International Journal of Academic Research in Business and Social Sciences
March 2013, Vol. 3, No. 3
ISSN: 2222-6990

Environmental Impact of Toxic Metal Load in Some Military Training Areas within the One Division of Nigerian Army, Kaduna, Nigeria

Georgina Nwaedozie
Department of Chemistry, Nigerian Defence Academy, PMB 2109 Kaduna, Nigeria

Yau Mohammed
Department of Chemistry, Nigerian Defence Academy, PMB 2109 Kaduna, Nigeria

Dahiru M Faruruwa
Department of Chemistry, Nigerian Defence Academy, PMB 2109 Kaduna, Nigeria

Jonathan M Nwaedozie.
Department of Chemistry, Nigerian Defence Academy, PMB 2109 Kaduna, Nigeria
Email: nwaedozie@yahoo.com

Abstract

The results of six trace metals in the three military training areas in Nigeria, within Kaduna metropolis, viz:- Armed Forces Command and Staff College, Jaji, Nigeria Air Force Base, Kaduna and Nigeria Army Depot, Zaria were determined using Atomic Absorption Spectrophotometer. The level of lead, copper, chromium, zinc manganese and Nickel were assessed. The samples were collected in the month of September and the highest concentration of lead was found in Nigerian Air Force base shooting range (526.49mg/kg). Lead was also found to be high in the Shooting range of Nigeria Army Depot, Zaria (216.49 mg/kg) while the Armed Forces Command and Staff College shooting range, Jaji has the least value (54.39mg/kg). The trend of trace metals in Nigeria Army Depot, Zaria , Shooting range is Mn > Pb > Zn> Cr>Cu >Ni while in Nigeria Armed Forces Command and Staff College Jaji, Shooting range it is Mn >Cr > Pb> Zn >Cu> Ni and at the Nigeria Air Force base, Kaduna it changes to Pb> Mn > Cu > Zn >Cr. The high value of Mn and Pb obtained in all the areas could be attributed to military activities. This result obtained indicates that military training areas are polluted with trace metals. The results are explained in terms of its health effect on the troops and the host community.

Keywords: Trace metals, Explosives, Hanger, Pollution,

Introduction

Over the last century, global industrialization, war and natural processes have resulted in the release of large amounts of toxic compounds into the biosphere. These have led to the problem of environmental pollution and ecological concerns. A pollutant is any material that is introduced into the environment as a result of man's activities and causes injury to the health of the environment, including life forms present in it, appliances installed in it and reduces the aesthetic quality of the environment (Goulden, 1978). Pollution thus is the occurrence in the environment of any substance or condition that is liable to cause harm or has deleterious effect on human health, plant and animal life or the aesthetic quality of land, water, air and socio-economic components of the environment.

Pollutants fall into main two classes: Inorganic and organic groups; Inorganic pollutants comprise of heavy metals such as Cadmium, Nickel, Cobalt, Mercury, Zinc and lead; non-metallic compounds and radioactive nuclear waste, while organic pollutants include petroleum products (such as, hydrocarbons, organic solvents, phenol compounds, explosives), fertilizers, herbicides and pesticides. Most of the pollutants enter the environment as emissions to the atmosphere or as discharge to water bodies or as dumps on land. Most of the material emitted to the atmosphere by man or industrial activities eventually return to the earth as particulate fall-out or with rain. When these materials return to land, they may be absorbed by the soil and eventually by the vegetation or they may be washed into the water ways. Materials discharged to the rivers may be metabolized by the plants and animals in the water thereby entering into the food chain. The non-degradable pollutants are those materials that either do not degrade or degrade very slowly in nature which include glass, detergents, heavy metals, plastics and thousands of manmade materials that do not degrade in the natural environment while biodegradable pollutants which rapidly decomposed under environmental conditions which include heat, carbon (iv) oxide, trioxonitrate (v) salts and other by products of metabolism. The pollutants may create problems when they accumulate in the environment and may eventually be transferred into living organism due to bioaccumulation. These pollutants are broadly divided into three categories namely air, water, and land. Air pollutants include substance like carbon (1V) oxide, particulate matter, NOx, Chlorofluorocarbons (CFCs), water pollutant includes sewage and other wastes, industrial waste water effluents while land pollutants include solid waste disposal, garbage, agricultural wastes and others.

In Nigeria, military activity dates back to the Colonial period when the British established various Armed Forces of Constabulary in the Northern and Southern part of Nigeria. These forces along the then forces of Nigerian and Sierra Leone were amalgamated in 1899. Subsequently northern and southern battalion of these forces became northern and southern regiment of West African forces until these regiments were amalgamated in 1940 to form the Nigerian regiment. These regiments saw periods of expansion especially through First and Second World Wars and alternately transformed into Nigerian army as a result of various constitutional developments which led to independence for Nigeria in 1960. The colonial army in Nigeria under took a lot of military expedition designed to consolidate British hold on the territory and secured British interest against those of other powers including the period of First World War.

