Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

Heavy Metal Status of Soils Affected by Leached Ash Refuse from Black Soap-Making at Ikere-Ekiti, Nigeria

O.J. Ayodele and Shittu, O.S
Department of Crop, Soil and Environmental Sciences, Ekiti State University, Ado-Ekiti, NIGERIA

Abstract

Large quantities of leached wood ash residue, after obtaining lye needed for black soap-making at a facility in Ikere-Ekiti, Nigeria, had piled up on the surrounding land during over five decades of operation. Surface (0-15 cm) and sub-surface (15-30 cm) soil samples taken at 0, 15, 30, 60, 75, 105 and 150 m from the ash refuse pile were analyzed and compared with an area not impacted by ash. The soils were slightly alkaline to moderately alkaline silty loam to sandy clay loams with medium to high organic matter, available P and exchangeable cations. The valley bottom (150 m) contained the highest values of these chemical fertility indices while Ca and Mg were most abundant at 0 m. The control soil sample was slightly acid with low organic matter and exchangeable cations. Distribution pattern of the heavy metals differed in relation to distance from the ash refuse pile: Co increased from 0 m to 75 m and decreased thereafter; Cr decreased from 0 m to 30 m and increased to the highest value at 60 m; Cd increased with distance; Pb had highest value at 30 m of the topsoil and 60 m of the sub-soil; Ni was highest at 150 min the topsoil and sub-soil. Soil pH showed significant negative correlations with Co and Cd in the topsoil and with Co and Ni in the sub-soil. Accumulative factors- contamination factor (CF) and pollution load index (PLI) - were calculated to assess heavy metal pollution. Contamination with Co, Cd and Ni was low in the surface and sub-surface samples and moderate to considerable for Cr and Pb. Pollution Load Index shows low heavy metal accumulation in the topsoil and sub-soil contamination at 60 and 90 m from the ash refuse pile. The short- and long-term health implications of heavy metal contamination of soils in the vicinity of ash refuse pile were discussed.

Keywords: wood ash, topsoil, subsoil, heavy metals, soil analysis, contamination, index analysis approach

Introduction

Industrialization to attain the goal of non-primary production, particularly manufacturing, is vital to socio-economic development and its level has been used to categorize countries as developed or undeveloped. Nigeria has enunciated policies predicated on the premise that industrialization contributes to economic growth, effective use of available resources, increased local content of industrial output, increased export of manufactured goods, reduction in import dependence and attraction of foreign investment capital (FMI, 2003). Intense activities needed for rapid growth in the industrial sector have brought out the need to recognize and understand the interrelationships between pollution, public health and environment.

All industrial activities use natural resources and produce some wastes discharged into the air, water and land to contaminate, pollute and degrade the environment. Several ecological and human disasters which have continuously occurred within the past 40 years implicate industries as the major contributors to pollution problems of various magnitudes and degradation of the environment. This is because industrial wastes (discharges, effluents and emissions) contain certain substances which include the heavy metals and organic chemicals (Gbadebo *et al.*, 2010). Heavy metals are among the most common pollutants whose occurrence in soils is an indication of man-induced pollution (from anthropogenic sources) rather than natural enrichment by geological weathering (Rabee *et al.*, 2011). The anthropogenic heavy metals accumulate readily in the topsoil and would cause toxicity to plants and animals with detrimental effects on human health (Ogunfowokan *et al*, 2005; Jimena *et al*, 2008).

Many brands of manufactured soaps are displayed on the shelves in supermarkets just as numerous varieties of hand-made ‘natural’ soaps exist. The process of soap-making is that developed centuries ago involving the saponification reaction between lye (alkaline solution got from leaching ash) and vegetable oil or animal fats (tallow). Industrial soap is produced in four basic steps: saponification- mixture of animal fat and coconut oil is mixed with caustic soda (sodium hydroxide, NaOH) and heated to produce the salt of long chain carboxylic acid; removal of glycerine; soap purification and finishing (Wansbrough, 2002). The environmental concern in soap manufacture was little, being related to noise pollution, because of safe transport and containment of raw materials and minimization of losses. However, spills of oils, caustic soda and perfumes occur through tank rupture or valve failure but which can be isolated and the effects neutralized. Also, factory wastes (discharges, effluents) are piped into interception tanks where alkalinity or acidity of the content is monitored and excess solids or light phase chemicals settled before draining into the municipal waste system. Off-spec products and wash-out water are re-processed rather than dumped. Besides, the manufacturing process is monitored through continuous measurement of key properties of raw materials, intermediates and finished products. With increase in the level of awareness and enactment of relevant environmental protection laws and enforcement agencies, environmental safety issues are now constantly addressed. For example, Regulation 36 of National Environmental Standards and Regulation Enforcement Agency is National Environmental (Pollution Abatement in Chemicals, Pharmaceuticals, Soap and Detergent Manufacturing Industries) Regulations, 2009 (Ladan, 2012)

