

Akamkpa Local Government Area is bounded by Akpabuyo and Biase and has latitude of $4^{\circ}.510$ N and $5^{\circ}.435$ and longitude of $8^{\circ}.7305^{\circ}$ E and $8^{\circ}.180^{\circ}$ E. Mfamosing community has a large expanse acre of land with characteristic mountain out crop which is said to be ninety five percent (95%) dominated by limestone. The inhabitants are predominantly farmers and they engage in palm oil production, rearing of livestock, while some of its indigenes also work with the cement manufacturing company (UNICEM).

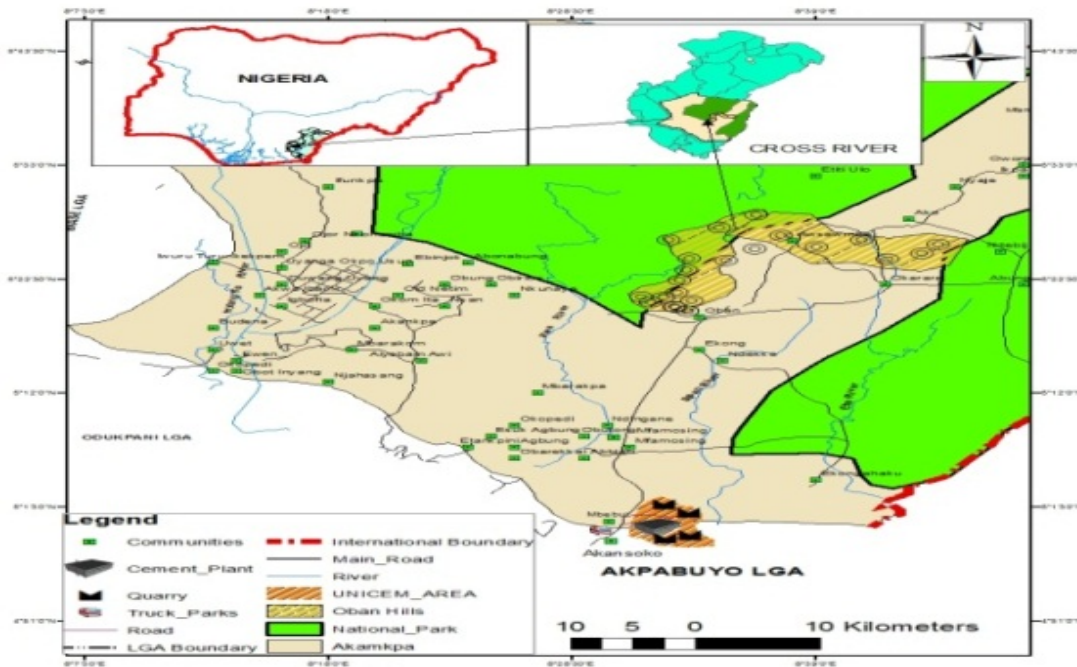


Fig.1 The study area

Sampling Station

This study was carried out in two different sampling stations. The first sampling station was located at Okon Ukpa in camp 2, where the major cement production activity takes place. The other sampling site was located at Aneheje and was used as control site. It is approximately 15 minutes drive from the company (UNICEM).

Station 1: This station was located at Okon Ukpa in Mfamosing community.

It is the heart of all the production activities of the United Cement Company of Nigeria (UNICEM) and has latitude of $4^{\circ}51'$ N and $5^{\circ}43'$ and longitude of $8^{\circ}73'$ E and $8^{\circ}18'$ E.

Station 2: According to the report of [5] it was found that soil contamination due to cement production drops sharply with increasing distance from the factory. This station is located at Aneheje and is about 15 minutes drive away from the cement manufacturing company in camp 11 and has latitude of $4^{\circ}.510$ N and $5^{\circ}.435$ and longitude of $8^{\circ}7305^{\circ}$ E and $8^{\circ}180^{\circ}$ E. This station was used as control site.

