Earthworms and Soil Pollution

MSc Thesis Summary by Ngai Ieng Chao: September 2009

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Aim

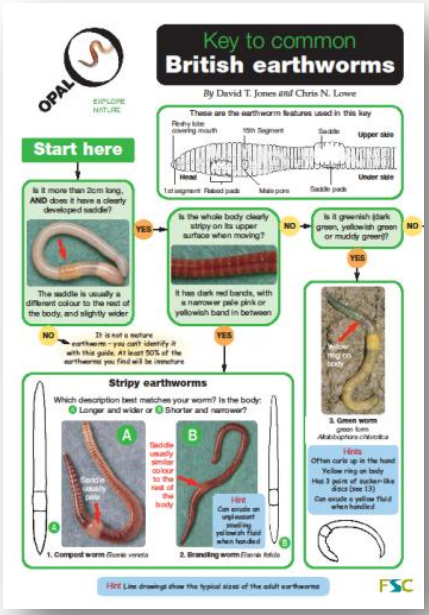
The overarching aim of this study is to investigate the links between soil, earthworms and soil pollution.

Objectives

- Develop a sampling strategy to have a better understanding of the links between soil pollution and earthworms;
- Investigate the relationship between soil properties and soil pollution;
- Explore the impacts of different soil properties on earthworm population, distribution, species and diversity, and ecological groups;
- Further investigate the effect of soil pollution upon earthworm population, distribution, species and ecological groups.

Introduction

Soil is a pivotal component of the environment, and it supports diverse and numerous forms of lives among which earthworms are always considered to be the representative organisms. In addition, soil is also a medium for the spread of pollutants and plays a critical role in determining the toxicity of pollutants. Soil dwellers like earthworms are inevitably subject to the toxicity effects of pollutants. On the other hand earthworms also have an impact on soil properties, structure and pollution. All these form the complex links between soil, earthworms and pollution which is the overall aim of this study.



There are many studies investigating the relationships between soil, earthworms and pollution. There is evidence that earthworm population, distribution and species are not only influenced by soil properties such as temperature, moisture, pH, compaction and texture etc. but also contaminant levels in the soil. However, most of the studies were carried out under laboratory and controlled conditions, and only a few were under field conditions. Even fewer field studies focused on the relationship between earthworms and toxicity levels of contaminants.

A Soil and Earthworm Survey was launched by the Open Air Laboratories which developed a Field Guide for the public to identify the earthworm species easily. This survey enables a vast database of soil properties and earthworm population and

species distribution across England and also forms a basis of this study.

Methodology

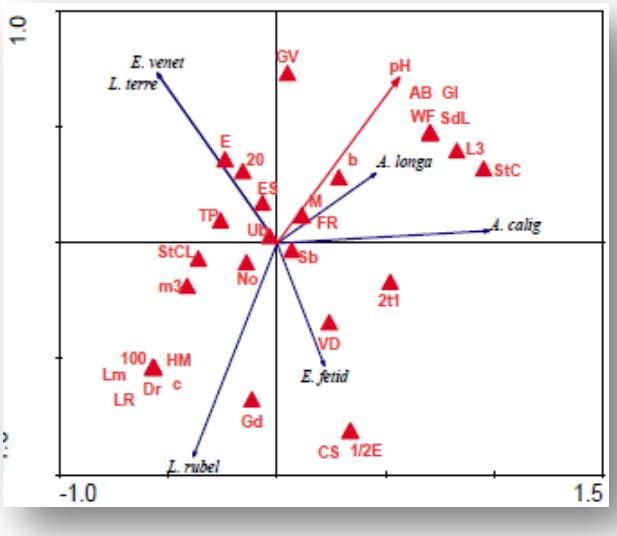
The first stage of this study was to review the past studies on the links between soil, earthworms and soil pollution. The outcome of this stage set the theoretical background and hypothesis for this study, and shed light on the next stage.