Black soap (Ose Dudu, Anago soap, Alata simena) is a hand-made specialty which has become popular for its skin rejuvenating properties, especially in reducing wrinkles and fine lines (Popovitch, 2013). It is a deep pore cleansing soap believed to cure acne, remove blemishes and heal dry and cracked skins. Black soap-making involves use of various natural ingredients and other secret additives such that the colour and texture of the product tend to differ among the tribes in West Africa. Ash is leached in pots and the leachate is mixed with vegetable oil (e.g. palm kernel oil) and stirred continually with moderate heat from fire wood until the mixture solidifies to form black soap which is allowed to cool and cut into pieces for use or sale. Unfortunately, with the low level of environmental awareness and because such small-scale operations are not captured in the environmental safety compliance and pollution abatement laws and regulations, degradation can go on unnoticed in the environment. Afao Quarter in Ikere-Ekiti, Ekiti State, is one of the places where black-soap is produced in Nigeria and after several years of operation, leached ash residue from the site has piled up and spread to adjoining land and down the slope by seasonal rainfall and runoff. Most of the area is now residential but occasional backyard garden crops (maize, leaf vegetables- amaranth, water leaf, bitter leaf; fruit vegetables- tomato, okra, garden egg; plantain/banana, pawpaw, citrus etc) are grown.

Wood ash contains typically low amounts of heavy metals, in relation to the level in the soil and amounts absorbed by the different species of woody trees and shrubs, and so may pose little threat to the environment. Average values of cadmium (Cd), copper (Cu), lead (Pb), mercury, nickel (Ni) and zinc (Zn) in wood ash are 3, 70, 65, 1.9, 20 and 233 $mg.kg^{-1}$ (Risse and Harris, 2011). When used as soil amendment, wood ash (pH= 9-13) raises soil pH and the heavy metals become chemically-bound to the soils which would reduce their solubility and bioavailability. Thus, the heavy metals may accumulate in the soil such that monitoring the levels has elicited substantial interest. This study was designed to assess the heavy metal threats to the adjoining soil environment posed by the long-term ash pile refuse from a black soap-making facility at Ikere-Ekiti, Nigeria in relation to distance from pollution source.

MATERIALS AND METHODS

Study Site: Afao Quarter, Ikere-Ekiti (lat. 7°39'N, long. 5°33'E) is renowned for the production of black soap. The study site is one of the places where black soap production had taken place for over 50 years before it was abandoned and on which a large quantity of leached ash refuse had piled up. The land has a northward slope into the basin formed by a nearby stream and was chosen for sampling because of susceptibility to contamination by runoff and other erosion agents from the refuse pile.

Soil sample collection, preparation and analysis: Sampling took place at specific distances: 0, 5, 15, 30, 75, 105 and 150 m from the ash refuse pile, and a control location where the influence of the ash was absent and labelled as TP_0, TP_{15}, TP_{30}, TP_{60}, TP_{75}, TP_{105}, TP_{150} and CP, respectively. Surface (0-15 cm) and sub-surface (15-30 cm) soil samples were taken randomly at the locations, bulked for a composite for each layer in the location.