The most important professional engagement of the Nigerian army since the time of independence was Nigerian Civil War of 1967 to 1970. Very little is known at present about the impact of military activities on the Nigerian environment during the colonial period. Also, the impact of the civil war on the Nigerian environment has not been fully investigated. In all of these trainings, explosives and ammunitions are used which result in the release of organic pollutants and heavy metals into the environment thereby causing threat to the health of animals and humans. Military training exercises were carried out in ranges and in obstacle crossing areas lead to release of organic pollutants and heavy metals in the environment. In Nigeria there had not been enough literature on the impact of military activities on the environment which necessitate this re- examination.

Toxicity Of Trace Metals And Health Effects

Heavy metals refer to any metallic element that has relatively high density and is toxic at low concentration (Daintith, 2000). These heavy metals include lead, vanadium, cadmium, mercury, nickel, copper, chromium, cobalt, manganese, and zinc etc. They are natural components of earths crust and cannot be degraded or destroyed. They tend to accumulate in the soil, plant and sea water. The behavior of trace-metals in the environment depends on their chemical forms. Therefore the determination of total metal concentration is often inadequate in completely representing trace metal present in the environment. This is very important for understanding of the fate of trace metals that is transport, reactivity and in general geochemical behavior on various biological and environmental areas (Battiston *et al*, 1993).

Lead is emitted from different sources such as mining and industrial fossil fuel burning. Lead wastes accumulate in aquatic biomass where it can remain accessible to human chain and to human metabolism for many years (Alloway, 1990). They are concentrated and passed up the food chain to human consumers. Whatever the source, Pb (II) ion can be toxic to plants and animals (Robinson, 1960) and is implicated in kidney and bone marrows diseases at high concentration (Lee and Muld 1979). Lead is used in cable coverings, ammunition and in the manufacture of tetraethyl lead and used as anti- knock compound in petrol.

Cadmium is present in the environment from cadmium – based batteries, incineration of wastes and petroleum industries. Cadmium adversely affects several important enzymes. It can cause painful bone disease, destruction of red blood cell and kidney damage at high concentrations. Cadmium industries result in cell injury and death by interfering with calcium regulation in biological systems (Abdullahi, 2006.). Cadmium does contaminate our food supply from local industrial and mining operations.

Manganese enter environment through food such as spinach, tea, and herbs. Manganese effects occur in the respiratory tract and in the brains. Symptoms of manganese poisoning are alienations, nerve damage and forcefulness (Abdullahi 2006).

Zinc concentration in soils is related to its possible uptake by crops and consequently affects crop and livestock in human diet. There are three major routes of entry for zinc into human body by inhalation, through the skin, or by ingestion (Toxicological Profile for zinc, 2005). Each type of exposure affects specific parts of the body and allows the uptake of different amount of zinc.

Chromium enters the air, water, and soil in the chromium (III) and chromium (VI) form through natural processes and human activities. The human activities that increase concentrations of chromium (III) are steel, leather, and textile manufacturing while the human activities that increase concentrations of chromium (V1) are chemical leather and textile manufacturing. Through coal combustion chromium will end up in air and through waste disposal chromium will end up in soils. Chromium in soil strongly attaches to soil particles and as a result it will not move towards ground water. In water chromium will absorb on sediment and become immobile. Acidification of soil can influence chromium uptake by crops. The health hazards associated with exposure to chromium are dependent on its oxidation state. The metal form is of low toxicity. The hexavalent form is toxic while the trivalent chromium compounds have been listed by the National Toxicology Program (NTP) as having inadequate evidence for carcinogenicity in experimental animals. People can be exposed to chromium through breathing, eating, or drinking water and through skin contact with chromium and chromium compounds. For most people eating food that contains chromium (111) ion is the main route of chromium uptake as Cr^{+3} ions occurs naturally in many vegetables, fruits, meats, and grains. Cr^{+3} ions are essential nutrient for humans and shortages may cause heart conditions, disruptions of metabolisms and diabetes. But the uptake of too much Cr^{+3} ions can cause health effects as well as skin rashes. Cr^{+6} ions is a danger to human health, mainly for people who work in the steel and textile industry. After breathing it in Cr^{+6} ions can cause nose irritations and nose bleeds. Cr^{+6} can also cause respiratory problems, weaken immune systems and kidney and liver damage and death.

