

HEAVY METALS CONCENTRATION AND ARTHROPOD POPULATION IN SOME SELECTED DUMPSITES FROM CALABAR, CROSS RIVER STATE, NIGERIA

ABSTRACT

The aim of this research is to investigate the influence of refuse dumping on arthropods population and heavy metals concentration in Calabar Cross River state, Nigeria. Soil, and arthropod samples were collected from Nassarawa, University of Calabar female hostel and Goldie market dumpsites which were labeled S1, S2, S3, and S4, respectively while same samples were picked from a plot of land labeled PC as a control. Arthropods were identified using light microscope and identification guide while heavy metals Cd, Pb, Cr, Ni, Co, As and Hg were analysed in soil and arthropods using Atomic absorption spectrophotometer (AAS). The results obtained showed 8363 arthropod individuals consisting of 19 species dominated by *Muscidae* (flies) family which constitutes about 20.39% whose presence indicates high level of pollution of the dumpsite and a possible health implication on people living around the dumpsites because these organisms are vectors for diseases such as yellow fever, malaria, Heavycholera and typhoid fever. Cadmium was the highest occurring heavy metal in dumpsites soil with a concentration of 1.457 ± 0.493 mg/kg in S4 while As was the lowest with a concentration of 0.001 ± 0.000 mg/kg in S1 and Hg was below detection limit in all dumpsites. In arthropods, Cd had the highest occurrence with a concentration of 0.020 ± 0.001 mg/kg in S4 while Pb in S2 and Co in S1 with concentration of 0.001 ± 0.000 each were the lowest occurring metals. Heavy metals concentration in soil and arthropods from the dumpsites was higher than that of the control which shows the influences of refuse dumping and strong (> 5) positive correlation between mean metal concentrations in soil and arthropods suggests that these arthropods can be used as bio-indicators of heavy metals contamination and accumulation. It is therefore recommended that wastes be segregated and proper disposal methods should be adopted.

Keywords: Heavy metals; Arthropods; Dumpsites; Calabar; WHO limits; Bioaccumulation

1. INTRODUCTION

Human activities such as industrialization, urbanization, commercial and household activities lead to the generation of large amount of waste in the environment. The waste production increases daily [1], and is compounded by population explosion, decreasing standards of living and low level of environmental awareness [2]. Municipal solid waste commonly known as garbage or refuse is wastes constituting of everyday items that are discarded by the public with variation from country to country and from city to city [3; 4]. The increasing demand for food and other life essentials arising from the increasing global population leads to increased

amount of wastes which are not adequately managed in Nigeria and result in the contamination of air, water and soil which pose serious public health threats [5]. Wastes from industrial, domestic and agricultural activities have elevated heavy metals bioavailability and their ecological impacts due to the dynamic interaction between spatial and temporal factors in the environment [6; 7]. These metals have found their way into living systems as a result of bioaccumulation and biomagnifications, causing several changes such as alterations in community structure, patterns of succession, nutrient cycling, energy flow and trophic dynamics, among others [8; 9].

Arthropods are invertebrate animals with an exoskeleton, a segmented body and jointed legs [10]. They have a very high functional biological diversity and sensitivity to environment which made them suitable for utility as biological indicators of sustainable ecosystem [11]. The potential bioindicators groups of arthropods include Acari, Collembola, Coleoptera, Hymenoptera and Araneae among others. This research was carried out to investigate the influence of refuse dumping on arthropods population and heavy metals concentration in Calabar Cross River state, Nigeria.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was conducted in Calabar Metropolis of Cross River State, Nigeria which is located between longitude $8^{\circ} 14' 11.34''$ E and $8^{\circ} 24' 13.30''$ E and latitude $4^{\circ} 51' 55.78''$ N and $5^{\circ} 06' 19.504^{\circ}58.04 227''$ N with an elevation of 4-51m above sea level [12]. Four dumpsites: Lemna ($008^{\circ}21'55.912''$ E and $05^{\circ}2'08.725''$ N), Nassarawa ($008^{\circ}21'35.168''$ E and $05^{\circ}4'51.544''$ N), University of Calabar female hostel ($008^{\circ}20'57.937''$ E and $04^{\circ}56'16.612''$ N) and Goldie market ($008^{\circ}20'29.34''$ E and $04^{\circ}56'29.198''$ N) were selected as sampling locations for this study while a plot of land ($008^{\circ}21'43.9''$ E and $04^{\circ}58.04 227''$ N) was selected as a control. These sampling locations and the control were labeled S1, S2, S3, S4 and PC respectively and samples were collected for a period of twelve months.

