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Quantification of the ecological impact of trace metals on the abundance and diversity of soil mites in a tropical landfill

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Quantification of the Ecological Impact of Trace Metals on the Abundance and Diversity of Soil Mites in a Tropical Landfill.

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Soil mites

- Essential Component of the Diverse Soil Fauna Community which comprises of :
- **Microfauna**:Protozoa (Phyla Sarcomastigophora and Ciliophora)
- **Mesofauna** :*Nematodes* (Phylum Nematoda) -<0.1mm
- **Microarthropods***:**mites (Order Acari)***,Springtails (Order Collembola),Rotifers (Phylum Rotifera)-0.1mm-5mm

  Macrofauna (>5mm)
- **Macroarthropods** - beetle and fly larvae (Order Coleoptera and Diptera),
  Cicada nymphs (Order Homoptera),
  Centipedes (Class Chilopoda),
  Millipedes (Class Diplopoda)

- **Earthworms** (Class Oligochaeta)

BASIC SCIENTIFIC CLASSIFICATION

- KINGDOM :Animalia
- PHYLUM :Arthropoda
- CLASS :Arachnida
- SUPER ORDER :Acarini
- ORDER: Oribatida, Gamasida,Actinedida
- FAMILIES :Several.
- GENUS :several genera
- SPECIES :many species

Identification : Working with mites requires a good microscope!

Basic features:Strong Exoskeleton,hardened by sclerotization and by mineralization.sizes and colouration varies.Finer distinguishing features are as provided in the identification charts.

Ecology:live in litter,low fecundity,obligately parthenogenetic,eggs hatch into nymphs,slow metaolic rate and development .

Why bother about the Soil Mites (SMs) ?=Ecological Significance of the SMs.

- Through feeding interactions with fungal and bacterial microflora, SMs regulate decomposition rate, affect nutrient cycling and play an important role in soil fertility.
- Hence,SMs are Basically Involved in Nutrient Cycling,Energy and Material Flow: **Soil Biogeochemistry and Trophic Dynamics.**
- **A significant contribution due to their**: profound interactions with their ecological niches as a result of sedentary life histories and relatively long life span=
- Especially the locally dominant Cryptostigmatid mites (The Oribatida group) (Badejo and Ola-Adams,2000)
- Constituting 50-60% of the Soil Microarthropod Fauna of Southwestern Nigeria (Badejo,1987)
- SMs abundance, species composition and diversity in a particular habitat serves as good indicators of soil quality (soil health)-**Used as Biomonitoring tools.**

Basic facts about Trace Metal Consciousness

-**Trace metals~also called heavy metals =density>5gcm3**
Group III- V + high atomic masses
(see periodic table 1) www.environmentalchemistry.com/periodic table

Historically,Trace metal impact consciousness arose and intensified from:

*Outbreak of Minamata disease in Japan in 1954-(Kiyoura, 1962)

*Cadmium poisoning (itai itai disease)- (Shimizu,1962)

*Lead poisoning (Snyder et al,1971)

- Heightened following the Environmental Revolution set off by Rachel Carson's in her book *SILENT SPRING.*

Ongoing awareness :enlightenment at local and global levels and the improved ,but very expensive methods of analyses-ICP-MS,etc.

-**Trace metal sources** –natural background and the anthropogenics: industrial,domestic and agricultural activities.

-**Trace Metal Bioavailability and Ecological Impact** :A Dynamic Interaction of Spatial and Temporal Factors (Nriagu,2004).

Levels of Quantification of Ecological Impacts of Trace Metals

- **Molecular** :chromosomal damage,sister chromatid exchange=mutagenic & ultimately embryotoxic and teratogenic effects +sexual maturation.

- **Cellular**:mediates physiological and biochemical activities
  Cytochrome P450,Protein synthesis,metallothioneins,heat stress proteins, Enzyme activity:Cholinesterase/sensory capacity,ATPase/adenylate energy exchange,Oxygen consumption rates,osmoregulation,eggshell thinning,hormonal and haematological changes,Pigmentation,immune function,etc

- **Tissue**: **Bioaccumulation**-
  Uptake kinetics
  Metabolism and excretion
  Complexation and storage.
  Tissue distribution and effects
  Bioconcentration
- **Organ** : Anatomical changes,weights and histochemistry.
  Developmental rates, abnormal growths:neoplasms/tumours.