Soil samples were air-dried, slightly crushed in agate mortar and pestle, and sieved to <2 mm. Particle size distribution, pH, organic matter, total nitrogen, available phosphorus, exchangeable cations and acidity, and available micronutrients of the soil samples were determined using the laboratory analytical procedures described in IITA (1979) Laboratory Manual. One gram (1 g) of each sample was weighed into a digestion tube and 100 ml of a mixture of concentrated nitric acid and perchloric acid (in 2: 1 v/v ratio) added. The mixture was heated at 150°C for 90 minutes on a Tecator Digestor and the temperature increased to 230°C for another 30 minutes. The digest was allowed to cool and washed into 50 ml volumetric flask and made up to mark. Heavy metals were determined from the digest on an atomic absorption spectrophotometer.

The extent of soil pollution was compared to a baseline concentration and indicators of heavy metal enrichment calculated.

(1) Contamination Factor (CF) = $\frac{C_m \text{ sample}}{C_m \text{ background}}$

where C_m (sample) = mean of the concentrations of individual metals from all distances

C_m (background) = background or baseline concentration of individual metal

The interpretation is as follows: $CF<1.0$= low contamination; $1<CF<3$= moderate contamination; $3<CF<6$= considerable contamination and $6<CF$= very high contamination

(2) Pollution Load Index (PLI) = $(CF_1 \times CF_2 \times CF_3\text{-------} CF_n)^{1/n}$

where n= number of metals investigated

CF= Concentration factor

= ratio of concentration of each metal in sample to the baseline soil

n= number of heavy metals

PLI value below or close to 1 means baseline heavy metal loads while >1 means heavy metal pollution or accumulation at the site

RESULTS

Table 1 shows some characteristics of the surface layer (0-15 cm) of soils in the study area. Soil pH was slightly alkaline to moderately alkaline compared to slightly acid in the control. The highest value (pH= 8.3) was obtained at 0 m and decreased with distance from the ash pile. The soil at 0 m was a silt loam, being mainly ash material; the control and soil at 150 m were sandy loams while the others were sandy clay loams. Soil organic carbon varied between 1.14 and 3.37%, with the highest value at 150 m compared to 0.46% in the control. Total N varied between 0.14 and 0.43% in samples from the location and was 0.06% in the control. Available P ranged between 9.4 and 33.9 mg.kg^{-1} while the trend of exchangeable cations was highest values of K at 30 m and 150 m, Ca and Mg at 0 m and Na at 150 m. The properties of sub-surface (15-30 cm) soil samples are shown in Table 2. The soil was a sandy loam at the control site; silt loam at 0 m while others were sandy clay loams. Soil pH ranged from 6.90 to 8.40 (neutral-alkaline) in the location and indicated a decrease with distance from ash refuse pile while the control was slightly acid (pH=6.30). Organic matter ranged from 0.93 to 3.40% in the location and was only 0.34% in the control sample.

The heavy metal contents of top soil (0-15 cm) and sub-soil (15-30 cm) samples are shown in Table 3. Co and Cd values were highest in the topsoil of the control while Pb, Cr and Ni have highest values at 30, 75 and 150 m location, respectively. Co and Ni were highest in the sub-soil of the control, Cr and Pb were more concentrated in the sub-soil at 60 m while the highest value of Cd was obtained at 150 m.

Correlation coefficients of top soil and sub soil properties with concentrations of heavy metals are shown in Tables 4. Co in the topsoil showed positive and significant correlation with sand content and negative correlation with silt, pH and ECEC. The correlation of Cd with pH was negative and significant. In the sub-soil there was strong correlation between Co and sand content while Co and Ni had negative significant correlation with soil pH. Table 5 shows the correlation matrix between the heavy metals in the topsoil and sub-soil samples. The pairs with positive correlations are Co/Cd, Cd/ Ni in the topsoil and Co/Ni, Cd/Ni in the subsoil while there was a negative correlation between Pb and Cd.

Table 6 shows the contamination factors calculated for the heavy metals at various distances from the ash pile refuse. The values were more than 1.0 for Cr in the topsoil throughout the study area and showed moderate contamination except at 60 m with considerable contamination. There was moderate Pb contamination at 30, 60 and 105 m and Ni at 150 m. Cd and Co had values of less than 1.0, indicating low contamination. The sub-soil was moderately contaminated with Cr; contamination with Pb was considerable over the 0-60 m distance and moderate thereafter while Cd contamination at 150 m was moderate. The contamination factors for Co and Ni were greater than 1.0. Average of the contamination factors for each metal showed that only Cr has contaminated the topsoil while the sub-soil has been contaminated by Cr and Pb. The PLI values are less than 1.0 for the surface layer of soils but increased from 0.37 at 0 m to 0.92 at 60-105 m. The trend was similar for the sub-soil with PLI less than 1.0 at 0-30 m and rose to more than 1.0 at 60 and 90 m.