Copper can be found in many kind of food, in drinking water and in air. When copper ends up in soil it strongly attaches to organic matter and minerals. As a result, it does not travel very far after release and it hardly ever enters groundwater. Copper does not break down in the environment and because of that it can accumulate in plants and in animals. Copper causes metal fever in man and in animal. Inhalation of dust and vapours of copper can irritate the nose, mouth and eyes and cause headaches, dizziness, and diarrhoea (ATSDR, 1997). Copper is widely employed in munitions, corrosive- resistant and decorative plating.

Nickel is released into the air by power plants and trash incinerators. It will settle to the ground or fall down after reactions with rain drops. Nickel can also end up in surface water when it is a part of waste water streams. Nickel compounds released to the environment will adsorb to sediments or soil particles and become immobile as a result. In acidic ground nickel is bound to become more mobile and it will often rise to the ground water. Nickel uptake will be high when people eat large quantities of vegetables from polluted soils. Plants are known to accumulate nickel and as a result the nickel uptake from vegetables will be eminent. Humans may be exposed to nickel by breathing air, drinking water, and eating food. Skin contact with nickel contaminated soil or water may result in nickel exposure. High nickel concentrations on sandy soils can damage plants. For animals high nickel concentrations can cause various kinds of cancer. For humans, high uptake of nickel will result in respiratory failure, prostrate cancer, lung cancer and nose cancer (Lenntech, 2001). Nickel is used in gas turbines and rocket engines.

Material And Methods

Sampling Location

The sampling sites for this work are the three military training formations located within 1 Division Kaduna state namely: Armed Forces Command and Staff, College, Jaji, Nigerian Army Depot, Chindit Barracks, Zaria and Nigeria Air Force Base, Kaduna.

Each location within an area was demarcated into five sections and 10 soil samples were collected and harmonized at various locations of the sites. This was done in consideration for accessibility, human and military activities.

Digestion of Sample for Total metal analysis

Dry soil samples were digested according to Ramos et al., (1994). 1g of sieved sample was placed into a beaker (100ml). This was extracted with a mixture of 4ml of 70% $HClO_4$ and 2ml of HNO_3 acid and the content was left in the oven at 100oC over night to obtain a white ash which was dissolved in 1 mol per dm^3 HCl. The digest was filtered into 50ml standard flask. The beaker was then rinsed with small portions of double distilled water and filtered into the flask. The mixture was made to mark with double distilled water and used for metal determinations. Duplicate analysis was done for each sample.

QUALITY **ASSURANCE TEST**

Quality control test was conducted on digested soil samples in order to evaluate the experimental procedures. This was done by spiking the pre-digested soil samples with multi element metal standard solution (0.5mgL-1, of Cd, Pb and Cr and 5mgL of Zn and Cu) (Awofolu, 2005).

$30cm^3$ of previously prepared multi-element standard solution (MESS) was drawn with graduated pipette and used to spike 1g of the pre-digested soil samples weighed in 100cm3 beaker. The spiked and 1g unspiked samples was digested as in section 2.30. The digestion was done in triplicate with blank digestion. The digest were run on Atomic Absorption Spectrometry equipment. Concentrations of metals in spiked and unspiked samples were used to calculate percentage recovery in order to validate the method. Values between 95 and 105 % were taken as good agreement.

FIELD AREA:

Geographically, Kaduna is nestled within the undulating Central Plans of Northern Nigeria. Specifically, the city is situated on longitude $7^o50'E$ and latitude $10^o50'N$ (fig.1). The lithology constitute migmatite, granite and a thoroughly weathered undifferentiated gneiss. Tropical ferruginous soils have developed over these rock types on the slopes and vertisols along flood plains of river Kaduna and its tributary streams.

The natural vegetation in the outskirts of the city is northern guinea savanna with the trees stratum dominated by Isoberlinia doka. It is a parkland savanna made up of tall grasses as the lower stratum. Within the city, the natural vegetation has been replaced by exotic species which are observable in the parks, gardens and roadsides.

Kaduna experiences tropical continental (savanna) type of climate which has two seasons in a year. The dry season which starts from mid to late October ends up in mid to late April. The wet season often last from April to October. Each season lasts for about six months. A mean annual rainfall of about 1200 mm is usually recorded in the rainy season. The hottest period starts from late February up to the beginning of the rains in April. The hottest month is April and the mean annual temperature is about 14.5^{o}C (76.1^{o}F).