- **System**: **E.g: Reproduction-**
  -Gamete viability/fertility
  -Larval development
  -Fecundity
  -Reproductive cycle and frequency.
  *Amongst other systems:excretory,respiratory,skeletal,

- **Individual :**

  -life expectancy

  -resistance and vulnerability to diseases,parasities and pathogens .

  -Behaviour

  *Rythmic activities

  *Motor activity:Burrowing

  *Avoidance/attraction to others

  *Reproductive behaviour.**:**

- **Ecological**

  -Community structure:Species richness,Dominant species,**Diversity** and indices.**Relative abundance** among species

  -Density/Biomass,Population dynamics

  -Habitat diversity and fragmentation

  -Indicator species

  -Endangered and Rare species,extinctions

  -Patterns of Succesion,Nutrient cycling ,Energy flow.

  -Trophic dynamics and structure

  -Biodiversity Conservation Status. **Modified from Odiete (1999) .**

Tools used for the Quantification of Trace Metal Impacts on Soil Mites in the Study.

- **The Study Area**

  -Location

  Aba Eku MSW landfill is located near Ibadan between Longitude 30º50‘, 40º50'E and Latitude 70º5 ', 70º30'N. The figure below shows the Map of the study area.

  -The Demarcated Plots

  -Five 10X10 M dimension plots were randomly marked out .

  -Control Site of same dimension marked at an elevated location 100M away from the edge of the landfill.

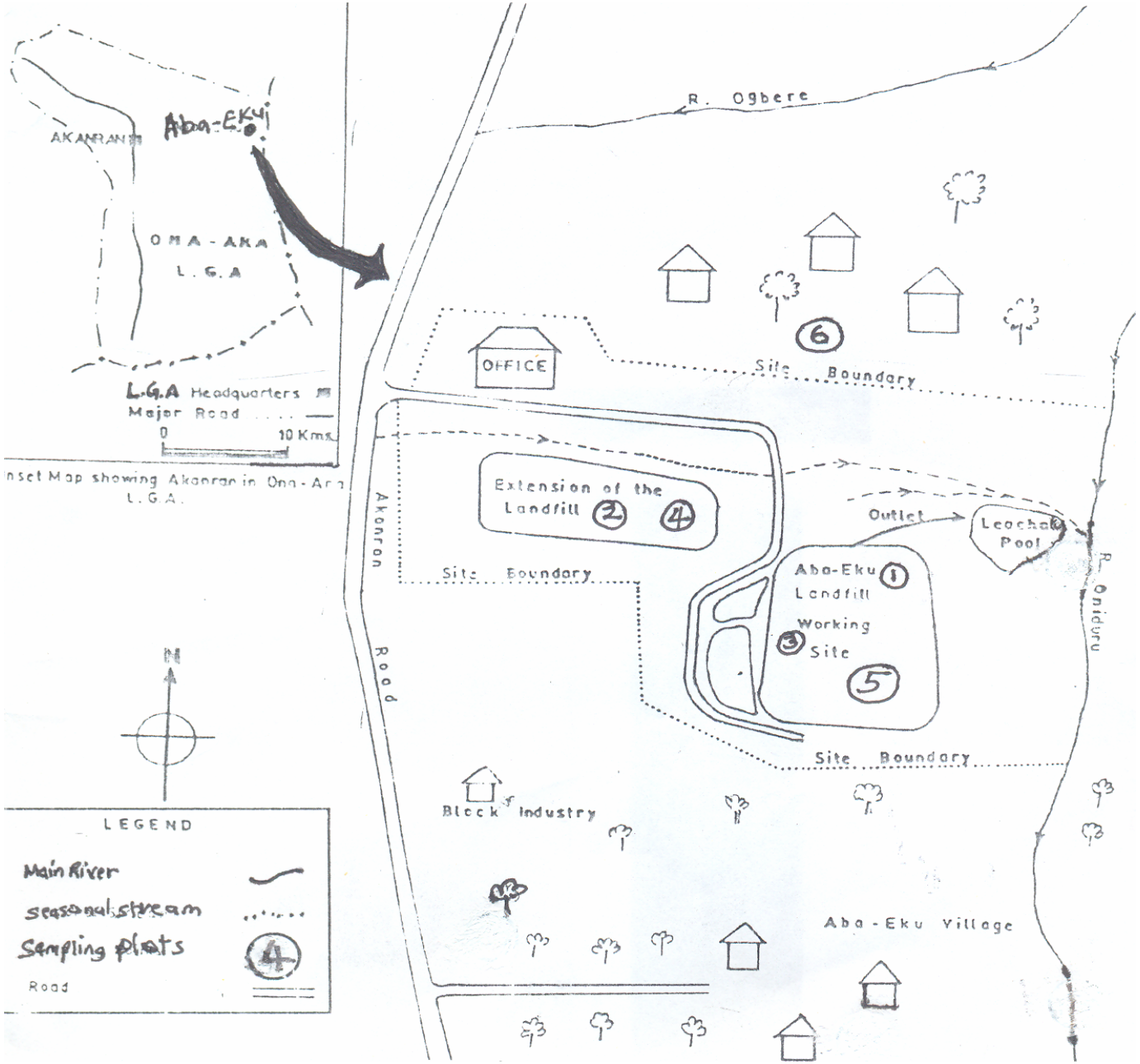
  -**Frequency of Sample collection: monthly** from April-July 2003 (n=4).Top 10cmof soil collected