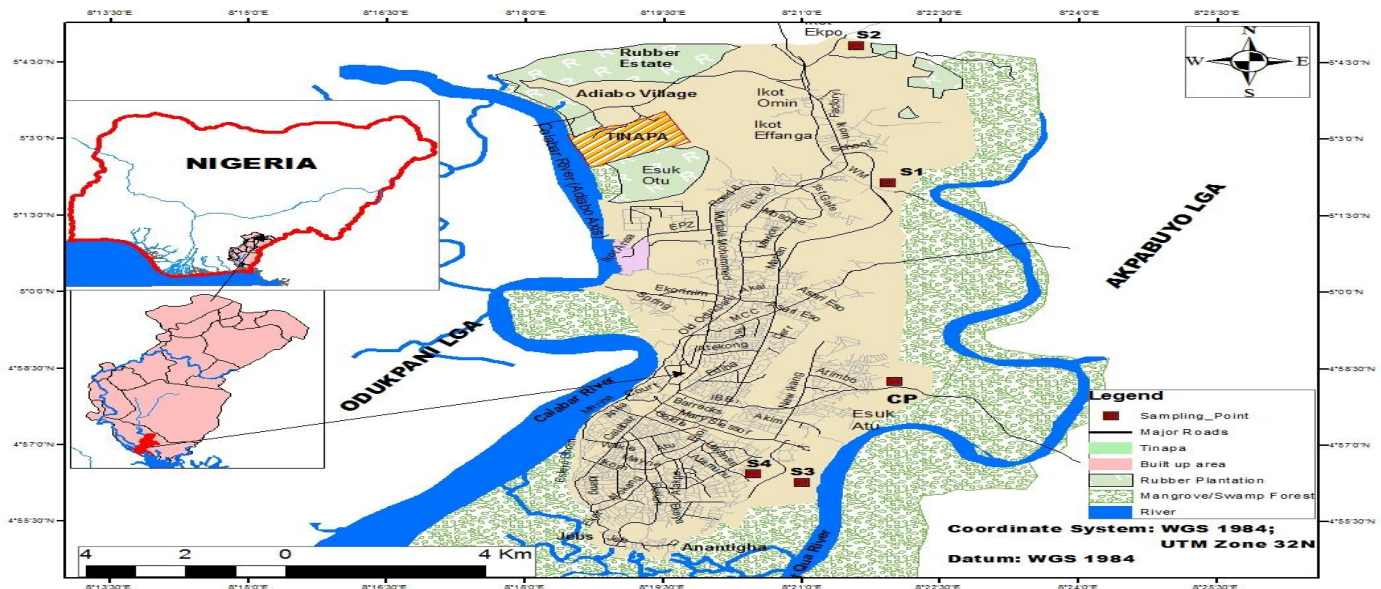


Figure 1: Map of Calabar showing the Sampling Locations

2.2 Sample Collection

Larger and more visible arthropods were collected by handpicking where hand gloves were worn and the arthropods picked into a plastic can during each visit to the dumpsites while smaller arthropods were collected using sticky traps designed with plywood the surface of which was coated with grease according to [13]. Water traps were made using five liter plastic buckets almost filled with water and detergent was added to reduce surface tension and enhance wetting of the arthropods, sweep net made from mosquito net and metal rod with wooden handle was used to catch flying arthropods and soil auger was used to bore depths into the dumpsites where arthropods were obtained

Soil samples were collected at the surface level (0-10cm depth) in duplicate from various locations in the different dumpsites. The collected soil samples from each dumpsite were thoroughly mixed to obtain a representative sample. The samples were put into labeled polyethene bags and transported to the Ministry of Science and Technology, Uyo, Akwaibom state, Nigeria for analysis.

2.3 Sample Preparation and Analysis

Arthropods were identified using the relevant identification guide (Atlas on the Biology of Soil Arthropods). They were viewed under a light microscope for differences in their mouthpart and footpart. Cockroaches, beetles and all flies were kept in specimen bottles containing 70% ethanol, millipedes and centipedes were kept in a cold dark place to prevent desiccation, while mosquitoes were kept in a Petridish containing filter paper placed over moist cotton wool. All arthropods analysed were washed with distilled water and anestized in a deep freezer, and

dried in oven at 60⁰c for 10 hours and then stored at room temperature in plastic tubes. The arthropods were grinded with a mortar and pestle to powder, samples were air dried, crushed and sieved with 2mm mesh before wet digestion. Well mixed samples of 1g each were taken in 250ml glass beaker and digested with 20ml of nitric acid, hydrofluoric and perchloric acid mixture in a ratio of 3:1:1 on a hot plate. After evaporation to near dryness, the samples were dissolved with 10ml of 2% nitric acid, filtered and then diluted to 50ml with distilled water [14]. Cadmium, lead, chromium, nickel, cobalt, arsenic and mercury concentration in the digested arthropods were determined by atomic absorption spectrophotometry using Shimadzu Atomic Absorption spectrophotometer (AAS) model AA 6800 equipped with zeeman background correction and graphite furnace. Standard solutions of each of the metals were aspirated to calibrate the AAS before aspiration of the sample.

Soil samples from dumpsites and the control were air dried, crushed and sieved with 2mm mesh before wet digestion. Well mixed samples of 1g each were taken in 250ml glass beaker and digested with 20ml of nitric acid, hydrofluoric acid, and perchloric acid mixture in a ratio of 3:1:1 on a hot plate. After evaporation to near dryness, the samples were dissolved with 10ml of 2% nitric acid, filtered and then diluted to 50ml with distilled deionized water [14]. Cd, Pb, Cr, Ni, Co, As and Hg concentrations in the digest were determined by atomic absorption spectrophotometry.

2.4 Statistical Analysis

One way analysis of variance (ANOVA) was used to determine the differences in arthropods numerical abundance and heavy metals concentration in arthropods and dumpsite soil across sampling locations while Pearson's correlation analysis was used to evaluate the relationship between heavy metals concentration in dumpsite soil and arthropods. All analyses were carried out using predictive analytical software (PASW) version 20 at 0.05 level of significance and their respective degrees of freedom.

