http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (23): 4311-4314, 2007
ISSN 1028-8880

Trace Elements in Sawdust Particles in the Vicinity of Sawmill in Sapele, Nigeria

G.E. Nwajei and C.M.A. Iwegbue
Department of Chemistry, Delta State University, P.M.B. 1, Abraka, Nigeria

Abstract: This study report the results of determination of concentrations of lead, cadmium, chromium, barium, arsenic and mercury in sawdust particles collected in the vicinity of wood sawmill in Sapele and its environs. The mean levels of the elements observed ranged from 40-250 mg kg^{-1} for Pb; 0.50 mg kg^{-1} for Cd; 1.46-160.50 mg kg^{-1} for Cr; 1.50-94.0 mg kg^{-1} for Ba; 32.0-84.0 mg kg^{-1} for As and 0.50-40 mg kg^{-1} for Hg. The levels of these trace elements observed in the sawdust particles exceeded permissible occupational exposure limits. Sawdust particles constitute serious health risk to human and the environment in general.

Key words: Sawdust, trace elements, health risk, environmental pollution

INTRODUCTION

The environment is constantly being spoiled and rendered very unsafe for human habitation and other organisms. This is attributed to various activities of man such as mineral exploitation, agricultural practices, industrial production, food processing, social, domestic and commercial activities.

The availability of lead in plant is dependent upon a contamination of soil condition and the response of the root to lead in the soil water (Andrews *et al*., 1989). Heavy metals have great significance due to their toxicity and accumulative behaviour and are not biodegradable, may undergo a global ecological cycle (Iwegbue *et al*., 2006). Lead aerosols are usually absorbed on mushrooms, trees, juice of ripe fruits and even the skin of animals causes lead poisoning in them (Lazor *et al*., 1999). The elevated metal concentrations in mushrooms from urban area are traceable to domestic wastes, emissions and effluents arising from industries while those mushrooms obtained from Abraka are due to the presence of Sawmills (Nwajei, 2005). Wide differences have been observed in elemental concentrations of arsenic, cobalt, chromium, iron, selenium and manganese in dust particulates collected from different locations (Ambulkar *et al*., 1994). Heavy metals produce toxicity by forming complexes or ligands with organic compounds (Wilspenyer, 1994). Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissue. The heavy metals that most commonly cause problems in humans are lead, mercury, cadmium, arsenic, nickel and aluminum. These metals tend to accumulate in the brain, kidneys and immune system where they can severely disrupt normal function (Passwater and Cranton, 1993; Gerstner and Huff, 1997).

Woodworking operations using dry wood generate more total dust and a greater amount of inhaleable dust particles than those using moist wood. Various studies have shown that the increase risk of nasal cancer is caused by wood dust rather than simultaneous exposures to other substances such as formaldehyde. Asthma may occur in worker exposed to wood dust (IARC, 1995). Wood dust is usually produced in woodworking industries as a by-product of manufacturing wood products. Heavy metals are known to be carcinogenic and wood dust is associated with carcinogenic effects because dust generated by woodworking typically consists of a high proportion of particles that are deposited in the nasal cavity, hence it became necessary for this study. The objectives of this study is determine concentrations of heavy metals in sawdust from various sawmills to view the provide information impact on human health and the environment.

MATERIALS AND METHODS

Description of study area: Amukpe, Ughradua and Okonoko are quarters in Sapele Local Government Area is situated in Niger Delta Basin of the Southern part of Nigeria. It lies between latitude 34° North and 35° South of the Equator and longitude 134.5° West and 126° East of the Greenwich Meridian covering an area of about 2500 km^2. Ethiope Local Government Area on the North West by Edo State bound it on the North West. West by Warri Local Government Area and South West by Okpe Local Government Area. Some of the areas are also by Ethiope River. The area is about 80-200 m above sea level and richly endowed with a number of natural resources, timber, fisheries, wildlife and petroleum, etc. Three major industries located in the study area include Eternit

Corresponding Author: C.M.A. Iwegbue, Department of Chemistry, Delta State University, P.M.B. 1, Abraka, Nigeria

Roofing Sheet Company, Africa Timber Plywood Industry (AT and P) and the Power Holdings Company of Nigeria (PHCN).

Sampling and analysis: Sawdust samples were collected in 15 sawmill locations from Amukpe, Ughradua and Okonoko quarters, all in Sapele metropolis. The sawdust was collected in clean plastic containers with stoppers. Immediately after collection they were air dried and returned to the stoppered plastic containers. The sawdust samples were sieved through 10 μm sieve and stored in a refrigerator prior to digestion.