DISCUSSION

The high soil pH in the location, especially at 0 m, is due to the ash which is rich in basic cations. Ash deposits from slash-and-burn agriculture tend to give surface layer of soils high pH in the first year after clearing forest vegetation for cropping (Lal, 1999). Nottidge *et al.* (2006) noted that soil pH increased linearly with amounts of ash added to an Ultisol in relation to significant reduction in soil exchangeable Al. The historical agricultural use of wood ash relates to the potentials for recycling nutrients used by trees for growth and development (Campbell, 1990) and as a liming agent. The presence of these nutrients in oxide form would explain the extent of alkalinity of wood ash (Hume, 2006) and its efficiency as limestone in neutralizing acidity in soils (Utzinger *et al*., 2008). The high organic matter level in the site can partly be attributed to the ash deposit and also to the fact that samples were taken from undeveloped plots in which several annual and perennial shrubs ensure adequate soil cover. The high available P and exchangeable cations are due to the influence of the ash as indicated by values at 0 m and which tended to decrease with distance. Addition of ash, as an amendment, caused significant increases in soil total N, available P, exchangeable Ca, and Mg and maintained effective cation exchange capacity in Ultisols such that it improved soil fertility and crop yield (Nottidge *et al*., 2006). The highest values of most soil chemical fertility indices at 150 m are due to poor drainage and accumulation of sediments typical of the inland valley systems (Ogunkunle, 2009).

The highest values of Co and Cd were obtained in the topsoil samples of the control probably due to enrichment from other processes. The Cu level was comparable to values obtained by Cottenie *et al.* (1981) and Fagbami *et al.* (1985). The heavy metals showed accumulation in the valley bottom in relation to sediments from runoff. Ghrefat and Yusuf (2006) noted that some heavy metals attached to soils can be removed by the action of water and get translocated elsewhere. Since the direction of water flow is downstream, dispersion by runoff causes the concentrations of heavy metals to be higher in the soils down slope than in nearby control sites (Ngole and Ekosse, 2012). Co and Ni were highest in the sub-soil of the control, Cr and Pb were more concentrated in the sub-soil at 60 m while the highest value of Cd was obtained at 150 m. The slight increases in heavy metal concentration with depth are attributed to the higher clay content in sub-soil (Lee *et al*., 1997; Paulo *et al*., 2005). However, Cernik *et al*. (1994) had observed that migration of heavy metals down the profile is naturally low and the solubility is determined by soil acidity. The ash-induced increase in pH in the surface layer is probably responsible for higher retention of heavy metals.

The negative correlations with pH are expected because heavy metal concentrations decrease with rise in soil pH. Long-term ash application caused reduction in heavy metal accumulation compared to controls, except for Cd, due to ash-induced rise in soil pH and decrease in solubility (Saarsalmi *et al*., 2001). Clay and organic matter dominate the colloidal fraction and exchange complex of mineral soils and should be able to retain heavy metals and ensure increased contamination as long as the nearby sources are active (Mmolawa *et al*., 2011) which, in this case, can come from the long-term presence of the ash refuse pile. The poor correlations with clay and organic matter do not support this view probably because of the greater influence of long-lasting liming effect. Co/Cd, Cd/ Ni in the topsoil and Co/Ni, Cd/Ni in the subsoil with positive correlations will be due to similar sources of enhancement and mutual existence in the soil, and nature of chemical and physical factors controlling their association in parent materials and in the processes involved in soil formation (Mmolawa *et al*., 2011). The strong negative correlation between Cd and Pb would suggest competition between the elements which occupy the same sites in the soil exchange lattice.