- **Extraction Procedure**

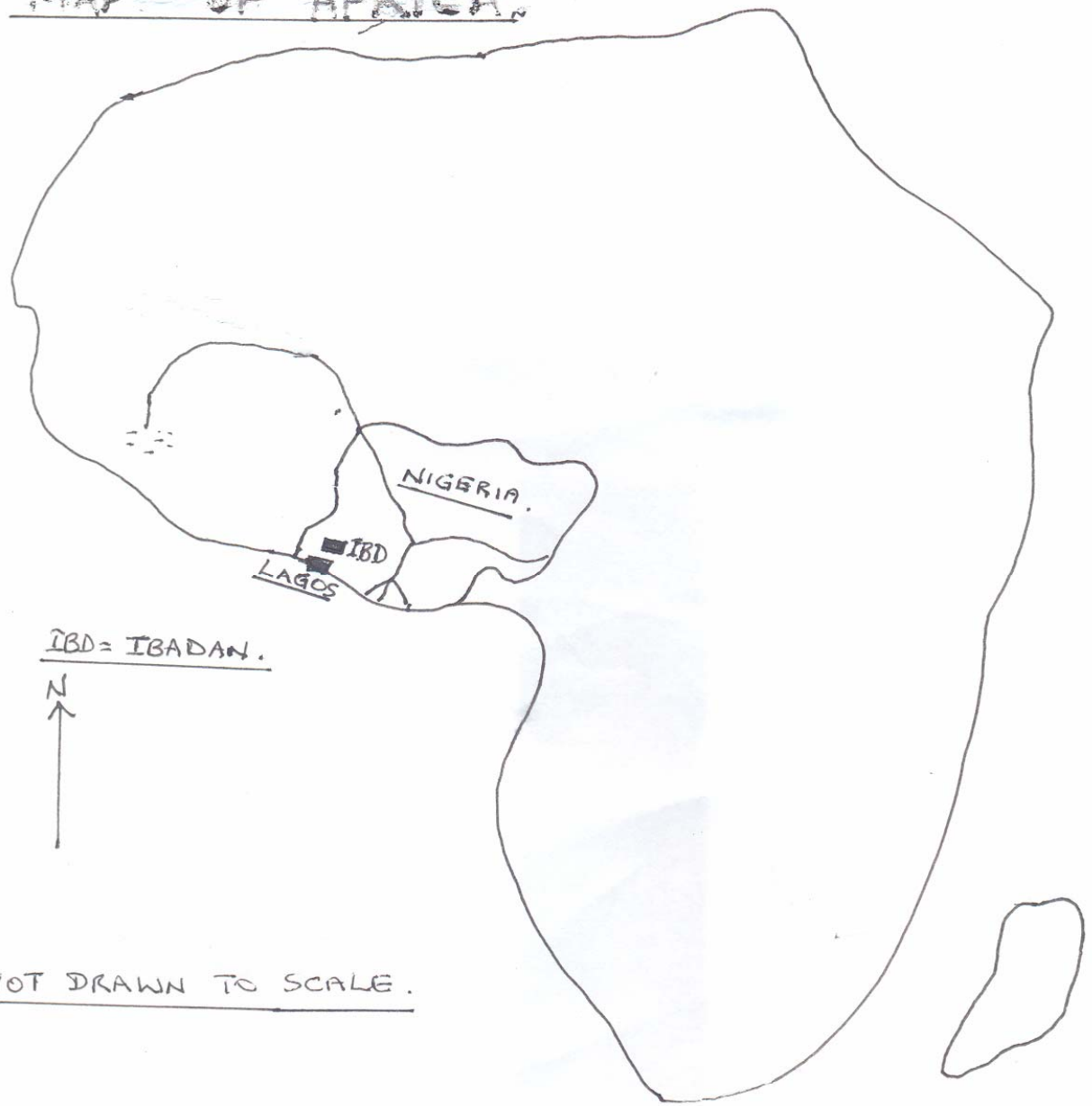
  -The Bukard –model of Berlesce-Tullgren funnel extractor was used to extract the soil microarthropods from the soil samples as described by Lasebikan (1974).