Sample Collection Technique

Sampling procedures are critical when assessing the distribution, abundance and species richness of invertebrates. Basic techniques have been described by [19] and good review of technique applied to land invertebrates is given by [10]. The sampling technique used was very simple and rudimentary. Growing vegetation was gently removed using cutlass, leaf debris and roots was also removed. Samples were randomly collected from within to a depth of 15cm and on soil surfaces around the study area at 25m apart. Soil litters was gently removed and placed in a polythene bag.

Cutlass was used to dig the soil and collect samples at the depth of 15cm. At each study site a total of 30 samples were collected for six times. A grand total of 360 samples were collected and each sample site labeled accordingly and transferred to Zoology and Environmental Biology laboratory for analysis. In the laboratory, soil samples were individually emptied into a tray and larger invertebrate fauna was sorted out using a pair of forceps and a magnifying glass. Soil was put in petri dish and observed under light microscope. Soil invertebrate seen was picked using forceps into specimen bottles containing 70% ethanol to ensure preservation. For smaller invertebrates, soil was passed through Berlese extraction funnel; heat was applied to lamp holder and held by a metal cylinder. The heat source was placed a few inches above the soil. To obtain maximum result 60wt bulb generating temperature at about $30-40^{\circ}$ c was used to heat for 2 - 3 hours. Invertebrates present were driven down through the sieve and funnel into a collecting beaker. Invertebrates were identified using land invertebrate picture books, use of keys available in standard textbooks and other related literatures.

RESULTS AND DISCUSSION

A total of 1427 invertebrate were obtained, out of which black ant (*Dorylus helvolus*) was the most abundant recording a total of 655(45.90%). This was followed by Nematode 144(7.98%), Springtail (*Dicyrtomina sp*) 79(5.53%), earthworm (*L.terresris*)

75(5.25%), grasshopper 65(4.55%), mite 54(3.78%), mole cricket (*Gryllotalpa sp.*) 44(3.08%), termite (*Macrotermes nigeriense*) 43(3.01%), beetle (*Colosoma sp.*) and millipede (*Polydesmus sp.*) both were 42(2.94%) respectively. Snail (*Helix sp.*) was 28(1.96%), spider (*Sceliphron sp.*) 15(1.05%), centipede 14(0.98%). Millipede (*Julus sp.*) and butterfly (*Papillio sp.*) were both 9(0.63%), praying mantis (*Mantis religiosa*) 8(0.56%), aphid (*Aphid sp.*) 4(0.28%), yellow and black wasp (*Vespula sp.*) 3(0.21%), dragonfly (*Brachymeria furcata*), moth (*Hedylidae sp.*), leafhopper (*Eurymela distincta*) and slug (*Vernicelloidea sp.*) all had 2(0.14%) each and insect larvae was 116(8.12%). Therefore, black ant and earthworm recorded higher percentage abundance than all other invertebrate sample during the study.

Out of the 4 phylum obtained, phylum arthropoda 1,208(85%) was the highest recorded out of which 796(65.89%) was recorded in Aneheje and 412(34.10%) in Unicem. This was followed by phylum nematoda 114(8%) with 74(65%) in Aneheje and 40(35%) in Unicem, phylum annelida with 75 (5%) with 58 (77%) in Unicem and 17(23%) in Aneheje, the phylum mollusca with 30 (2%) with 4 (13.3%) recorded in Unicem and 26(86.6%) recorded in Aneheje. (Fig.1) This result indicates that they were a significant difference (P<0.05) in the distribution of various identified land invertebrates among themselves and among the study locations.

In terms of invertebrates classes, the class insecta recorded highest with 1,074 (75%), arachnida 69(5%), secernentea 114(8%) myriapoda 65(5%), clitellata 75 (5%), and gastropoda 30(2%).