PLI is used to compare the overall heavy metal status and so, level of contamination that had occurred in different places. It represents the number of times by which the status of heavy metals in a study area exceeds the background concentration and gives a summative indication of the overall level of pollution or toxicity in a particular sample (Rabee *et al*., 2011). The low CF values for Co and Cd, moderate to considerable values for Cr, Pb and Ni in the surface and sub-surface layers of soils in the study area are responsible for the low PLI values (<1.0) for the location. The low PLI for surface layer and subsoil at 0-30 m and increase to 0.92 to 0.96 at 60 and 105 m and 1.02 and 1.13 at 60 and 90 m, respectively meant heavy metal enrichment in relation to the direction of runoff and so deposition of surface soil materials eroded from the upper slope locations.

The heavy metals that should be of concern in the environment are Cr, Ni and Pb. However, soil Pb values are lower than 75 mg.kg^{-1} critical level (Kabata-Pendias and Pendias, 1992) and 70-300 mg.kg^{-1} international threshold values in soils given by EU, UK, USA and Canada Regulation Systems (CCME, 2001). Besides, it is less than 100 mg.kg^{-1} maximum permissible limits in soils (FAO/WHO, 2001) and so would not pose serious environmental problems. The threshold value for Ni at 40 mg.kg^{-1} (Kabata-Pendias and Pendias, 1992) and the range of 50 to 210 mg.kg^{-1} as international threshold values (CCME, 2001) suggest that it is not a pollution threat. Greman and Vodnik (2003) had noted that high Ni level would pose a threat if plants grown in enriched soils are consumed by man and livestock. Also Cr is lower than 400 mg.kg-1 maximum permissible limit (WHO/FAO, 2001) and 180-1,500 mg.kg^{-1} threshold values used in the EU, UK and USA and but exceed the 6.4 mg.kg^{-1} of the Canadian regulatory system (CCME, 2001). Once elevated heavy metal concentration occurs in any component of the environment, it cannot be completely eliminated but the effect can be mitigated through immobilization. The use of plants to accumulate the contaminants and so restrict the dissemination from the source of pollution has been an interesting aspect of environmental research. Some plants are indicators of pollution (Nathalie and Sylvie, 2002). Excluders limit the levels of heavy metal translocation within them and maintain low concentration in their shoot over a wide range of soil levels while accumulators concentrate the elements in their tissue and so can be used to extract them from contaminated sites (Rotkittikhum *et al*., 2006).

REFERENCES

Campbell, A.G. 1990. Recycling and disposing of wood ash. *Tappi Journal* 73: 141-146

CCME, 2001. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table. Canadian Council of Ministers for the Environment, Winnipeg, Canada.

Cernik, M., Federer, P., Borkovec, M. and Sticher, H. 1994. Modelling of heavy metal transport in a contaminated soil. *J. Environ. Qual.* 23: 1239-1248

Cottenie, A., Kang, B.T., Kiekens, L., and Sajjapongse, A. 1981. Micronutrient status. In: Greenland, D.J. (Ed) Characterization of Soils in Relation to their Classification and Management: Examples from Areas in the Humid Tropics. Oxford University Press, Oxford: 149-163

Fagbami, A., Ajayi, S.O. and Ali, E.M. 1985. Nutrient distribution in the basement complex soils of the tropical dry rainforest of south-western Nigeria: 2. Micronutrients- zinc and copper. *Soil Science* 139: 531-537

FMI, 2003. Industrial Policy of Nigeria (Policies, Incentives, Guidelines and Institutional Framework). Federal Ministry of Industry, Garki, Abuja, Nigeria. 68pp.

Gbadebo, A.M., Taiwo, A.M. and Eghele, U. 2010. Environmental impact of drilling mud and cutting wastes from the Igbokoda On-shore Oil Wells. *Indian J. Sci and Tech* 3: 504-510

Ghrefat, H. and Yusuf, N. 2006. Assessing Mn, Fe, Cu, Zn and Cd pollution of bottom sediments of Wadi Al-Arab Dam, Jordan. *Chemosphere* 65: 2114-2121.

Greman, A. and Vodnik, S. 2003. Heavy metals in the environment. *J. Environ. Quality* 32: 500-506

Hume, E. 2006. Wood Ashes: How to use them in the Garden. Ed Hume Seeds.com

IITA, 1979. Selected Methods of Soil and Plant Analysis. *Manual Series* No 1. International Institute of Tropical Agriculture, Ibadan.70pp.

