HEAVY METALS IN SOME TERMITE SPECIES AND THEIR NESTS IN OJO, LAGOS, NIGERIA

[1]DENLOYE, Abiodun A. [2]ABDULSALAM, Lateef, [2]BAKRE, Sena, [2]AJELARA, Oluwakemi and [3]OLOWU, Rasaq

[1]Department of Zoology and Environmental Biology, Faculty of Science, Lagos State University, Ojo, Lagos.

[2]Centre for Environment and Science Education (CESE), Lagos State University (LASU), Lagos.

[3]Department of Chemistry, Faculty of Science, Lagos State University (LASU), Lagos.

Corresponding Author: Denloye, A. A. Department of Zoology and Environmental Biology, Faculty of Science, Lagos State University, Ojo, Lagos. **Email:** bio_denloye@yahoo.com **Phone:** +234 8033205593

ABSTRACT

Termites feed on decaying organic matter including plant parts and wood, concentrating heavy metals in the process. The main campus of Lagos State University was surveyed for termite species and their heavy metal contents. Nests including mounds, wooden structures and discarded wood products were observed for termite activities and the insect samples collected for identification and subsequent metal analyses. Composite samples of selected termite species and the soil or wood dust around them were respectively digested and analyzed for the presence of Iron (Fe), Potassium (K), Sodium (Na). Zinc (Zn) Cadmium (Cd), Copper (Cu), Chromium (Cr), Lead (Pb), Nickel (Ni) and Cobalt (Co) using Atomic Absorption Spectrophotometer (AAS). The results showed that Macrotermes bellicosus (Isoptera: Macrotermitinae), Reticulitermes flavipes (Isoptera: Rhinotermitidae) and Kalotermes flavicollis (Isoptera: Kalotermitidae) occurred on the main campus of Lagos State University in Ojo, Lagos. Heavy metal analyses of termite castes showed that M. bellicosus worker had Ni, Fe, Cd, Co, Pb, Na and K with Fe having the highest concentration of 24.6 mgL^{-1} while Co had the least (0.03mgL^{-1}). The reproductive caste had the highest concentration (4.68 mgL^{-1}). The Soldier of M. bellicosus showed the presence of all metals detected in its worker caste excluding Cu & Ni with Fe having the highest concentration (5.12mg/L). The Soldier and Worker castes of Kalotermes similarly showed the presence of the same metals as M. bellicosus soldier. Analyses of data by Kyplot showed high correlation between heavy metal concentrations in study termite species relative to their nest materials.

Keywords: Heavy metals, Termites, Worker, Soldier, Winged Reproductive, Kyplot analysis

INTRODUCTION

Heavy metals in soil have been attracting considerable attention lately owing to their non–degradablity relative to organic pollutants. These metals may vary in importance and roles as they are essential to plants at low concentrations but become toxic when they are in higher quantities. Some edible mushrooms are also intimately associated with various termite species thereby becoming sources from which metals may be taken up (Nyeko and Olubayo, 2005).

It has been established that termite species are agents of soil denudation due to their feeding on soil as well as construction of their nests (Malaka, 1996; Caschuk *et al.*, 2006; Musa *et al.*, 2014), and in the process accumulate large amount of metals in their bodies, resulting in physiological toxicity

(Devcota and Schmidt, 1999, 2000; Heliovara and Viaisanen, 1990; Hsu *et al*., 2006; Heckel and Keener, 2007). Furthermore, heavy metals could be transported to organisms on the higher position from insects along food chains resulting in bioaccumulation and eventual toxicity (Zheng *et al*., 2008). Recent studies that monitored the fate of heavy metals in the environment, made use of some predatory insects as bio–indicators due to their high abilities to accumulate metals from their environment (Nummelin *et al*., 2007). Termites may also therefore serve as bio-indicators of metals in the environment. Also, studies have been carried out on the accumulations of metals in soils, plants and vegetables from some environments and, concentrations of metals are usually found higher in sites closest to the smelting industries or such other environments requiring the discharge or use of metallic materials. In Abeokuta, southwestern Nigeria for example Idowu *et al.* (2007), reported that mechanic sites had higher concentration of metals than other five sites compared. However, there is a dearth of information in the metal accumulation in termites from Ojo, Lagos.

Another issue of concern is that bioaccumulation of heavy metals in terrestrial food chains is considered the most important source of non – occupational human exposure to the elements; just as most heavy metals are highly toxic and persistent. It follows therefore that consumption of termite species by man would be a veritable source of metal transfer and accumulation in the food chain. One of the experimental species in this study (*Macrotermes bellicosus*) is well relished among rural folks in southwestern Nigeria, including Lagos. Anomalous environmental levels of metal concentration from such insects warrant concern. It is hence pertinent to know the presence or absence of metals in these insects. It is on the foregoing that this study is predicated. The aim of this study is to determine heavy metals namely Cd, Cu, Fe, Ni, Pb, Na, K, Zn, Cr and Cobalt in termite species from Ojo, using Lagos State University, Ojo Campus as study location.

MATERIALS AND METHODS

Study Site: The study site is Lagos State University, Ojo – Campus, along Lagos – Benin Republic expressway, located in the Urban Area of Lagos State. The campus is composed of about 15,000 students with other people engaging in different commercial activities. The land use pattern within the school environment varies from construction, subsistence farming with landscaping and other different purposes such as roads, sport complex and other social activities. The various activities within the school may account for high heavy metal presence in the school environment.

Source, Collection and Processing of Experimental Samples: Soil termites were obtained from three locations in the Ojo (main) campus of the Lagos State University as follows: Location I - opposite Faculty of Education, Location II - behind MBA Building and Location III - Faculty of Management Science. Termite collection was carried out by excavation through the mounds or nests in decaying wood and wood products. The winged reproductive, soldier and worker castes of *Macrotermes bellicosus*, *Reticulitermes flavipes* and *Kalotermes flavicollis* respectively were collected using plastic scapel and brush. Also, soil samples from the mound/nest of each termite species were collected into polythene dispensing envelopes, sealed and subsequently analyzed for heavy metals respectively.

Preparation of Samples; Each of the termite species collected was respectively digested and analyzed for heavy metals. Prior to digestion each collection was dried in a Gallenkamp Hotbox oven at 50 ^{o}C over 3 hours. Dried samples were respectively stored in the refridgerator at temperature of 25 ± 3 ^{o}C using sealed nylon bags prior to analysis in order to prevent spoilage.

Experimental Analysis: Each termite sample was prepared and analyzed for heavy metals by Atomic Absorption Spectrophotometry (AAS) using the method of AOAC (1977).

The AAS analysis of each metal was carried out at specific wavelength namely Pb, 217.00 nm; Zn, 213.90 nm; Cd, 228.90 nm; Fe, 324.70 nm; Na, 587.00 nm; K, 766.50 nm; Co, 240.70 nm; Cr, 351.90 nm; Cu, 324.80 nm and Ni. The determination of sample elemental components was carried out using spectrophotometry with an Atomic Absorption Spectrophotometer (model 200-A Buck). The heavy metals were concentrated by iron exchange resin method. Hence, a series of standards of varying concentrations were prepared for all cations and their corresponding absorbance values were recorded.

Data Analysis: Heavy metal concentration values obtained from AAS were subjected to Kyplot analyses from which significant relationships between accumulation of heavy metals in termite species and their inhabited sites were established.

RESULTS

Concentration of Heavy Metals in Termite Samples: Various heavy metal concentrations in the termite samples analysed are summarized in Table 1. Zn, Cd, Co. Fe, K and Na were detected at various concentrations in all the termite specimens. The two metals, Cr and Pb were not detected in all termite samples while Ni was detected only in worker caste of *M. bellicosus* at a low concentration of 0.04 mgL^{-1} (Table 1). Similarly, copper was only detected in the reproductive castes of *M. bellicosus*. Also, Cr and Pb were not detected in the termite species. The most highly concentrated heavy metal accross all termite specimens analyzed was Fe with the highest concentration detected in the worker caste of *Kalotermes flavicollis.*

Relationship between Heavy Metal Concentrations in Termite Species and the Occurrence of Metals in Nest Materials: Kyplot analyses (Table 2) indicate varying relationships between the presence of heavy metals in termite species and their nest materials. The results show that among the three test castes of *M. bellicosus*, the winged reproductive gave the lowest Kyplot value (t = 1.47) which was significantly lower than metal concentrations in each of the other test *M. bellicosus* castes, while that of the worker caste was the highest (15.04).

Comparison of heavy metal concentrations in termites and soil or wood nest materials show that *Kalotermes* ($p \leq 0.01$) had significantly higher metal concentrations relative to *Reticulotermes flavipes* ($p \leq 0.01$) (Table 1).

The order of accumulation of the metals in the *Reticulotermes* sp with respect to their concentration in this order Co < Ni < Cd < Zn < Na < K < Fe. While in *Kalotermes* sp, the order of accumulation of the metal is in the order of Co < Ni < Cd < Zn < Na < K < Fe (Tables 1 and 2).

DISCUSSION

This study shows the heavy metals present in three castes of *Macrotermes bellicosus*, soldier caste of *Reticulotermes flavicollis* and worker of *Kalotermes flavipes* collected from Ojo, Lagos. It therefore gives a ground for reference and documentation of these heavy metals in this part of Lagos. Knowing the type of heavy metals present in an environment is key to understanding the properties of such resources as soil and understanding the health implications and usage to which it can be put. This knowledge can also help to explain certain phenomena and observations relevant to environmental health of particular locations such as bioaccumulation of chemical constituents. A study by Bakre *et al.* (2004) details the concentration of some heavy metals in the vegetables grown along the Lagos Badagry Expressway and in Iba town both of which sandwich the location of the sample collection sites of this present study. The results reported here would therefore be complimentary with those of Bakre *et al.* (2004).

The present study was premised on the possibility of take-up of heavy metals through the consumption of termites. The results obtained indicate the high possibility of this suspected take-up since the heavy metals were detected in both the insects as well as the nest materials. This is consistent with the findings of Bakre *et al.* (2004) who reported that Cd, Pb

Table 1: Heavy metal concentrations (mgl^{-1}) in termite castes

Termite Species and Castes	Sample	Ni	Zn	Cd	Co	Fe	Cu	Cr	Pb	Na	K
Macrotermes bellicosus **(Worker)**	T1	0.04	0.73	0.08	0.03	24.6	0	0	0	3.55	4.65
M. bellicosus **(Reproductive)**	T2	0	0.43	0.12	0.03	3.92	0.67	0	0	4.46	4.68
M. bellicosus **(Soldier)**	T3	0	0.12	0.10	0.05	5.12	0	0	0	3.14	2.83
Reticulotermes flavipes **(Soldier)**	T4	0	1.03	0.1	0.05	15.20	0	0	0	5.68	9.27
Kalotermes flavicollis **(Worker)**	T5	0	0.58	0.08	0.05	47.60	0	0	0	3.74	3.09

Table 2: Kyplot analyses of soil and wood samples of termite nests for heavy metals

Parameters	Analyses of termite Samples and heavy metals in nest materials				
	Metals in termites Versus nest soil materials			Metals in termites Versus nest wood materials	
	Macrotermes bellicosus			*Reticulotermes*	*Kalotermes*
	Worker	Reproductive	Soldier	Soldier	Worker
Covariance Matrix (CM)	280.64	35.10	53.80	556.43	1915.61
t- value (t)	15.05	1.47	3.46	3.94	36.43
Probability (P)	$P \leq 0.001^{***}$	$P > 0.05$	$P \leq 0.01^{**}$	$P \leq 0.01^{**}$	$P \leq 0.001^{***}$
Significance Level	HS	NS	S	S	HS
Correlation Coefficient (R)	98.27 %	46.15 %	77.37 %	81.26 %	99.69 %
Coefficient of Determination (R^2)	96.58 %	21.30 %	59.87 %	68.04 %	99.40 %

and Hg were detected in high concentration in the fresh and boiled leafy vegetables analyzed. The findings of Ajayi and Adedire (2007) established the nutritional content of subterranean termites namely *Macrotermes subhyalinus* (Rambur) which confirms that the practice of consumption of these insects has nutritional advantage and is therefore capable of enhancing indulgence in the use of termites as delicacy. This implies that consumers of the termite species used in this present study would be taking up and accumulating the heavy metals detected in these termite species.

It is important to note that insects which serve as media for heavy metals pick-up from their surroundings and the level detected are directly proportional to the heavy metal load in the surrounding of the samples analyzed. For example Idowu *et al* (2007) reported that the metals detected in *Zonocerus variegatus* L in Abeokuta were higher in mechanic sites than other sampled locations. The proximity to the LASU – Isheri Expressway which is a very busy route for vehicular traffic does not seem to count in this particular study as Nickel, Cu, Cr and Pb were not detected in most of the termite samples analyzed (Table 1) whereas they were detected in high concentrations in previous experiments carried out using fresh vegetables (Bakre *et al*, 2004). The reproductive caste of *M. bellicosus* is well relished as a delicacy among the locals in south west Nigeria from where these samples were collected for analyses. The report of Idowu *et al* (2014) that these termite species is not an efficient accumulator of heavy metals from the surrounding soil allays the fear of consumers with respect to heavy metal poisoning. It is fairly well established that some insects serve as media for the transfer of heavy metals into their consumers. The present study demonstrates that attention should also be focused on the termites in this study as carriers of the detected heavy metals into consumers.

The trend of accumulation in this study shows that Fe, K, Na, Zn, Cd, Ni and Co were accumulated by both *Reticulitermes* and *Kalothermes* species. Thus these metal accumulations are similar in both species and in the order of accumulated quantities. Evidently, the rate of accumulation of Ni, Zn and K in *Reticulotermes* species are 100%, 20.55% and 33.55% respectively higher than those in *Kalotermes* species while Fe, and Na metals were 48.33% and 5.08% respectively when both were compared using their per cent increase. This observed trend may indicate the differential abilities of various termite species and castes to accumulate heavy metals for their physiological needs. There is need for further studies to very this supposition.

The foregoing observation tends to support the suggestion of Ewuim (2013) that termites can be used as entomoremediators of soils polluted by heavy metals. Entomoremediators are described as insects capable of being used as agents of decontaminating polluted soil (Ewuim, 2013). The results of this study show that *R. flavipes* and *K. flavicollis* accumulated high quantities of Fe, K, Na, Zn, Cd, Ni and Co. This suggests that these too termite species may be considered as candidates in decontaminating soils polluted by these heavy metals.

REFERENCES

AOAC (1997). Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC). 16th Edition, Association of Official Analytical Chemists, Washington DC, USA.

AJAYI, O. E. and ADEDIRE, C. O. (2007). Nutrient characteristics of the subterranean termite *Macrotermes subhyalinus* (Rambur) (Isoptera; Termitidae). *Nigerian Journal of Entomology* 24: 42 – 47.

BAKRE, S., DENLOYE, A. A. B. and OLANIYAN, O. (2004). Cadmium, lead, and mercury in fresh and boiled leafy vegetables grown in Lagos, Nigeria. *Environmental Technology,* 25: 1 – 4.

DEVCOTA, B. and SCHMIDT, G. H. (2000). Accumulation of heavy metals in food plants and grasshopper from the Taigetos Mountains, Greece. *Agriculture, Ecosystem and Environment,* 78: 85 – 91.

EWUIM, S. C. (2013). Entomoremediation – A novel insitu bioremediation approach. *Animal Research International,* 10(1): 1681 – 1684.

HECKEL, P. F. and KEENER, T. C. (2007). Sex differences noted in mercury bioceomolation in *Magicicada casini. Chemosphere,* 69: 78 – 81.

HSU, M. J., SELVARAJ, K. and AGORAMOORTHY, G. (2006). Taiwan's industrial heavy metal pollution threatens terrestrial biota. *Environmental Pollution,* 143(2): 327 – 334.

IDOWU, A. B., ADEMOLU, K. O. and BAMIDELE, A. J. (2014). Nutrition and heavy metal levels in the Mound Termite, *Macrotermes bellicosus* (Smeathman) (Isoptera; Termitidae) at three sites under varying land use in Abeokuta, South Western Nigeria. *African Entomology,* 22(1): 156 – 162.

IDOWU, A. B., WEWE, N. and AMUSAN, A. A. S. (2007). Heavy metal content of variegated grasshopper, *Zonocerus variegatus* (L) (Orthoptera; Pygomorphidae) collected from various locations in Abeokuta, Ogun State, Nigeria. *Nigerian Journal of Entomology,* 24: 35 – 41.

KASCHUK, G., PIRES-SANTOS, P. C., ALMEIDA, J. A., SINHORATI, D. C. and BERTON-JUNIOR, J. F. (2006). Termite activity in relation to natural grassland soil attributes. *Scientia Agricola,* 63(6): 583 – 588.

MALAKA, S. L. O. (1996). *Termites in West Africa*. University of Lagos Press, Lagos, Nigeria.

MUSA, M. B., AJAYI, F. A. and ABDULHADI, B. J. (2014) Denudation effect of termiataria and characterization of associated termite species in Laffia, Nasarawa State, Nigeria. *European Scientific Journal,* 10(30): 186 – 195.

NUMMELIN, M., LODENIUS, M. and TULISALO (2007). Predatory insects as bioindicators of heavy metal pollution. *Journal of Environmental Pollution,* 145: 1339 – 1347.

NYEKO, N. and OLUDAYO, F. M. (2005). *The Participatory Assessment of Farmers Experiences of Termites Problems in Agroforestry in Tororo District, Uganda*. Agricultural Research and Extension Network Papers, Number 143, Overseas Development Institute, London, United Kingdom.

ZHENG, D. M., WANG, Q. C., ZHANG, Z. S., ZHANG, N. and ZHANG, X. W. (2008). Bioaccumulation of total and methyl mercury by arthropods. *Bulletin of Environmental Contamination and Toxicology,* 81: 95 – 100.