3. RESULTS AND DISCUSSION

3.1 Composition and Abundance of arthropods in dumpsites

A total of 8363 arthropod individuals, consisting of 19 species, belonging to 14 families were collected from all the dumpsites through-out the study. The arthropod families represented were muscidae, psychodidae, fannidae, calliphoridae, culicidae, blattidae, serabaediae, scolopendridae, theraphosidae, glyllidae, julidae, tettigoniidae, papilionidae and formicidae. The family muscidae was represented by *Musca domestica*(20.39%), *Ophyra leucostoma* (12.44%) and *Stomoxys calcitrans*(7.27%). Psychodidae was represented by *Clogmia albipunctatus*(5.06%), while fanniidae was represented by *Fannia scalaris*(4.98%). Calliphoridae was represented by *Chrysomya rufifacies* (3.25%) and *Chrysomya megacephala*(3.06%). Culicidae was represented by *Aedes aegypti*(6.07%) and *Anopheles gambiae*(6.46%). Blattidae was represented by *Periplaneta americanus*(8.41%). Serabaediae was represented by *Canthon pelularis* (1.74%) and *Onthophagus obliquus*(1.60%). Scolipendridae was represented by *Scolopendra subspinipes* (2.04%). Theraphosidae was represented by *Chromatopelma cyaneopubescens* (0.51%). Gryllidae was represented by *Scapsipedus marginatus*(1.38%). Tettigoniidae was represented by *Tettigonia viridissima*(2.17%). Julidae was represented by *Ommatoiulus sabulosus*(2.90%). Papilionidae was represented by *Papilio demodocus*(1.70%) and formicidae was represented by *Dorylus gribodoi* (8.46%) (Table 1).

Throughout the study, the most abundant arthropod species was *Musca domestica*, having 1706 individuals (20.39%), while the least abundant species was *Chromatopelma cyaneopubescens* with 43 individuals (0.51%). Throughout the study, Muscidae was the most abundant arthropod family (40.10% abundance) while *Theraphosidae* was the least abundant family (0.51% abundance). Lemna (S1) dumpsite had the highest number of individual organisms (2835 individuals), while Goldie market (S4) dumpsite had the lowest number of individual organisms (1558 individuals). The control (PC), had a lower numerical abundance of arthropods (250 individuals), compared to each of the studied dumpsites.

Table 1: Composition and Relative Abundance of Arthropods in Dumpsites from Calabar

| S/N | Phylum | Class | Order | Family | Genus | Species | PC (control) | | S1 | | S2 | | S3 | | S4 | | Total | |
|-----|------------|-----------|-------------------|----------------|---------------|-------------------------------------|--------------|-------|-----|-------|-----|-------|-----|-------|-----|-------|-------|-------|
| | | | | | | | No | %R0 | No | %Ro | No | %Ro | No | %Ro | No | %Ro | No | %Ro |
| 1. | Arthropoda | Insecta | Diptera | Muscidae | Musca | <i>Musca Domestica</i> | 0 | 0 | 638 | 22.50 | 447 | 19.79 | 313 | 18.28 | 308 | 19.76 | 170 | 20.39 |
| 2. | Arthropoda | Insecta | Diptera | Muscidae | Ophyra | <i>Ophyra Leucostoma</i> | 0 | 0 | 368 | 12.98 | 271 | 12.00 | 201 | 11.74 | 201 | 12.90 | 104 | 12.44 |
| 3. | Arthropoda | Insecta | Diptera | Muscidae | Stomoxys | <i>Stomoxys Calcitrans</i> | 0 | 0 | 187 | 6.59 | 179 | 7.92 | 125 | 7.30 | 117 | 7.50 | 608 | 7.27 |
| 4. | Arthropoda | Insecta | Diptera | Psychodidae | Clogmia | <i>Clogmia albipunitatus</i> | 0 | 0 | 142 | 5.00 | 129 | 5.71 | 87 | 5.08 | 66 | 4.23 | 424 | 5.06 |
| 5. | Arthropoda | Insecta | Diptera | Fanniidae | Fannia | <i>Fannia scalaris</i> | 0 | 0 | 139 | 4.90 | 113 | 5.00 | 82 | 4.78 | 83 | 5.32 | 417 | 4.98 |
| 6. | Arthropoda | Insecta | Diptera | Calliphoridae | Chrysomya | <i>Chrysomya rufifacies</i> | 0 | 0 | 81 | 2.85 | 76 | 3.36 | 56 | 3.27 | 59 | 3.78 | 272 | 3.25 |
| 7. | Arthropoda | Insecta | Diptera | Calliphoridae | Chrysomya | <i>Chrysomya megacephala</i> | 0 | 0 | 80 | 2.82 | 80 | 3.54 | 49 | 2.86 | 47 | 3.01 | 256 | 3.06 |
| 8. | Arthropoda | Insecta | Diptera | Culicidae | Aedes | <i>Aedes aegypti</i> | 15 | 6.00 | 163 | 5.74 | 133 | 5.89 | 121 | 7.06 | 91 | 5.69 | 508 | 6.07 |
| 9. | Arthropoda | Insecta | Diptera | Culicidae | Anopheles | <i>Anopheles Gambiae</i> | 25 | 10.00 | 171 | 6.03 | 150 | 6.64 | 108 | 6.30 | 101 | 6.48 | 541 | 6.46 |
| 10. | Arthropoda | Insecta | Diptera | Blattidae | Periplaneta | <i>Periplaneta amesicanus</i> | 18 | 7.20 | 260 | 9.17 | 190 | 8.41 | 141 | 8.23 | 113 | 7.25 | 704 | 8.41 |
| 11. | Arthropoda | Insecta | Coleopteran | Serabaedidae | Canthon | <i>Canthon Pelularis</i> | 38 | 15.20 | 47 | 1.65 | 40 | 1.77 | 34 | 1.98 | 25 | 1.60 | 146 | 1.74 |
| 12. | Arthropoda | Insecta | Coleopteran | Serabaedidae | Onthophagus | <i>Onthophagus obliquus</i> | 45 | 18.00 | 41 | 1.44 | 43 | 1.90 | 28 | 1.63 | 22 | 1.41 | 134 | 1.60 |
| 13. | Arthropoda | Chilopoda | Scolopendromorpha | Scolopendridae | Scolopendra | <i>Scolopendra subspinipes</i> | 10 | 4.00 | 60 | 2.11 | 45 | 1.99 | 39 | 2.27 | 27 | 1.73 | 171 | 2.04 |
| 14. | Arthropoda | Arachnida | Araneae | Theraphosidae | Chromatopelma | <i>Chromatopelma cyangeaibescus</i> | 5 | 2.00 | 11 | 0.38 | 11 | 0.48 | 12 | 0.70 | 9 | 0.57 | 43 | 0.51 |
| 15. | Arthropoda | Insecta | Orthoptera | Gryllidae | Scapsipedus | <i>Scapsipedus marginatries</i> | 15 | 6.00 | 28 | 0.98 | 29 | 1.28 | 31 | 1.81 | 28 | 1.79 | 116 | 1.38 |
| 16. | Arthropoda | Diplopoda | Julida | Julidae | Ommatoiulus | <i>Ommatonlus sabulosus</i> | 5 | 2.00 | 47 | 1.65 | 47 | 2.08 | 46 | 2.68 | 42 | 2.69 | 182 | 2.17 |
| 17. | Arthropoda | Insecta | Orthoptera | Tettigoniodae | Tettigonia | <i>Tettigonia viridissima</i> | 20 | 8.00 | 94 | 3.31 | 62 | 2.74 | 47 | 2.74 | 40 | 2.56 | 243 | 2.90 |
| 18. | Arthropoda | Insecta | Lepidoptera | Papilionidae | Papilio | <i>Papilio Demodocus</i> | 38 | 15.20 | 42 | 1.48 | 37 | 1.63 | 35 | 2.04 | 29 | 1.86 | 143 | 1.70 |
| 19. | Arthropoda | Insecta | Hymenoptera | Formicidae | Dorylus | <i>Dorylus gribodoi</i> | 16 | 6.40 | 236 | 8.32 | 176 | 7.79 | 157 | 9.17 | 139 | 8.92 | 708 | 8.46 |
| | | 4 | 9 | 14 | | 19 | 250 | 100 | 283 | 99.9 | 225 | 99.9 | 171 | 99.9 | 155 | 99.9 | 836 | 99.9 |
| | | | | | | | | | 5 | | 8 | | 2 | | 8 | | 3 | |