Jimena, M.G., Roxana, O., Satiana, Z., Margarita, H., Susana, M. and Inas-Isla, M. 2002. Industrial effluents and surface waters genotoxicity and mutagenicity evaluation of a river of Tucuman, Argentina. *J. Hazardous Materials* 155: 403-406

Kabata-Pendias, A. and Pendias, H. 1992. Trace Elements in Soils and Plants. 2nd Edition. CRC Press, Boca Raton. 365pp.

Ladan, M.T. 2012. Review of NESREA Act 2007 and Regulations 2009-2011: a new dawn in environmental compliance and enforcement in Nigeria. Law Environment and Development (LEAD) Journal 8: 118-140

Lal, R. 1999. Land use and cropping system effects on restoring soil carbon pool of degraded Alfisols in Western Nigeria. In Lal, Kimble, J.M. and Stewart, B.A. (Eds). Global Climate Change and Tropical Ecosystems. Advances in Soil Sciences. CRC Press, Boca Raton: 157-165.

Lee, B.D. Carter, B.J. Basta, N.T. and Weaver, B. 1997. Factors influencing heavy metal distribution in six Oklahoma benchmark soils. *Soil Science Society of America Journal* 61: 218-223

Mmolawa, K.B., Likuku, A.S. and Gaboutloeloe, 2011. Assessment of heavy metal pollution in soils along major roadsides areas in Botswana. *African Journal of Environmental Science and Technology* 5: 186-196

Nathalie, K. and Sylvie, D. 2002. Environmental risk of applying sewage to agricultural field. *J. Environ. Quality* 31: 1522-1527

Ngole, V.M. and Ekosse, G.I.E. 2012. Copper, nickel and zinc contamination in soils within the precints of mining and landfilling environments. *International Journal of Environmental Science and Technology* 9: 485-494

Nottidge, D.O., Ojeniyi, S.O. and Asawalam, D.O. 2006. Effect of different levels of wood ash on soil chemical properties in an acid Ultisol of southeast Nigeria. *Nigerian J. Soil Sci*. 16: 109-114

Ogunfowokan, A.O., Okoh, E.K., Adenuga, A.A. and Asubiojo, O.I. 2005. An assessment of the impact of point source pollution from a university sewage treatment oxidation pond on a receiving stream- a preliminary study. *J. Applied Sci*. 5: 36-43

Ogunkunle, A.O. 2009. Management of Nigerian soil resources for sustainable agricultural productivity and food security. In: Fasina, A.S. *et al*. (Eds). Management of Nigerian Soil Resources for Enhanced Agricultural Productivity: Proceedings of 33rd Annual Conference of Soil Science Society of Nigeria; held at University of Ado-Ekiti, Nigeria; March 9-13 2009: 9-25

Paulo, C., Gomes-Mauricio, P.F., Fontes-Aderbal, G. da Silva, Eduardo de, S.M., Netto, A.R. 2005. Selectivity sequence and competitive adsorption of heavy metals by Brazilian soils. *Soil Science Society of America Journal* 69: 353-361

Popovitch, T. 2013. About African Black Soap. http://ww.ehow.com/about_us.aspx

Rabee, A.M., Al-Fatlawy, Y.F., Abd-own, A.N. and Nameer, M. 2011. Using Pollution Load Index (PLI) and Geoaccumulation Index (I-Geo) for the assessment of heavy metals pollution in Tigris River sediment in Baghdad Region. Journal Of Al-Nahrain University (Science) 14: 108-114

Risse, M. and Harris, G. 2011. Best Management Practices for Wood Ash Used as an Agricultural Soil Amendment. Soil Acidity and Liming. Internet In-service Training, University of Georgia Cooperative Extension. http://hubcap.clemson.edu/-blpprt/bestwoodash.html

Rotkittikhun, R., Krautrachue, M., Chaiyarat, R., Ngernsanaruay, C., Pokethitiyook, P., Paijitprapaporn, A. and Baker, A.J.M. 2006. Uptake and accumulation of lead by plants from the Bo Ngam lead mine area in Thailand. *Environ. Pollution* 144: 681-688 Regulation

Saarsalmi, A.,Mãlkõnen, E. and Piirainen, S. 2001. Effects of wood ash fertilization on forest soil chemical properties. *Silva Fenn*. 35: 355-368