  -Identification was done to generic level using keys and illustrations from Evans et al, (1967), Norton (1990).

  -Abundance expressed as number/m^2 in the demarcated plots (landfill and undisturbed subsets).


AKANRAN
Aba-Eku
OMA-AKA
L.G.A
L.G.A Headquarters
Major Road
0
10 Kms
Inset Map showing Akanran in Oma-Aka L.G.A.
R. Ogbere
OFFICE
6
Site Boundary
Extension of the Landfill
2
4
Outlet
Leachate Pool
Akanran
Road
Site Boundary
Aba-Eku Landfill
1
Working Site
3
5
R. Oniduru
Site Boundary
Block Industry
Aba-Eku Village
N
LEGEND
Main River
seasonal stream
Sampling plots
4
Road

MAP OF AFRICA.



IBD = IBADAN.

N

NOT DRAWN TO SCALE.

- **Trace Metal Analysis of Landfill Soil Samples.**

  -Shimadzu Atomic Absorption Spectrophotometer (AAS) was used for the analysis of soil samples from the demarcated plots.

  - Two grams of oven dried and pulverized soil sample was weighed into digestion flasks.

  -A mixture of concentrated HNO_3 and $HClO_4$ (2:1) was added and then digested on a digester until a clear solution was obtained .

  -The clear solution was cooled ,transferred completely into 100ml volumetric flask using distilled water, filtered and finally made up to the mark.

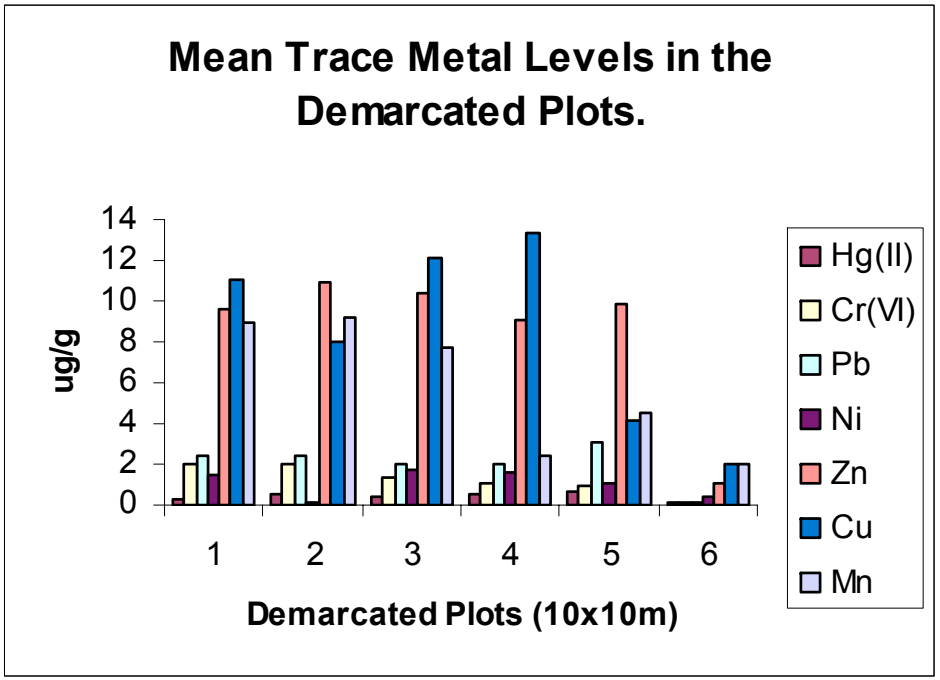
  -Analysis for trace metals in the samples was carried out in duplicates at their appropriate wavelengths using the AAS facility.