More so, the result showed variation in the class abundance in different sampling stations. Out of the 1,074 (75%) recorded by the class insecta, Unicem was 379(35%), while Aneheje recorded 695(65%), the class arachnida 69(5%) with Unicem 21(30%), Aneheje 48(70%), the class secernentea 114(8%) with Unicem 40(35%), Aneheje 74(65%), the class myriapoda 65(5%) with Unicem 12(18%), Aneheje 53(82%), the class clitellata 75(5%) with Unicem 58(77%), Aneheje (23%), and the class gastropoda 30(2%) with Unicem(13%) and Aneheje (87%). Taxa richness calculation as Margalef's index (d) was least in Unicem (2.88) and high in Aneheje (2.93) with 0.05 away from each other. Furthermore, Shannon-Weiner diversity index that was calculated for each site showed Unicem to be 0.92 and Aneheje was 0.81 also with 0.05 differences away from each other. Equitability was least in Aneheje (0.28) and highest in Unicem (0.31). The two stations had more or less equal diversity with insignificant different indices value. The phylum arthropoda is by far the largest phylum in animal kingdom.



Percentage composition and relative abundance of invertebrate fauna in the various sampling sites in Mfamosing, Akamkpa L.G.A, Cross River State

TAXA	UNICEM	%	ANEHEJE	%	TOTAL	%
Arthropoda						
Collembola						
<i>Dicyrtomina sp.</i>	30	5.83	49	5.36	79	5.53
Isoptera						
<i>Macrotermes nigeriense</i>	19	3.69	24	2.62	43	3.01
Orthoptera						
<i>Gryllotalpa sp.</i>	16	3.11	28	3.06	44	3.08
<i>Locusta migratoria</i>	47	9.14	18	1.97	65	4.55
Hymenoptera						
<i>Dorylus helvolus</i>	209	40.66	446	48.84	655	45.90
<i>Vespula sp.</i>	-	-	3	0.32	3	0.21
Coleoptera						
<i>Colosoma sp.</i>	11	2.14	31	3.39	42	2.94
Odonata						
<i>Brachymeria furcata</i>	2	0.38	-	-	2	0.14
Dictyoptera						
<i>Mantis religiosa</i>	2	0.38	6	0.65	8	0.56
Lepidoptera						
<i>Papillio sp.</i>	7	1.36	2	0.21	9	0.63
<i>Hedylidae sp.</i>	0	-	2	0.21	2	0.14
Homoptera						
<i>Eurymela distincta</i>	2	0.38	-	-	2	0.14

<i>Aphid sp.</i>	1	0.19	3	0.32	4	0.28
<i>Insect larvae</i>	33	6.42	83	9.09	116	8.12
Myriapoda						
Chilopoda						
<i>Scolopendra sp.</i>	4	0.77	10	1.09	14	0.98
Diplopoda						
<i>Polydesmus sp.</i>	8	1.55	34	3.72	42	2.94
<i>Julus sp.</i>	-	-	9	0.98	9	0.63
Arachnida						
Arenida						
<i>Sceliphron sp.</i>	4	0.77	11	1.20	15	1.05
Acarina						
<i>Oribatidae sp.</i>	17	3.3	37	4.05	54	3.78
Mollusca						
Gastropoda						
Pulmonata						
<i>Helix sp.</i>	4	0.77	24	2.62	28	1.96
<i>Veronicelloidea sp.</i>	-	-	2	0.21	2	0.14
Anellida						
Clitellata						
Oligochaeta						
<i>L. terrestris</i>	58	11.28	17	1.86	75	5.25
Nematoda						
<i>Secernentea sp.</i>	40	7.78	74	8.10	114	7.98
Total	514	100	913	100	1427	100