Two gram of the sieved sawdust was weighed and digested in acid mixture prepared from 15 mL nitric acid and 3 mL perchloric acid. The solutions were kept on a hot plate at 130°C for 2 h. The clear digest was slowly evaporated and on cooling, the solution was filtered and the filtrate was diluted to 25 mL using deionized water. The solutions were stored at 4°C prior to analysis. The metal content of the sample solution was determined using atomic absorption spectrophotometry (Buck Scientific Model 210 VGP). Mercury and Arsenic was determined using atomic absorption spectrophotometry equipped with cold vapour and hydride generation assemblies, respectively. The reliability of the whole analytical procedure was assured by spiking already analysed sawdust samples with known concentrations of metals and reanalyzed. The percentage recoveries for the metals are 93% for lead, 91% for cadmium, 90% for barium, 94% for arsenic; 92% for chromium and 98% for mercury.

RESULTS AND DISCUSSION

The results of determination of lead, cadmium, chromium barium, arsenic and mercury in sawdust samples collected around the wood saw mill sites in Sapele and its environs are given in Table 1. The concentration of pattern of heavy metals in the dust particles follows the order As>Cr>Pb>Ba>Hg>Cd. Little or no data are currently available on the heavy metal status of sawmill dust hence comparison in this study will be made with street and household dust. Analysis of variance (ANOVA) ($p<0.05$) revealed that there is no significant difference in the mean concentration of lead collected from given site at the different sampling regimes. However, significant variability exists in sites 7, 8, 9, 10, 14 and 15. The concentrations of lead observed in the various sampling sites appear to be similar. This could be due to the nature of wood sawed in this area. Sites 5, 7 and 15 showed significant higher levels of lead compared to any other sites. The concentrations of lead observed in this study lower than concentration of lead in falling dust

Table 1: Mean±SD of trace elements in sawdust particles collected in the vicinity of Sawmill in Sapele

		Trace metals in mg kg^{-1} dry weight					
Site		Pb	Cd	Cr	Ba	As	Hg
1	Mean±SD	4.00±1.63	0.50±0.23	1.46±0.30	15.50±2.89	60.00±9.24	40.50±2.89
	Range	2.00-6.00	0.30-0.70	1.20-1.72	13.00-18.00	52.00-68.00	38.00-43.00
2	Mean±SD	4.00±1.16	0.50±0.116	119.50±16.74	19.50±2.09	48.00±6.93	4.50±1.73
	Range	3.00-5.00	0.40-0.60	105.00-134.00	17.50-21.50	42.00-54.00	3.00-600
3	Mean±SD	4.00±0.58	0.50±0.12	89.85±4.34	17.50±2.89	60.00±3.46	3.00±0.41
	Range	3.50-4.50	0.40-0.60	82.00-97.00	15.00-20.00	57.00-63.00	2.50-3.50
4	Mean±SD	4.00±0.41	0.50±0.23	87.00±0.08	10.00±2.31	72.00±3.46	1.00±0.23
	Range	3.50-4.50	0.30-0.70	80.00-94.00	8.00-12.00	69.00-75.00	0.80-1.20
5	Mean±SD	250.00±34.64	0.50±0.35	108.00±9.24	94.00±3.27	60.00±5.77	1.00±0.35
	Range	220.00-270.00	0.20-0.80	100.00-115.00	90.00-98.00	55.00-65.00	0.70-1.30
6	Mean±SD	4.00±1.12	0.50±0.23	110.50±6.35	13.00±3.46	48.00±2.31	2.00±1.16
	Range	3.00-5.00	0.30-0.70	105.00-116.00	10.00-16.00	46.00-50.00	1.00-3.00
7	Mean±SD	250.00±57.74	0.50±0.29	136.50±7.51	7.00±1.73	48.00±2.89	1.50±0.58
	Range	200.0-300.0	0.00-1.00	130.00-143.00	5.50-8.50	45.50-50.50	1.00-2.00
8	Mean±SD	4.00±0.88	0.50±0.19	119.50±10.39	15.00±2.08	60.00±4.16	1.50±0.17
	Range	2.50-5.50	0.34-0.66	110.00-128.00	13.20-16.80	56.40-63.60	1.35-1.65
9	Mean±SD	4.00±1.33	0.50±0.21	148.00±22.46	35.00±5.25	48.00±6.14	0.50±0.23
	Range	2.85-5.15	0.32-0.68	128.55-167.45	30.45-39.55	42.68-53.32	0.30-0.70
10	Mean±SD	4.00±2.31	0.50±0.16	70.00±4.04	14.50±2.48	48.00±4.85	1.00±0.52
	Range	2.00-6.00	0.36- 0.64	66.50-73.50	12.35-16.65	43.80-52.20	0.55-1.45
11	Mean±SD	4.00±1.73	0.50±0.25	160.50±17.67	67.00±5.77	72.00±8.66	1.50±0.35
	Range	2.50-5.50	0.28-0.72	145.20-175.80	62.00-72.00	64.50-79.50	1.20-1.80
12	Mean±SD	4.00±0.92	0.50±0.37	79.00±10.39	23.50±4.04	84.00±10.39	1.00±0.46
	Range	3.20-4.80	0.18-0.82	70.50-88.50	20.00-27.00	75.00-93.00	0.60-1.40
13	Mean±SD	4.00±1.04	0.50±0.17	84.50±15.24	1.50±0.40	48.00±9.238	2.00±1.10
	Range	3.10-4.90	0.35-0.65	70.80-97.20	1.15-1.85	40.00-56.00	1.05-2.95
14	Mean±SD	4.00±1.21	0.50±0.35	124.50±10.39	9.50±2.66	60.00±6.00	2.00±0.58
	Range	2.95-5.05	0.20-0.80	115.50-133.50	7.25-11.80	54.80-65.20	1.50-2.50
15	Mean±SD	250.00±22.52	0.50±0.23	86.00±6.93	72.00±5.49	36.00±4.19	4.00±1.39
	Range	230.50-269.50	0.30-0.70	80.00-92.00	67.25-76.75	32.00-40.00	2.80-5.20