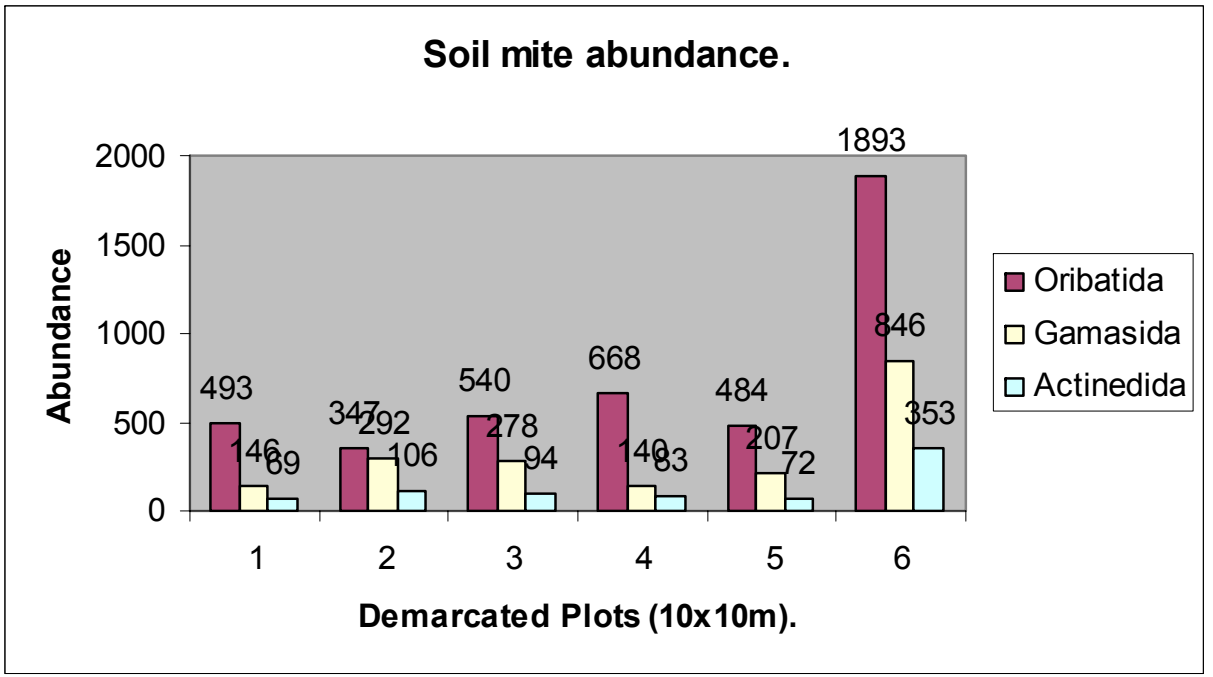
RESULTS

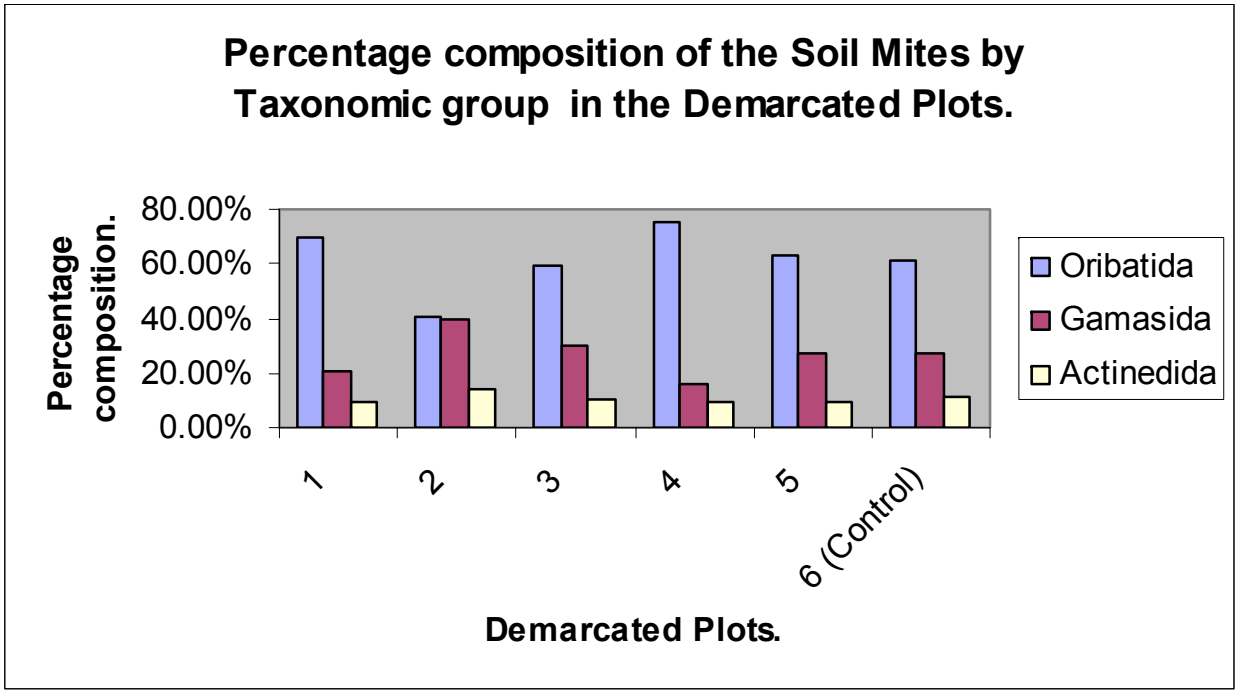
Table1: Mean heavy metal levels (µg/g) of the demarcated plots in the Aba-Eku landfill (n=4)

Plots		Hg (II)	Cr (VI)	Pb	Ni	Zn	Cu	Mn	Fe (II)
	1	0.32	1.96	2.45	1.5	9.6	11.13	8.93	30.25
	2	0.49	2.03	2.38	0.08	10.96	8.06	9.18	21.38
	3	0.37	1.33	1.99	1.74	10.46	12.07	7.72	32.91
	4	0.58	1.06	2.04	1.6	9.01	13.31	2.34	37.24
	5	0.67	0.98	3.01	1.01	9.87	4.08	4.57	25.12
Control	6	**0.18**	0.07	0.12	0.41	1.06	2.03	1.97	12.98
Mean		0.44	1.24	2.00	1.06	8.49	8.45	5.79	26.65
High		0.67	2.03	3.01	1.74	10.96	13.31	9.18	37.24
Low		0.18	0.07	0.12	0.08	1.06	2.03	1.97	12.98

Results (Contd.)




Soil mite abundance.
Abundance
2000
1500
1000
500
0
493
146
69
347
292
106
540
278
94
668
140
83
484
207
72
1893
846
353
1
2
3
4
5
6
Demarcated Plots (10x10m).
Oribatida
Gamasida
Actinedida


Percentage composition of the Soil Mites by Taxonomic group in the Demarcated Plots.
Percentage composition.
80.00%
60.00%
40.00%
20.00%
0.00%
1
2
3
4
5
6 (Control)
Demarcated Plots.
Oribatida
Gamasida
Actinedida

The Berger-Parker Dominance Index (BPDI)=

- BPDI -% contribution of each species/family/taxonomic group to the total number of soil mites in each study plot.
- ≥10 % density =Dominant
- Sampled Plots with relatively higher number of dominant groups are an indication of an Unstable Community in **transition** with several ecological opportunities for different niches.
- It is an indication of natural or anthropogenic impacts that upsets the balance for opportunistic colonization and flourishing of less viable species with the attendant problem of alien invasion.**But,soil mites are sedentary in nature=biomntrg tools.**
- Is this then the ideal situation for biodiversity conservation ?
  Due to Ecological damage/imbalance+Transitory nature of the behemoth created .
- Relatively fewer dominant groups could mean virgin habitats in the early stages of invasion or a stable community as other ecological parameters may confirm.