Source: Field survey, 2022

[14] Reports that approx. 713,500 species or about 80% of all the species in the animal kingdom are arthropod. Looking at the figures and tables put together, there was differences in the abundance of invertebrates fauna obtain from the two sampling stations. Margalef's index which is the measure of species richness calculated for Unicem was 2.88 and Aneheje was 2.9. Shannon-Weiner index showed that Unicem was 0.92 and 0.87 in Aneheje. However, what was interesting here is how close these numbers are. The fact that the indices are 0.05 away from each other disproved my expectation that they would not be diverse invertebrate species at the industrial area of Mfamosing (Okon Ukpa) when compared to industrial free area of Aneheje considering the high level of environmentally unfriendly threat posed by the cement production factory on soil and litter-dwelling invertebrates. This findings is supported by the report of [13] in their work, the authors compared invertebrate fauna collected from industrialized location of Pioneer Park, Kenton County, Kentucky that of Withrow Nature preserve, Cincinnati, Ohio a non-industrial location. Their overall result showed that each site was pretty similar when it came to species richness and diversity of organisms within the sample locations. Furthermore [7] reported that geophagus organisms (those that taking in large amount of soil during feeding on well decomposed organic material) and those living on or near the soil surface may have greater exposure to chemical than worm feeding on litter pulled down into burrows in the sub-soil. This supports our findings which showed high abundance of earthworm (*L. terrestris*) in Unicem and a competitive number of nematode.

[3] asserted that nature has provided biodiversity with certain form of habitat and not as adaptable as man to the surrounding. Thus, the expansion of human population and unfolding of human's horizon to exploit resources for economic and other purposes tend to displace such indigenous resources and can even put some species into extinction, if not addressed with caution. The capacity of invertebrate to be adaptive to changing environment varies within species. This study revealed the absence of Millipede (*Julus sp.*), leafhoppers (*Hedyllidae sp.*), and Centipede (*Scolopendra sp.*) was also reported to be relatively low. This absence can be attributed to the fact that this organism (*Julus Sp.*) tend to fold or "play death" when they are disturbed or encounter obstacle. This may compel them to migrate. Furthermore, hymenoptera, collembolans were found in both sampling stations at high abundance, collembolans are considered biological regulators and have important functions in ecosystems. They are known to feed on bacteria, fungi, mineral soil particles, organic matter, protozoa and nematodes and increase soil respiration and accelerate nitrogen mineralization. The activities of cement production in unicem factory has been going on for years now and so one would expect invertebrate to have developed enhanced resistance to this threat and adapted to it. Soil invertebrate like the mole cricket may remain dormant or inactive when natural environment is disturbed.

Conclusion

Frequent disturbance of natural invertebrate habitat by pollutants such as dust, noise, vibrations, gaseous emission, and air-borne particles from the cement production factory (Unicem) will produce low population of invertebrate fauna. This no doubt will affect the physiological activities of soil and litter-dwelling invertebrates most especially those at the quarry site. The implication of these is

that some of the invertebrate may have retarded growth while others may be compelled to migrate. This work will serve as a tool of information for researchers and pave the way for other works that will precede this one.

As indicated by the indices, both locations are very diverse this is a positive aspect that came out of this work. More intensive studies are therefore recommended to investigate other parameters this research work could not cover such as seasonal variations in the distribution of land invertebrate, determining the abundance and distribution of soil invertebrate present at each study location in terms of the different soil layers and evaluating the characteristics that enhance the survival of invertebrate in an industrialized location such as Okon Ukpa (Unicem), Mfamosing.

Acknowledgement

The author wishes to thank the Department of Zoology and Environmental Biology Laboratory, University of Calabar, Calabar and Professor Oku Ene for their supports.