Results And Discusion

The results of total trace metals concentrations of lead (Pb), copper (Cu), chromium (Cr), nickel (Ni), manganese (Mn), and zinc (Zn) have been assessed using Atomic Absorption Spectrophotometer at various military training areas of Nigerian Air Force Base (NAF) Kaduna, Armed Forces Command and Staff College (AFCSS), Jaji, and Nigerian Army Depot, Chindit Barrack, Zaria.

The results of mean total concentrations of trace metals in soil samples determined in the three training areas are shown in Table3.1 below while Figure 1 also represents the graphical presentation of their distributions.

Table 3. 10: Total Metal Concentrations at Various Sections of Military Training Areas (mg/Kg)

Area	Zn	Ni	Pb	Cr	Cu	Mn	Cd
Depot							0
SR	27.231	1.394	216.499	22.35	14.249	243.966	
Depot							0
OBS	34.525	0.0559	17.1878	17.35	0.291	243.47	
AFCSC							0
SR	39.81	3.515	54.394	69.399	9.237	244.451	
APC SR	14.382	BDL	14.39	5.547	BDL	58.511	0
AFK H	33.927	1.778	42.116	18.169	2.395	208.27	0
AFK SR	15.359	BDL	526.731	7.924	35.1156	92.248	0
WHO							

International Journal of Academic Research in Business and Social Sciences
March 2013, Vol. 3, No. 3
ISSN: 2222-6990

These values suggest that the area which is used as military training grounds is polluted. Small arms firing ranges are essential to military training but releases bullets that are pulverized upon impact and are released into the soil. Lead, antimony, copper, and zinc are the primary chemicals composed of these bullets.

The concentrations of manganese were found to be highest in all the areas with the Nigerian Army Depot, Zaria having the highest value and Air Force base, Kaduna the least. This is not unexpected because Nigeria Army Depot, Zaria is the place where the bulk of fighting soldiers are trained in this country for the Army, in which range classification is one of their majors. It follows the trend Depot>AFCSS>NAF. The concentrations of nickel within the training areas is small and in some areas like APC and NAF shooting range it was beyond detectable limits.. Copper were beyond detectable levels in APC SR and was found to be highest in Air Force shooting range with a value of 35.116mg/kg. The high concentrations of manganese in most of the areas could not be accounted for except it could have been due to anthropogenic and natural sources. Lead was quite high in all the shooting range as compared to obstacle crossing areas. The concentration of zinc in all the sites studied is high too confirming their presence in the training area. The concentration of copper is higher in the shooting area than in the obstacle crossing area which is similar to the observation made by C Goad and Halsey, (1982.). Biologist Aturo Massol and radio chemist Elba Diaz conducted an unpublished study in January, 2001 that showed vegetables and plants growing in the civilian area of Vieques were highly contaminated with heavy metals such as lead, cadmium, and copper. The United States Navy used Vieques Puerto Rico for training and testing weapon from 1941 to May 1, 2003. The presence of these toxic metals bears a lot of health risk factors and acts as biological poisons even at parts per billions levels (Nwaedozie, 2008).

The mean concentration of trace metals in Armed Forces Command and Staff College, Jaji is given in the table 1. The trend in concentrations of trace metals is as follows Mn> Cr> Pb> Zn> Cu> Ni>Cd in shooting range area while the trend in concentrations of trace metals in Armory Personnel sites is Mn> Pb> Zn> Cr. In the two areas sites studied, the concentration of manganese is highest with a range of 58.51 to 244.51. Its presence is attributed to anthropogenic sources. Lead concentration is also high with a range of 14. 39 to 54. 39 and this is expected since it is a major component of bullet released in the studied area. Zinc, a secondary component of bullet released into the soil is also implicated. Nickel and Copper were not present in detectable limit in the two sites studied.

The results of total concentrations of trace metals in Nigerian Air force, Kaduna is provided in the table 3.10 and follow the trend Mn>Pb > Zn >Cr > Cu >Ni for the Air Force Hanger. The result shows that the concentration of manganese is high with a range of 92 to 208.28 while that of nickel is lowest (1.778) at Air Force Hanger area. The lead concentration (526.731) at Air Force Shooting range is quite appreciable. The trend of trace metal concentration in the Shooting range is differsent from that of the Air Force Hanger and is as follows: Pb> Mn > Cu > Zn > Cr. The result of metal content concentrations in Nigeria Army Depot, Zaria is shown in Table3.10 The trend in concentrations of trace metals in shooting range is Mn >Pb > Zn > Cr >

Cu> Ni. The concentration of Mn is highest (243.966) while that of Ni is least (1.394). In the Obstacle Exercise area the trend of trace metal concentrations is Mn > Zn > Cr > Pb > Cu > Ni.