Berger-Parker Dominance Index (species / number ratio expressed in percentage of soil mites in the study area.

			Plots			
Mite group	1	2	3	4	5	6
Oribatida						
Annectacarus	25	0	2	0	1	3
Belba	0	9	0	0	4	12
Dolicheremaeus	4	0	0	13	0	14
Eremulus	0	0	15	0	0	0
Galumna	4	0	3	2	9	3
Haplozetes	0	4	0	3	30	0
Machadobelba	7	14	0	0	3	5
Oppia	20	0	0	40	0	6
Oribates	3	0	7	0	29	7
Pilizetes	0	16	0	2	0	7
Scheloribates	24	0	2	0	0	8
Teleioliodes	5	9	0	35	2	0

Gamasid-a						
Rhodacarus	0	25	0	1	0	5
Polyasipidae sp.1	0	0	25	3	0	7
Protodinichidae	0	9	0	0	12	0
Uropodidae sp.1	0	0	10	0	0	6
Uropodidae sp.2	3	8	0	0	10	6
Actinedida						
Bdellidae	3	0	0	1	0	3
Caeculidae	2	7	0	0	0	7
Rhagidiidae	0	0	36	0	0	1
Number of Taxonomic groups.	11	9	8	9	9	16
Number of dominant groups	3	3	4	3	4	2

Relationship between the trace metal contamination and soil mites

Correlation coefficient (r) values between the means of the trace metals in landfill plots and soil mite taxa.

	Hg(II)	Cr (vi)	Pb	Ni	Zn	Cu	Mn	Fe(II)
Oribatia	0.131	-0.681	0.459	-0.318	-0.828	0.602	-0.760	0.949*
Gamasi-da	-0.099	0.249	-.077	-0.515	0.953*	-0.285	0.522	-0.565
Actinedi da	-0.099	0.597	-0.481	0.857	0.736	0.131	0.336	0.286

*Correlation is significant at the 0.05 level (2-tailed)

Discussion

- The heavy metal contamination measured in this study serve as an indication of the extent of pollution as a result of the landfill site in Aba-Eku, Ibadan .

- the soil mite can serve as biological indicators showing the degree of ecological imbalance caused by the solid wastes .

- the correlation that exists between the trace metal levels in the soil and abundance and distribution of soil mites at the demarcated plots indicates that the former tends to control the later.
- For example, there was significant correlation between Fe(II) and oribatid mites ($r=0.949, p>0.05$),Zn and gamasid mites ($r=0.953, p>0.05$). =strong sensitivity.

- Studies elsewhere have shown similar trends in the effects of heavy metals on the soil mite community (Heikens *et al,* 2001, Nahmani and Lavelle, 2002; and Migliorini, *et al, 2004)*

Assertions from the Study

- The soil in Aba Eku landfill site Ibadan is contaminated by some trace metals.
- Cr,Ni,Zn,Cu,Mn,and Fe concentrations exceed guideline limits of 1µg/g and 10µg/g for Fe set by the Federal Ministry of Environment.
- The soil mite densities fluctuated with the trace metal levels in the landfill and control plots.

Upshot

- **The report has appeared in the most recent issue of the British Ecological Society *Bulletin Vol 35:3, May 2005, p. 39.***
- **A paper for peer-review based on this study is being prepared and this forum offers the opportunity for contributions to improve the quality of the work for publication.**
- **Further analysis and follow up studies will hopefully be carried out using Canoco Program for Redundancy Analysis (RDA) in order to relate community composition to environmental variables in diverse landfills in SouthWest Nigeria.**
- **RDA combines the tools of multiple linear regression and principal component analysis to provide further highlights on the quantifiable effects of (variables) trace metals on the soil community.**
- **Adoption of a multidisciplinary approach with collaborators with strengths in modeling of ecological phenomenon + hopefully develop my basic understanding and application of modeling ecological dynamics using different data sets.**

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Thank You for your attention .