Utzinger, J.D., Brooks, W.B. and Touse, R.D. 2008. Effect of Wood Ashes on Garden Soil. Landscape Facts-Cooperative Extension Service, Ohio State University LF-CP 24-79

Wansbrough, H. 2002. Soap and Detergent Manufacture. XI. Detergents-A-Soap. New Zealand Institute of Chemistry. 13pp. nciz.org.nz/ChemProcesses/detergents/11A.pdf

WHO/FAO, 2001. Codex Alimentarius Commission: Food Additives and Contaminants. Joint FAO/WHO Food Standards Programme, 2001. ALINORM 01/12A: 1-289.

Table 1: Physical and chemical characteristics of the top soil at specific distances from ash refuse pile

Property	Control	0 m	15 m	30 m	60 m	75 m	105 m	150 m
Sand, %	60	30	53	46	48	58	50	55
Silt, %	22	56	18	22	30	16	21	25
Clay, %	18	14	29	32	22	26	29	20
Texture	SL	SiL	SCL	SCL	SCL	SCL	SCL	SL
pH	6.3	8.3	7.6	7.7	7.8	7.5	7.8	7.1
OM, %	0.42	2.31	1.23	2.41	1.68	1.95	1.80	3.43
Total N, %	0.02	0.16	0.11	0.32	0.22	0.24	0.26	0.52
Available P	8.12	24.35	10.32	30.40	13.40	22.54	20.52	36.85
Exch. K	0.13	0.82	0.30	1.16	0.40	0.84	0.68	2.01
Ca	1.50	13.20	7.10	7.60	8.20	6.30	9.10	7.80
Mg	0.82	9.10	6.03	6.20	6.70	4.95	6.80	5.20
Na	0.13	0.49	0.36	0.55	0.40	0.51	0.49	0.94
Acidity	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ECEC	2.75	23.61	13.79	15.15	15.70	12.61	17.07	15.95
Mn	82.20	16.00	11.30	50.80	43.22	65.50	33.20	55.20
Fe	39.20	30.40	20.30	44.20	57.80	66.80	66.20	49.50
Cu	1.05	1.61	1.22	1.44	1.80	2.43	1.10	1.85
Zn	11.00	20.60	7.15	12.85	45.70	44.15	38.05	18.85

Table 2: Physical and chemical characteristics of sub-soil samples at specific distances from ash refuse pile

Property	Control	0 m	15 m	30 m	60 m	75 m	105 m	150 m
Sand, %	65	35	62	56	66	60	54	45
Silt, %	16	48	07	17	15	16	20	30
Clay, %	19	17	31	27	25	24	26	25
Textural class	SL	SiL	SCL	SCL	SCL	SCL	SCL	SL
pH	6.30	8.40	7.50	6.80	7.10	6.90	7.30	7.20
OM , %	0.34	2.40	0.93	1.93	1.12	1.48	1.82	3.40
Total N, %	0.02	0.12	0.07	0.09	0.05	0.09	0.10	0.20
Aavailable P	6.91	23.20	7.31	21.12	9.85	18.31	19.57	33.40
Exchangeable K	0.08	0.75	0.24	0.98	0.35	0.98	0.39	12.57
Ca	0.96	14.11	4.21	9.02	7.48	14.67	6.81	11.38
Mg	0.50	5.84	3.92	1.99	3.73	2.89	9.54	9.18
Na	0.15	0.75	0.55	0.51	0.67	0.61	0.56	0.52
Acidity	0.20	0.00	0.01	0.14	0.01	0.02	0.01	0.01
ECEC	1.89	21.45	8.92	12.64	12.24	19.17	17.31	23.66
Extractable Mn	86.40	14.60	10.50	59.80	58.70	54.90	34.20	55.20
Fe	42.00	26.30	19.90	56.50	68.10	60.20	60.70	49.50
Cu	1.05	1.45	1.21	1.44	2.27	2.70	1.43	1.85
Zn	9.00	16.80	14.15	10.65	36.95	60.30	29.70	18.85

Table 3: Heavy metal contents of topsoil (0-15 cm) and sub-soil (0-30 cm) samples taken at specific distances from the ash refuse pile.