in the eastern areas of Mazowiekie province (Krolak, 2000) and street dust of Istabul, Turkey (Yetimoglu *et al*., 2007), street and household dust from Bahrain (Alhter and Madany, 1993). Apart from food, the major source of lead to human body is through inhalation of lead contaminated dust. Lead has been associated with reduced IQ, learning disabilities, slow growth, hyperactive, antisocial behaviour and impaired hearing. Lead is known to damage the liver kidney and reproductive system, basic cellular processes and brain function (Dahiya *et al*., 2005). Like lead, the concentrations of cadmium show no significant variability. However, the levels of cadmium observed in given site at different sampling regime show significant variation. The levels of cadmium observed in the sawdust particle in this study are lower than any other metals studied. The levels of cadmium found in the present study are of comparable to 0.3 mg kg^{-1} observed in street dust of Istanbul Turkey (Yetimoglu *et al*., 2007) and lower the levels reported for falling dust (10.8 mg kg^{-1}) in Poland (Krolak, 2000) and in street and household dust (72 and 37.0 mg kg^{-1}) from Bahrain (Alhter and Madany, 1993).

Chromium showed no significant variability when samples collected from the same site are compared. However significant variability ($p<0.05$) exist when different sites are compared. Chromium is the second most abundant element in this study. The highest level of chromium was found in site 1 (160.0 mg kg^{-1}). The major source of chromium in sawdust chemicals used in wood preservation. For example, Jack and Bhattacharya (1998) and Bahattacharya *et al.* (2002) have noted that chemicals such as copper sulfate, boliden salt (BIS-salt) mixed with zinc sulfate and chromated copper arsenate (CCA) have be used as common wood preservative for more than 50 years. Chromium (VI) is a known carcinogen. Inhalation of sawdust particles containing excessive amount of chromium could induce cancer in human. The concentration of chromium reported in the studies are higher the levels found in falling dust (Krolak, 2000) and similar to levels reported for street dust in Bahrain (Alhter and Madany, 1993).

The concentrations of barium in dust particles showed appreciable variation ($p>0.05$) when sites are compared. The high levels of barium was found in sites 5, 11 and 15. Barium is extremely toxic, excessive concentration of barium in sawdust particles present a potential health risk to human in the vicinity of these facilities. The levels of barium reported in this study is higher than levels encountered in soils (Nwajei *et al*., 2007). Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), American Conference of Government Industrial Hygienists (ACGIH) sets Occupational exposure limit of 0.5 mg m^{-3} for an 8 h workday. OSHA exposure limit for barium sulfate dust in air 5-15 mg m^{-3}. NIOSH recommends that 50 mg m^{-3} be considered immediately dangerous to life and health (Anonymous, 2004). The levels of barium observed in the sawdust particles in all sites exceeded the OSHA exposure limits for barium sulfate dust in air. The mean concentrations of arsenic in sawdust particles in these sites varies between 36.0-84.0 mg kg^{-1}. The high levels of arsenic in the sawdust is associated with chemicals such the mixture of Boliden (BIS) and zinc sulphate and CCA used for industrial wood preservation. The wood preservative contains about 27.7-36.0% of diarsernic pentoxide AS_2O_5 as its major component (Jacks and Bhattacharya, 1998). Ocupational Safety and Health Administration (OSHA) maximum permissible exposure limit for work place airborne arsenic is 10 μg m^{-3} for breathing sawdust or burning smoke from wood containing arsenic. The levels of arsenic we found in sawdust particles exceeded the OSHA maximum permissible limits. Arsenic is highly poisonous to human. Arsenic damage many tissues including nerves (peripheral polyneuropathy, axonal degeneration), stomach and intestine. Breathing high levels of arsenic can give sore throat and irritation of lungs. Site 1 has significant higher concentration of mercury ($p<0.05$) than any other sites, apart from this site, the levels of mercury in the sawdust samples range between 1.00-45.0 mg kg^{-1}. The levels of mercury observed in the sawdust particles are higher than workplace air limit of 1 mg/10 m^3. Mercury is extremely toxic. Exposures to higher levels of mercury can permanently damage the brain, kidneys and developing fetus. Inhalation of high concentration cause acute pulmonary edema and interstitial pneumonitis and kawaski disease, which seem to be immonologically mediated and is similar to pink disease (Anonymous, 2004).