The study clearly revealed variations in the abundance of arthropods between the studied dumpsites and this could be due to the differences in the composition of the waste in each dumpsite. The observed higher arthropods abundance in the dumpsite soil compared to the control could be due to the adaptation of the arthropods to dumpsites [15]. The arthropods distribution in the studied dumpsites was dominated by dipterans, which were very few in the control. The high abundance of dipterans indicates high level of pollution of the dumpsite, and this has a possible implication on the health of people living around the dumpsite, because dipterans are vectors for diseases such as yellow fever, malaria, cholera and typhoid fever [15]. High abundance of *Musca domestica* in dumpsites may be due to the ability of dumpsites to support their breeding [15]. *Musca domestica* were also more dominant because they are usually associated with domestic waste disposal facilities, where the accumulating organic matter provides suitable breeding conditions [16]. The near absence of dipterans in the control soil also confirms the contamination of dumpsites soil and the serenity of the control soil samples.

3.2 Heavy Metals Concentration in Dumpsite Soil

The control (PC) soil had lower concentrations of each studied heavy metal compared to that of the dumpsites. In S1 dumpsite, Cadmium (Cd) ranged from 0.062-1.241, with a mean and standard deviation of 0.605 ± 0.316 mg/kg, while lead (Pb) ranged from 0.010 - 0.195, with a mean and standard deviation of 0.082 ± 0.070 mg/kg. Chromium (Cr) ranged from 0.018-0.375 with a mean and standard deviation of 0.208 ± 0.098 mg/kg, while nickel (Ni) ranged from 0.104- 0.162, with a mean and standard deviation of 0.124 ± 0.016 mg/kg. Cobalt (Co) ranged from 0.004 – 0.112, with a mean and standard deviation of 0.034 ± 0.030 mg/kg, while arsenic (As) ranged from 0.001- 0.003, with a mean and standard deviation of 0.001 ± 0.000 . Mercury (Hg) was not detected through-out. The decreasing heavy metal trend in the soil was Cd>Cr>Ni>Pb>Co>As.

In S2 dumpsite, Cadmium ranged from 0.412- 0.602, with a mean and standard deviation of 0.485 ± 0.054 mg/kg. Lead ranged from 0.011-0.146 with a mean and standard deviation of 0.057 ± 0.054 mg/kg. Chromium ranged from 0.0394- 0.523, with a mean and standard deviation of 0.447 ± 0.039 mg/kg. Nickel ranged from 0.021- 1.101, with a mean and standard deviation of 0.328 ± 0.418 mg/kg. Cobalt ranged from 0.013- 0.470, with a mean and standard

deviation of 0.065 ± 0.128 mg/kg. Arsenic ranged from 0.001 - 0.005, with a mean and standard deviation of 0.003 ± 0.001 mg/kg. Mercury was not detected through-out. The decreasing heavy metal trend was Cd>Cr>Ni>Co>Pb>As.