(a) Top soil (0-15 cm)

	Control	0 m	15 m	30 m	60 m	75 m	105 m	150 m
Co	11.60	1.85	6.65	6.15	6.90	10.50	7.15	6.60
Cr	14.60	27.80	20.15	22.15	45.40	30.60	27.90	23.40
Cd	9.13	4.93	5.58	6.43	6.68	6.73	7.63	8.85
Pb	37.43	4.83	26.78	54.90	46.25	34.63	41.85	12.50
Ni	44.93	35.48	8.13	13.65	17.90	11.18	33.35	46.13

(b) Sub-soil (15-30 cm)

Co	11.90	3.25	6.30	6.85	6.75	11.00	6.10	6.75
Cr	22.90	36.15	19.40	24.35	42.20	33.55	27.40	23.85
Cd	8.83	6.08	6.10	6.10	7.08	6.80	7.45	9.03
Pb	18.23	54.43	57.78	55.00	57.80	49.91	17.68	19.65
Ni	37.28	13.38	27.90	19.25	19.93	24.03	18.43	26.93

Table 4: Correlation coefficients of the relationships between soil properties and heavy metal content of soils in the vicinity of ash refuse pile

	Sand	Silt	Clay	pH	OM	ECEC
Topsoil						
Co	0.91	-0.77	0.20	-0.79	-0.52	-0.91
Cr	-0.28	0.23	0.10	0.56	0.20	0.45
Cd	0.77	-0.46	-0.12	-0.83	-0.06	0.65
Pb	0.35	-0.59	0.59	-0.13	-0.36	-0.39
Ni	-0.01	0.33	-0.67	-0.43	0.13	-0.11
Sub-soil						
Co	0.73	-0.54	-0.08	-0.86	-0.48	-0.56
Cr	-0.25	0.34	-0.39	0.31	0.04	0.33
Cd	-0.04	0.17	-0.25	-0.50	0.11	-0.07
Pb	-0.01	-0.08	0.22	0.36	-0.16	-0.01
Ni	0.62	-0.59	0.04	-0.69	-0.47	-0.32

Table 5: Correlation matrix of the relationships between heavy metals in the soils

a) Topsoil (0-15 cm)

Metals	Co	Cr	Cd	Pb	Ni
Co	-	-0.22	0.66	0.47	-0.01
Cr		-	-0.22	0.17	-0.31
Cd			-	0.15	0.64
Pb				-	-0.45
Ni					-
b) Sub-soil (15-30 cm)					
Co	-	-0.20	0.41	-0.31	0.76
Cr		-	-0.24	0.40	-0.58
Cd			-	-0.83	0.64
Pb				-	-0.45
Ni					-

Table 6: Contamination factors in the top soil and sub-soil of a vicinity affected by ash refuse pile.

Distance (m)	Co	Cr	Cd	Pb	Ni
Topsoil					
0	0.15	1.90	0.54	0.12	0.78
15	0.51	1.38	0.61	0.72	0.18
30	0.53	1.53	0.70	1.47	0.30
60	0.59	3.10	0.73	1.23	0.39
75	0.91	2.09	0.73	0.92	0.25
105	0.62	1.91	0.83	1.11	0.74
150	0.57	1.60	0.96	0.33	1.02
Average	0.39	2.38	0.63	0.57	0.32
Sub-soil					
0	0.27	1.57	0.68	2.98	0.35
15	0.52	0.71	0.69	3.16	0.75
30	0.57	1.06	0.69	3.01	0.51
60	0.56	1.84	0.80	3.17	0.53
75	0.92	1.46	0.77	2.73	0.64
105	0.51	1.19	0.84	0.96	0.49
150	0.56	1.04	1.02	1.07	0.72
Average	0.42	1.37	0.70	3.04	0.44

Table 7: Pollution Load Index for heavy metals in soils as affected by leached ash refuse pile from black soap-making operations

Distance from ash refuse pile (m)	PLI (Topsoil)	PLI (Sub-soil)
0	0.37	0.75
15	0.35	0.90
30	0.76	0.89
60	0.92	1.07
90	0.80	1.13
105	0.96	0.75
150	0.78	0.86

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar