardis T, Chettri MK, Papaioannou A, Zachariadis G, Stratis J. A study of metal distribution from fuels using trees as biological monitors. Ecotoxicology and Environmental Safety. 2001;48(1):27-35.
13. Blowes DW, Readon EJ, Jambor JL, Cherry JA. The formation and potential importance of cemented layers in inactive sulfide mine tailings. Geochimica Cosmoshimica Acta. 1991;55(4):965-978.
14. Robert B. Finkelman. Health impacts of coal: Facts and fallacies. A Journal of the Human Environment. 2007;36(1):103-106.
15. Shih RA, Hu H, Weisskopf MG, Schwartz BS. Cumulative lead dose and cognitive function in adults: A review of studies that measured both blood lead and bone lead. Environmental Health Perspectives. 2007; 115(3):483-492.
16. Tong S. Lead exposure and cognitive development: Persistence and a dynamic pattern. Journal of Pediatrics and Child Health. 1998;34(2):114-118.
17. Canfield RL, Henderson Jr. CR, Cory-Slechta DA, Cox C, Jusko TA, Lanphear BP. Intellectual impairment in children with blood lead concentrations below 10 μg per deciliter. The New England Journal of Medicine. 2003;348:1517-1526.
18. Needleman H, McFarland C, Ness R, Fienberg S, Tobin M. Bone lead levels in adjudicated delinquents: A case control study. Neurotoxicology and Teratology. 2003;24(6):711-717.
19. Rahman M, Tondel M, Chowdhury IA, Axelson O. Relations between exposure to arsenic, skin lesions and glucosuria. Occupational and Environmental Medicine. 1999;56(4):277-281.
20. Rupali Rakhunde, Dipali Jasudkar, Leena Deshpande, Juneja HD, Pawankumar Labhasetwar. Health effects and significance of arsenic speciation in water. International Journal of Environmental Sciences and Research. 2012;1(4):92-96.
21. Reuer MK, Bower NW, Koball JH, Hinostroza E, De la Torre Marcas ME, Hurtado Surichaqui JA, Echevarria S. Lead, arsenic, and cadmium contamination and its impact on children's health in La Oroya, Peru. International Scholarly Research Network. 2011;2012(231458): 12.
DOI: 10.5402/2012/231458
22. Smith AH, et al. Cancer risks fom arsenic in drinking water. Environmental Health Perspective. 1992;97:259-267.
23. Pontius W, Brown G, Chen C. Health implications of arsenic in drinking water. Journal of American Water Works. 1994; 86(9):52-63.
24. Shilpi Oberoi, Aaron Barchowsky, Felicia Wu. The global burden of disease for skin, lung, and bladder cancer caused by arsenic in food. Cancer Epidemiol Biomarkers Prev. 2014;23(7):1187-1194.

25. Duble RL, Thomas JC, Brown KW. Arsenic pollution from underdrainage and runoff from Gulf Greens1. Agronomy Journal. 1978;70(1):71-74.
26. Belluck DA, Benjamin SL, Sampson J, Johnson B. Widespread arsenic contamination of soils in residential areas and public spaces: An emerging regulatory or medical crisis? International J. Toxicol. 2003;22:109-128.
27. Stilwell D, Gorny KD. Contamination of soil with copper, chromium and arsenic under decks built from pressure treated wood. Environmental Contamination and Toxicology. 1997;58:22-29.
28. Stilwell DE, Graetz TJ. Copper, chromium and arsenic levels in soil near traffic sound barriers built using CCA pressure–treated wood. Bull. Environ. Contam. Toxicol. 2001;67:303-308.
29. Lebow S, Williams RS, Lebow P. Effect of simulated rainfall and weathering on release of preservative elements from CCA treated wood. Environ Sci Technol. 2003;37(18):4077–4082.
30. Zagury G, Samson R, Deschenes L. Occurrence of metals in soil and groundwater near chromated copper arsenate treated utility poles. J Environ Qual. 2003;32(2):507–514
31. Cao X, Ma LQ. Effects of compost and phosphate on plant arsenic accumulation from soils near pressure treated wood. Environ. Poll. 2004;132:435-442.
32. David E. Stilwell, Craig L. Musante, Brij L. Sawhney. Copper, chromium, and arsenic in soil and plants near coated and uncoated CCA wood, Proceedings of the Annual International Conference on Soils, Sediments. Water and Energy. 2010;11: article 10.
33. Shiralipour A. Arsenic uptake released from CCA treated lumber by Florida vegetable crops. Report HW155-04. Florida Center for Solid and Hazardous Waste Management, Gainesville, FL; 2004.
34. Mortimer WP. The environmental persistence and migration of wood pole preservatives. Report for the Canadian Electrical Association, CEA, Montreal, Quebec, Canada; 1991.
35. Mielke HW. Lead in New Orleans soils: New images of an urban environment. Environmental Geochemistry and Health. 1994;16(3-4):123-128.
36. Mielke HW, Smith MK, Gonzales CR, Mielke PW. The urban environment and children's health: Soils as an integrator of lead, zinc and cadmium in New Orleans, Louisiana, U.S.A. Environm-ental Research. 1999;80(2):117-129.
37. Rotkin-Ellman M, Solomon G, Gonzales CR, Agwaramgbo L, Mielke HW. Arsenic contamination in New Orleans soil: Temporal changes associated with flooding. Environmental Research. 2010; 110(1):19-25.
38. Brajesh Dubey, Helena M. Solo-Gabriele, and Timothy G. Townsend. Quantities of arsenic-treated wood in demolition debris generated by Hurricane Katrina. Environ. Sci. Technol. 2007;41(5):1533-1536.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14879