In S3 dumpsite, Cadmium ranged from 0.529- 0.0746, with a mean and standard deviation of 0.611 ± 0.068 mg/kg. Lead ranged from 0.136- 0.513, with a mean and standard deviation of 0.270 ± 0.116 mg/kg. Chromium ranged from 0.127- 0.481, with a mean and standard deviation of 0.293 ± 0.123 mg/kg. Nickle ranged from 0.062- 0.326, with a mean and standard deviation of 0.152 ± 0.087 mg/kg. Cobalt ranged from 0.001 - 0.0112, with a mean and standard deviation of 0.032 ± 0.045 mg/kg. Arsenic ranged from 0.012- 0.027, with a mean and standard deviation of 0.017 ± 0.005 mg/kg. Mercury was not detected through-out. The decreasing heavy metal trend was Cd>Cr>Pb>Ni>Co>As.

In S4 dumpsite, Cadmium ranged from 1.012- 2.074, with a mean and standard deviation of 1.457 ± 0.493 mg/kg, while lead ranged from 0.724-2.003, with a mean and standard deviation of 1.198 ± 0.47 mg/kg. Chromium ranged from 1.612- 2.032, with a mean and standard deviation of 1.866 ± 0.156 mg/kg, while nickel ranged from 0.113 - 0.326, with a mean and standard deviation of 0.226 ± 0.057 mg/kg. Cobalt ranged from 0.201 - 0.561, with a mean and standard deviation of 0.343 ± 0.126 mg/kg, while arsenic (As) ranged from 0.010- 0.037, with a mean and standard deviation of 0.019 ± 0.008 mg/kg. Mercury (Hg) was not detected through-out. The decreasing heavy metal trend was Cr>Cd>Pb>Co>Ni>As.

The distribution of heavy metals in soil samples across the different dumpsites and the control is shown in figure 2. The heavy metals concentration in soil samples varied between dumpsites and were also lower in the control soil samples. The concentration of cadmium, lead, chromium, nickel, cobalt (S2 and S4 dumpsites) and arsenic (S3) in the soil of each studied dumpsite varied significantly compared to the control ($p < 0.05$). S4 had higher concentration of cadmium, lead, chromium, cobalt and arsenic compared to other dumpsites. The concentration of cadmium in S4 dumpsite, concentration of lead, chromium, nickel in all the studied dumpsites and arsenic concentration in S2, S3 and S4 dumpsites were all above the WHO acceptable limits for heavy metals in soil.

Variations in heavy metals concentrations in soil from different dumpsites could be due to the difference in the composition of each dumpsite and disposal habits [17]. Also, the concentrations of heavy metals in the dumpsites were higher than that of the control soil samples which corroborated with the findings of [14] who reported higher values of metals in refuse dumpsite soils. The higher concentration of heavy metals in dumpsite soil could be attributed to the solid waste disposed in the dumpsites which over time dissociate and add their metallic content to the soil [18].

3.3 Heavy Metals Concentration in Arthropods

The mean cadmium in Arthropods from the control (PC) site was lower than those from the dumpsites. Lead, chromium, nickel and cobalt were not detected in the control site. In S1 dumpsite, the concentration of cadmium in arthropods ranged from 0.017 – 0.020, with a mean and standard deviation of 0.018 ± 0.001 mg/kg, while lead ranged from 0.001 – 0.005, with a mean and standard deviation of 0.003 ± 0.002 mg/kg. Chromium ranged from 0.001 – 0.006, having a mean and standard deviation of 0.003 ± 0.002 mg/kg, while nickel ranged from 0.001 – 0.005, with a mean and standard deviation of 0.003 ± 0.001 mg/kg. Cobalt ranged from 0.001 – 0.002, with a mean and standard deviation of 0.001 ± 0.000 mg/kg. Arsenic and mercury were below detectable limit. The heavy metals concentration in arthropods had a decreasing trend of $Cd > Pb > Cr > Ni > Co$.

In S2 dumpsite, the concentration of cadmium in arthropods ranged from 0.010 – 0.012, with a mean and standard deviation of 0.011 ± 0.001 mg/kg, while lead ranged from 0.001 – 0.002, with a mean and standard deviation of 0.001 ± 0.000 mg/kg. Chromium ranged from 0.001 – 0.009, having a mean and standard deviation of 0.004 ± 0.003 mg/kg, while nickel ranged from 0.001 – 0.005, with a mean and standard deviation of 0.003 ± 0.001 mg/kg. Cobalt ranged from 0.001 – 0.002, with a mean and standard deviation of 0.002 ± 0.000 mg/kg. Arsenic and mercury were below detectable limit. The heavy metals concentration in arthropods had a decreasing trend of $Cd > Cr > Ni > Co > Pb$.

In S3 dumpsite, the concentration of cadmium in arthropods ranged from 0.001 – 0.011, with a mean and standard deviation of 0.008 ± 0.004 mg/kg, while lead ranged from 0.009 – 0.012, with a mean and standard deviation of 0.010 ± 0.001 mg/kg. Chromium ranged from 0.001 –

0.004, having a mean and standard deviation of 0.002 ± 0.001 mg/kg, while nickel ranged from 0.001 – 0.003, with a mean and standard deviation of 0.002 ± 0.001 mg/kg. Cobalt ranged from 0.001 – 0.002, with a mean and standard deviation of 0.002 ± 0.000 mg/kg. Arsenic and mercury were below detectable limit. The heavy metals concentration in arthropods had decreasing trend of $Pb > Cd > Cr > Ni > Co$.

In S4 dumpsite, the concentration of cadmium in arthropods ranged from 0.019 – 0.022, with a mean and standard deviation of 0.020 ± 0.001 mg/kg, while lead ranged from 0.011 – 0.024, with a mean and standard deviation of 0.017 ± 0.006 mg/kg. Chromium ranged from 0.002 – 0.014, having a mean and standard deviation of 0.007 ± 0.006 mg/kg, while nickel ranged from 0.001 – 0.004, with a mean and standard deviation of 0.002 ± 0.001 mg/kg. Cobalt ranged from 0.001 – 0.002, with a mean and standard deviation of 0.002 ± 0.000 mg/kg. Arsenic and mercury were below detectable limit. The heavy metals concentration in arthropods had decreasing trend of $Cd > Pb > Cr > Ni > Co$. The distribution of heavy metals in arthropods from the different dumpsites and the control (PC) is shown in figure 3. The heavy metals concentration in arthropods varied among the dumpsites and were also lower in the control samples. The heavy metals were all within the WHO limit.

Variations in heavy metals concentration in arthropods from different dumpsites and the control could be due to differences in the composition of each dumpsite [17]. These variations in the concentration of heavy metals could also be due to the difference in age of dumpsites [19; 20]. Heavy metals concentration in arthropods from all studied dumpsites were higher than that of the control which is similar to the findings of [21] who also reported higher values of metals in *Crocothemis servilia* (dragon fly), *Oxya hyla* (acridid grasshopper) and *Danaus chrysippus* (nymphalid butterfly) compared to the control. The higher concentration of heavy metals in these studied arthropods could be attributed to the fact that solid waste disposed in the dumpsite over time biodegrades and add their metallic content to the soil, which eventually bio-accumulate in the arthropods [18]. This was further confirmed by the correlation analysis which generally portrayed strong positive relationship between metal concentrations in soil from dumpsites and arthropods and suggests that these arthropods can be used as bio-indicators of heavy metals contamination and accumulation [22].