References

- [1] A. Abbas, and N. Morad, "Industrial discharge and their effect to the environment", Intech open publication. 274, 2013.
- [2] I. Abbott, "The influence of fauna on soil structure. Animals in primary succession: the role of fauna in reclaimed lands". Cambridge university press.pp.39-50, 1989.
- [3] M. L. Adeola "Wildlife conservation in Nigeria to Projected Trend in Human Population. Land Use Desertification and the Quality/Quantity of Tropical Rain Forest", FAN conf. Proceeding. pp. 326-330, 1991.
- [4] J. M. Anderson, "Spatrotemporal effect of invertebrate on soil processes", *Biology and Fertility of Soil* 6:189-203, 1988.
- [5] O. I. Asubiojo, P. O. Aina, A. F. Oluwole, W. Arshed, O. A. Akanle, and N. M. "Effects of cement production on the elemental composition of soils in the neighbourhood of two cement factories, water, air and soil pollution", *Kluwer Academic Publishers*, 5(58): 819-828, 1991.
- [6] N. M. Collins, "Termite population and their role in litter removal in Malaysia rain forest", In S. L. Sutton, T. C. Whitmore, and A. C. Chad (eds). *Tropical Rainforest: Ecology and Management*. Blackwell scientific publications, oxford. Pp.311-325, 1983.
- [7] E. A. Curl, P. J. Edwards, C., Elliot & Leahey, "The conjugation and accumulation of metabolites of cypermethrin by earthworms". *Pesticide Science* 20: 207-222, 1987.
- [8] A. R. Dexter, "Tunnelling in soil by earthworm", *Soil Biology and chemistry* 10:447-449, 1978.
- [9] C. A. Edwards, "Testing the effects of chemicals on earthworms: The advantages and limitations of field tests". In *Ecotoxicology of Earthworms*. P. W. Greig-Smith (eds). Intercept Ltd. Pp. 75-84, 1992.
- [10] C. A. Edward, "The assessment of Population of Soil-inhabiting invertebrates. *Agric., Ecosystem and Environment*. 34: 145-176, 1991.
- [11] A. D. Mackay, J. K. Syers, J. A. Springett and P. E. H. Gregg, "Plant availability of phosphorus in superphosphate and a phosphate rock as influenced by earthworms", *Soil Biology and Biochemistry*, 14:281-287, 1982.
- [12] J. C. Y. Marinissen and J. Book, "Earthworm amended Soil Structure: Its influence on Collembola populations in grassland", *Pedobiologia* 32:243-352, 1988.
- [13] N. Mark and R. Snow, "Effects of a frequently disturbed industrial area of leaf titler invertebrate communities", *Biology Labs, Science* pp. 177, 2010.
- [14] A. Moldenke, C. Shaw, and J. R. Boyle, "Computer-driven image-based soil fauna taxonomy" *Agric, Ecosystem and Environment* 34:177-185, 1990.
- [15] B. Raphael, G. Thiago, A. Cintya, G. Tarnains, and S. O Carmon, "Soil contamination with heavy metals and petroleum derivatives: Impacts on Edaphic Fauna and Remediation Strategies", *Intech. Science* pp. 176-198, 2013.
- [16] S. P. Rushton, "Earthworm in pastoral agriculture" *Outlook on Agric.*, 17:341-346, 1988.

- [17] E. Samuel, and D. Aynalem, "Assessing the effect of cement dust emission on the physico-chemical nature of soil around messebo area", Tigray, North Ethiopia. *Int. J. econ. Env. Geol.* 3(2): 12-20, 2012.
- [18] A. N. Sharpley, and J. K. Syers, "Potential role of earthworm cast for phosphorus enrichment of run-off waters. *Soil Biology and Chemistry* 8:341-346, 1976.
- [19] T. R. E. Southwood, "Ecological Methods", *Chapman and hall*. London, England, 1978.
- [20] B. H. Svensson, U. Bostrom, and L. Klemmedson, "Potential for higher rates of denitrification in earthworm cast than the surrounding soil", *Biology and Fertility of Soil* 2:147-149, 1986.
- [21] J. K. Syers, A. N. sharpley and D. R. Keeny, "Cycling of nitrogen by surface casting earthworms in a pasture ecosystem", *Soil Biology and Chemistry.* 11:181-185, 1979.
- [22] P. A. M. Van Amelsvoort, M. van Dongen, and P. A. vander Werf, "The impact of collembolla on humidification and mineralization of soil organic matter", *Pedobiologia* 31:103-111, 1988.
- [23] T. G. Wood, "Termite and the soil environment", *Biology and fertility of soils.* 6:228-236, 1988.