These values suggest that the military environments studied which are used for military training and testing of weapons are polluted and contain trace metals in appreciable quantities. The soil samples were collected in September during dry season when military training is high. Therefore the above results will to a great extent represent a true reflection of the soil characteristics within the period of the season. The values also confirm that the military sites are a breeding ground of toxic substances filtering into our soil and water supply everyday. Contamination at military base in the USA alone is estimated at 50 million acres (Top 10 Contaminants, 2001). These are acres that are used for bombing and training; however military industrial contamination is a world wide problem. A small arm firing ranges introduces bullets into the environment. Lead is the contaminant of concern at these ranges. The trace metal concentration values for lead ranges from 14.39 to 526.73 with highest concentration occurring at Air Force Base, Kaduna shooting range. The trend of lead concentration is AFKSR > DSR>AFCSCSR> AFKH> DOS> APCSR. Lead contamination of living environment is well documented. According to Odukoya and Ajayi (1987), lead is very toxic and has chronic health implication even at low levels. Excessive exposure to it causes mental retardation in children and renal disease. Long term exposure to lead has also been noted to cause other serious health hazards (Essien, 1992). The variation of manganese shows a different pattern from lead. The range of manganese is 58.51 to 244.45 with the highest concentration occurring at Armed Forces Command and Staff College shooting range. The value of manganese was noticed to be high in most of the area studied. The high concentration could mean that source of pollution due to presence of manganese is from anthropogenic source and not from military activities. The range of copper is from 0.291 to 35.12. The trend of copper is AFKSR > DSR> AFCSCSR> AFKH >DOB. The concentration of Copper is below detectable limit in Armory Personnel Carrier exercise area. The value of copper (35.11mg/kg) a secondary component in bullet is highest in Air Force Base Shooting range just as with lead. This is not unexpected since the two metals are present in bullet composition (Goad and Halsey, 1982). With short term exposure to copper especially in water, gastrointestinal distress may occur and with long term exposure one may experience liver or kidney damage. The zinc concentration range is from 14.38 to 39.81. The variation of zinc is AFCSCSR>DOB> APKH> DSR>AFKH> APCSR. The presence of zinc is expected as it is a secondary component of bullet used in military training areas. Zinc is toxic to plants before it accumulates in sufficient concentrations to affect animals or humans. Consequently high concentration of zinc kills or stunts plant growth. Although zinc has been found to have low toxicity to man, prolonged consumption in large doses can result in some health complications such as fatigue, dizziness and neutropenia (Nwaedozie, 2008). The nickel concentration ranges from 0.0559 to 3.515. Its trend is AFCSCSR> AFKH>DSR>DOB. The concentration of nickel is below detectable limit in Air Force Base Hanger and in Amory Personnel Carrier Exercise area. The essentiality of nickel to man has not been demonstrated (Teo and Chem, 200). Its properties such as strength, high ductility, good thermal and catalytic properties, confer on it a high commercial importance and make it a daily input in many industrial applications. The chromium concentration ranges from 5.547 to 69.39. The trend of chromium is AFCSCSR> DSR> AFKH>DOB>AFKSR>APC. Okonkwo et al reported high levels of Pb, Ni, Cd, Cr, and Ag in soil samples and roots and leaves of coco yam and cassava harvested from an abandoned waste sites in Umuahia, South east of Nigeria. The ANOVA statistical analysis of the results shows that at 95% confidence interval the toxic metals investigated shows similar behavioral patterns in the three locations, Depot Zaria, Armed Forces and Command and Staff College jaji and Nigerian Air force Base Kaduna. Also while Ni, Zn, Cr and Cu show same behavior, the Pb and Mn exhibit same pattern. This is not unexpected as both are the major constituent of amour used in these military training areas. The table of ANOVA is shown in Appendix I,

Conclusion

The result obtained from this work shows that military activities could release toxic metals into the environment. Trace metal concentration of lead, manganese, nickel, zinc, copper and chromium varied spatially throughout the study locations. Some of the metals especially manganese and chromium could not be traced to immediate pollution activity of the Armed forces and must have arisen from anthropogenic and natural sources. The behavior of elements in the environment depends on their chemical form. Therefore, the determinations of total metal concentration in the environmental samples do not completely produce useful data that are directly related to potential health risks. This has been done by the determinations of their geochemical distribution which has shown that the toxic metal of lead and manganese not only pollute the military training areas but are available for plant uptake and eventually affect the troops. My subsequent attention will be on the Phyto-remediation of theses pollutants using various plants.

Acknowledgement

The authors wish to acknowledge the immense assistance received from the Defence Industries Corporation of Nigeria and the Department of Chemistry Nigerian Defence Academy for the Spectroscopic analysis of trace metals.

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