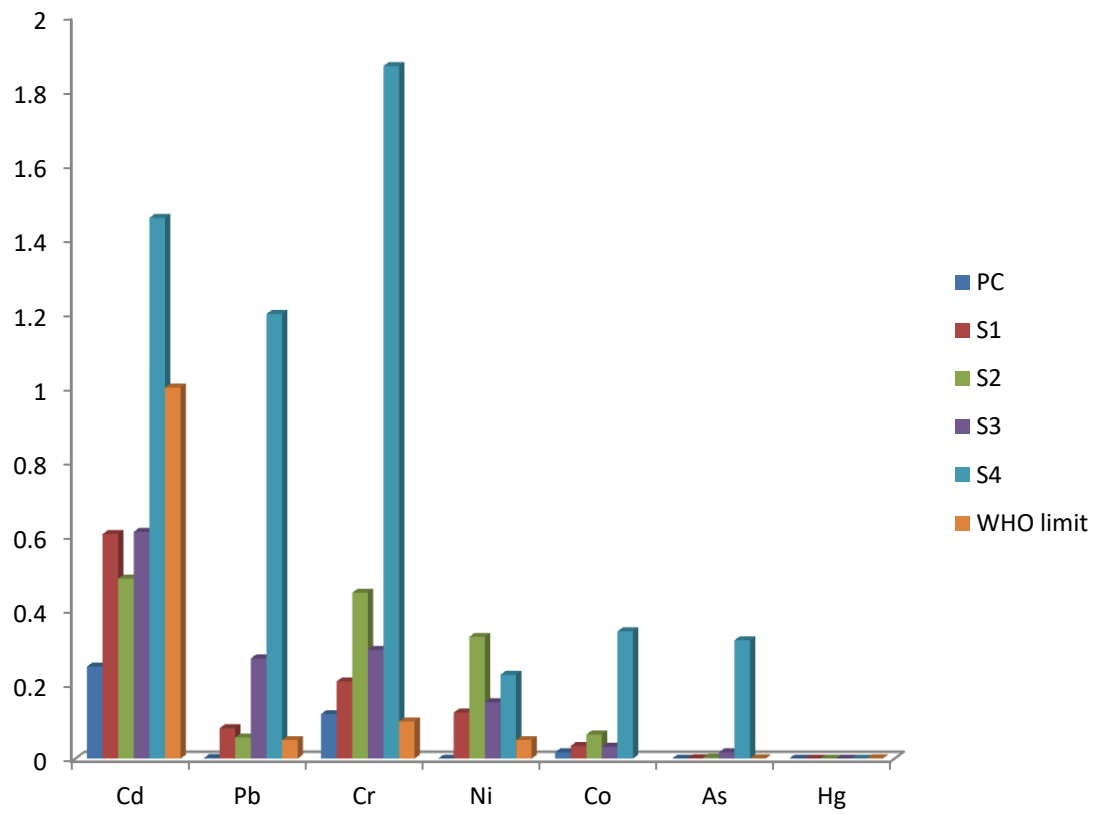


Figure 2: Heavy Metals Concentration in Soil from Selected Dumpsites in Calabar

UNDER REVIEW

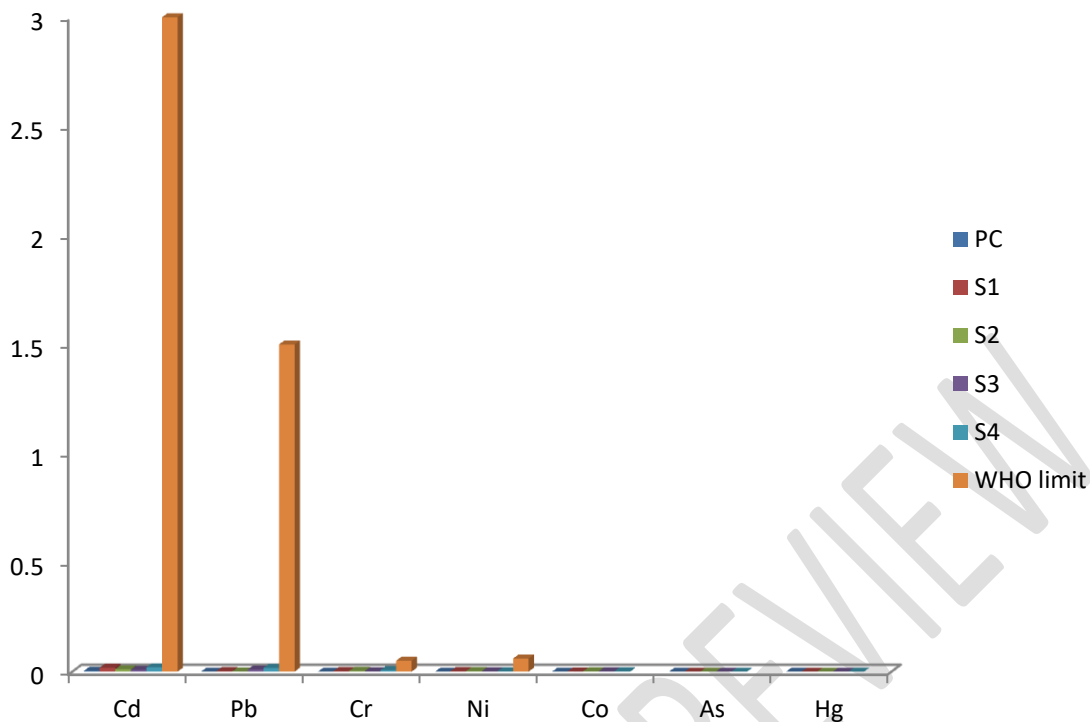


Figure 3: Heavy Metals Concentration in Arthropods from Selected Dumpsites in Calabar

3.4 Relationship between Heavy Metals Concentration in Soil and Arthropods from Dumpsites in Calabar

Pearson's correlation analysis showed strong positive relationship between mean heavy metals concentration in dumpsite soil and arthropods in Calabar with the highest r -value being 0.9944 in Co/Cr and lowest r -value was 0.3019 in Ni/Pb relationship. Table 2 shows the r -values of relationship between mean heavy metals concentration in dumpsite soil and arthropods.

[23] found high heavy metals concentration in insects during their study on metal accumulation in insects near a Copper smelter and floatation factory in Bulgaria. Positive correlation in Pb and Cd concentrations between insects and plants was observed and this was attributed to the feeding habit of the insects.

Table 2: Correlation Matrix showing the Relationship between Mean Heavy Metals in Soil and Arthropods during the Study

| | Cd | Pb | Cr | Ni | Co | As | Hg |
|----|--------|--------|--------|--------|--------|--------|--------|
| Cd | 1.0000 | | | | | | |
| Pb | 0.9740 | 1.0000 | | | | | |
| Cr | 0.9675 | 0.9729 | 1.0000 | | | | |
| Ni | 0.4072 | 0.3019 | 0.4677 | 1.0000 | | | |
| Co | 0.9543 | 0.9715 | 0.9944 | 0.3929 | 1.0000 | | |
| As | 0.6510 | 0.4891 | 0.5133 | 0.6532 | 0.4851 | 1.0000 | |
| Hg | 0.3920 | 0.5508 | 0.8311 | 0.7390 | 0.457 | 0.5209 | 1.0000 |

4. CONCLUSION AND RECOMMENDATION

In this study, a total of 8363 arthropod individuals, consisting of 19 species belonging to 14 families were collected from all the dumpsites. These arthropods were dominated by *Muscidae* (flies) family which constitutes about 20.39% indicating high level of contamination at the dumpsites as the refuse are not segregated. Heavy metals concentration in soil and arthropods from the dumpsites was higher than that of the control which shows the influences of refuse dumping and portrays health hazard to the people living in the vicinity of these dumpsites as some metals were above the WHO permissible limits. There was generally a strong positive correlation between mean metal concentrations in the dumpsite soil and arthropods which indicates mobility and bioaccumulation of these metals from soil to arthropods and suggests that they can be used as bio-indicators. It is therefore recommended that wastes be segregated and proper disposal methods should be adopted.

COMPETING INTEREST: The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

Sam-Uket N. O. carried out the field work and analysed the samples. Bate G. B. conducted the statistical analyses and arranged the manuscript for publication.