CONCLUSION

According to the data presented in this study. It can be concluded that sawdust particles contain elevated levels of Cd, Pb, Ba, Cr, As and Hg and the levels of these elements in dust particle exceeded permissible occupational exposure limits for a 8-hour workdays.

Sawdust particles constitute seriously environmental health risk not only the worker in these mills but to general environment since dust particles with such elevated levels of metals could contaminate air, soil and surface water bodies in the vicinity of such facilities.

ACKNOWLEDGMENTS

The author wishes to acknowledge Miss Theresa W. Aruegbe for her assistance in sawdust samples

collection. Secondly, the authors are grateful to Mr. Harrison Igene and Mr. Esohe Uwumarongie of Green Consultants Limited, Benin City for atomic absorption analysis.

REFERENCES

Alhter, A.S. and S.M. Madany, 1993. Heavy metal in street and household dust in Bahrain. Water Air and Soil Pollut., 66: 111-119.

Ambulkar, N.M., N.L. Chutke, A.L. Aggarival and A.N. Garg, 1994. Multielemental analysis of ambient air dust particulates from a cement factory by Neutron activation. Sci. Total Environ., 141: 93-101.

Andrews, S.M., M.S. Johnson and J.A. Cooke, 1989. Distribution of trace elements pollutants in a contaminated grassland ecosystem established on melaliferous fluorspar tailings. J. Environ. Pollut., 58: 73.

Anonymous, 2004. Heavy metal toxicity. http://www.tuberose.com.

IARC, 1995. Wood dust: IARC monographs on the evaluation of carcinogenic risk of chemicals to human. Lyon, France, International Agency for Research on Cancer, 62: 35.

Bahattacharya, P., A.B. Mukherjee, G. Jack and S. Nordqvist, 2002. Metal concentration at a wood preservation site: Characterization and experimental studies on remediation. Sci. Total Environ., 290: 165-180.

Dahiya, S., R. Karpe, A.G. Hegde and R.M. Sharma, 2005. Lead, cadmium and nickel in chocolates and candies from suburban areas of Mumbai. India J. Food Comp. Anal., 18: 517-522.

Gerstner, B.C. and J.E. Huff, 1997. Clinical toxicology of mercury. J. Toxicol. Environ. Health, 2: 167-471.

Iwegbue, C.M.A., G.E. Nwajei and N.O. Isirimah, 2006. Characteristic levels of heavy metals in sediment and dredged sediment of municipal creek in the Niger Delta, Nigeria. Environmentalist, 26: 129-133.

Jack and Bhattacharya, 1998. Arsenic contamination in the environment due to the use of CCA-wood preservative. In: Arsenic in wood preservatives. Part 1. Exemption Substance Project Swedish National Chemicals Inspectorate KEMI Report 3/98, pp: 7-75.

Krolak, E., 2000. Heavy metals in fall dust in Eastern Mazowieckie Province. Polish J. Environ. Stud., 9: 517-522.

Lazor, A.C., R.T. Reilly, W.B. Whitten and J.E. Ramsey, 1999. Real-time surface analysis of individual air-borne environmental particles. Environ. Sci. Technol., 23: 3993-4001.

Nwajei, G.E., 2005. Trace metals in mushrooms from urban and rural areas in delta state of Nigeria. J. Chem. Soc. Nig., 30: 1-4.

Nwajei, G.E., C.M.A. Iwegbue and M.I. Okafor, 2007. Heavy metal in surface soil under waste dumps from Onitsha Nigeria. J. Biol. Sci., 7: 405-408.

Passwater, R.A. and E.M. Cranton, 1993. Trace Elements Hair Analysis and Nutrition. Hew Canan Ct: Keasts, pp: 38.

Wilspenyer, M., 1994. Heavy metals in hair samples from Australia and Italy. Sci. Total Environ., 156: 235-242.

Yetimoglu, E.K., O. Ercan and K. Tosyali, 2007. Heavy metal contamination in street dust of Istabul (Pendik to Levent) E-5 Highway. Annali di Chimica, 97: 227-235.