REFERENCES

1. Ojiegbe, R. U. (2005). Study of Waste Disposal Site and its Ground Water Contamination Potential. *International Journal of Natural and Applied Sciences*, 1, 21-24.
2. Nwoke, B. E. B. and Nwoke, E. A. (2006). Contributions of Occupational Hazards and Environmental Degradation on Emergence and Re-emergence of Disease. Proceedings of the 3rd world Annual National Conference of Occupational Safety and Environmental Health Management in Nigeria, No. 8-11, Nnamdi Azikiwe University Awka Anambra State Nigeria, 7-16.
3. Afon, A. O. and Okewole, A. (2007). Estimating the Quantity of Solid Waste Generation in Oyo, Nigeria. *Waste Management Research*, 25, 371-379.
4. Ogwueleke, T. C. (2009). Municipal Solid Waste Characteristics and Management in Nigeria. *Iran Journal of Environmental Health, Science and Engineering*, 6 (3), 173-180.
5. Onyido, A. E., Okolo, P. O., Obiukwu M. O. and Amadi E. S. (2009). A survey of Vectors of Public Health Diseases in Un-disposed Refuse Dumps in Awka Town, Anambra State, Southeastern Nigeria. *Research Journal of Parasitology*, 4, 22-27.
6. Kapusta, P. and Sobczyk, L. (2015). Effects of Heavy Metal Pollution from Mining and Smelting on Enchytraeid Communities under Different Land Management and Soil Conditions. *Science of the Total Environment*, 536, 517-526.
7. Asuquo F. E. and Bate G. B. (2020). Bioaccumulation of Heavy Metals in Mangoes (*Mangifera indica* L.) found in the Vicinity of Gold Mining Sites of Zamfara State, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology* 12(1): 45–58.
8. Odiete, W. O. (1999). *Environmental physiology of animals and pollution*. Lagos: Diversity Resources, 257.
9. Bate G. B. and Yunana B. D. (2020). Heavy Metals and Petroleum Hydrocarbon Concentration in Water and Periwinkles (*Tympanotonus fuscatus* L.) obtained from Calabar River, Cross River State, Nigera. *International Journal of Environment, Agriculture and Biotechnology* 5(3): 664–672.
10. Mehdi J., Dutta J. and Kalita M. C. (2020). Biomonitoring Ecosystem: Modeling Relationship with Arthropods. *IntechOpen* 94313.
11. David W. L. and John R. S. (2006). Arthropods as Ecological Indicators of Sustainability in Canadian Forests. *The Forestry Chronicle* 82(3): 344–350.
12. Eze, E. B. and Effiong, J. (2010). Morphometric Parameters of the Calabar River Basin. Implication for Hydrologic Process. *Journal of Geography and Geology*, 2(1), 1916-9787.
13. Ahmed, A. B. (2011). Insect Vectors of Pathogens in Selected Undisposed Refuse Dumps in Kaduna Town, Northern Nigeria. *Science World Journal*, 6(4), 21-26.
14. Abida, B., Ramaiah, M., Harikrishna, I., K., and Veena, K. (2009). Analysis of Heavy Metals Concentration in Soil and Lichens from various Localities of Hosur Road, Bangalore, India. *E-Journal of Chemistry*, 6(1), 13-22.
15. Popoola, K. O. K. and Amusat, A. I. (2015). Effect of Soil Properties on Arthropod Biodiversity in Dumpsites in Ibadan, Oyo State, Nigeria. *Researcher*, 7(5), 45-50.

16. Dave, G., Lara, C., Derwent, M., Michael, E., Hanley, D. W., Dunn, S. R., and Abolins, A. (2005). Predicting Calyprate Fly Population from the Weather, and Probable Consequences of Climate Change. *Journal of Applied Ecology*,42: 795-805.
17. Luter, L., Akaahan, T. J., and Simon, A. (2011). Heavy Metals in Soils of Auto-mecahnric Shops and Refuse Dumpsites in Makurdi. *Journal Applied. Science. Environment*,15(1), 207-210.
18. Oni, A. A., Ossai, A. W. and Lawal, T. K. (2011). Macro-faunal Diversity of a Contaminated Dumpsite in Ibadan, Nigeria. *Elixir Bio Diver*,39(1), 4905.
19. Taylor, R. and Allen, A. (2006). Waste Disposal and landfill: Potential Hazards and Information Needs. In O. Schmoll, G. Howard, J. Chilton and I. Chorus (Eds.),*Protecting Groundwater for Health: Managing the Drinking-water Sources*. London: IWA Publishing Quality, 55.
20. Johnson, C. A., Richner, G. A., Vitvar, T., Schittli, N. and Eberhard, M. (1998). Hydrological and Geochemical Factors affecting Leachate Composition in Municipal Solid Waste Incinerator Bottom ash Part I: The Hydrology of Landfill Lostorf, Switzerland. *Journal of Contaminant Hydrology*,33, 361-376.
21. Azam, I., Afsheen, S., Zia, A., Javed, M., Saeed, R., Sarwar, M. K. and Munir, B. (2015). Evaluating Insects as Bioindicators of Heavy Metals Contamination and Accumulation near Industrial Area of Gujrat, Pakistan. *Biomedical Research International*,1(1), 1 – 9.
22. Diener, S., Zurbrugg, C. and Tochner, K. (2015). Bioaccumulation of Heavy Metals in the Black Soldier Fly, *Hermetia illucens* and Effects on its Life Cycle. *Journal of Biological Sciences*,1(4), 261 – 270.
23. Karadjova I and Markova E. (2009). Metal Accumulation in Insects (Orthoptera, Acrididae) Near a Copper Smelter and Copper-Flotation Factory (Pirdop, Bulgaria). *Biotechnology and Biotechnological Equipment* 23(1): 204 – 207.