The second stage involved field sampling to investigate these potential links in the field. Sampling strategy was developed by combining the Geochemical Baseline Survey of the Environment (G-BASE) project by British Geological Survey (BGS) and Earthworm and Soil survey by Open Air Laboratories (OPAL) network. Two pilot study areas which are Hammersmith in West London and Camden in North London have been sampled and analysed for mercury concentrations by BGS. Field sampling of this study was carried out on the basis of the pilot studies. Besides sampling soil, earthworms were also collected and identified on the total 151 sampling sites. Every sampling site in this study was located at the centre of each the four 500mx500m quadrates within every National Grid one kilometre square. A 20cmx20cm square pit was dug to a depth of 10cm in the soil, and then a series of soil tests and earthworm sampling were carried out in light of the guidance in the OPAL Soil and Earthworm Survey. Further, mustard was used as vermifuge for extracting the deep burrowing earthworms. Any earthworms encountered at every sampling location were hand-sorted then identified and collected. Three categories of data were recorded in this study: site characteristics, soil properties and earthworm number and species.

The last stage of this study was data analysis. Species diversity of earthworms at each sampling site was indicated by the Simpson index and Shannon index. Non-parametric tests were employed to determine whether there was significant relationship between soil, earthworms and pollution. Mann-Whitney test was used when there were only two categories in the environmental variable, while Kruskall-Wallis analysis was applied when three or more categories existed.

Furthermore, Spearman rank correlation analysis was undertaken to study the correlation coefficient between two variables.

Finally, ordination was applied to produce a meaningful summary of the patterns underlying the multivariate data in this study, and investigate the relationships between environmental variables and data of species and earthworm ecological groups. Detrended Correspondence Analysis and Redundancy Analysis (RDA) were used, and the outcomes were visualized by biplots. Further analysis was carried out by XY attribute plots with general linear modelling testing whether a significant relationship existed.



RDA ordination biplot for environmental variables and earthworm species.

Environmental Variables and Soil Pollution

Statistical analysis showed that there was no significant relationship between the tested environmental variables and mercury concentrations in soils except for the factor of objects in the soil. The descending order of the medians of mercury concentrations in soils with different objects is construction material, glass, metal, other and none. Further analysis also revealed that soils with unusual objects had significantly higher mercury levels than those without unusual objects.

Environmental Variables and Earthworms

No significant relationship was demonstrated between the tested environmental variables and earthworm population. Further investigation on the presence of plant roots in soils revealed that it was statistically correlated with earthworm population. Soils with plant roots support greater populations of earthworms than those with no plant roots. In addition, Spearman rank correlation test shown a weak correlation between earthworm population and pH with the most earthworms appeared in pH 6.0.

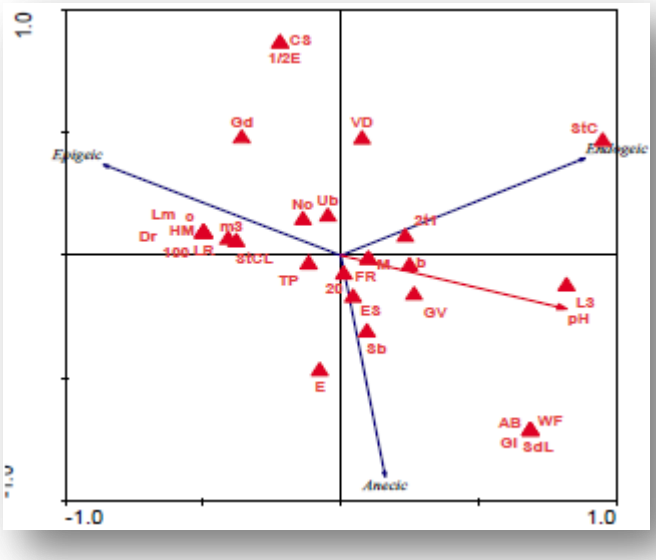
Further analysis on juvenile and adult populations indicated that all the tested environmental variables did not show significant relationships with both the populations of juvenile and adult earthworms. But a weak correlation was found to appear between pH values and juvenile populations.

Environmental Variables and Earthworm Species and Ecological Groups

The results of ordination and XY attribute plots indicated that the population of earthworm species *L. rubellus* had a significantly negative relationship with pH values. However, no relationship was found between the tested environmental variables and the population of different earthworm ecological groups.

Earthworms and Soil Pollution

The outcome of the analysis demonstrated that mercury concentration did not have significant effects on the presence and population of earthworms. Furthermore, there was also no correlation shown between mercury levels and earthworm species and ecological groups.



RDA Ordination biplot for earthworm ecological groups and environmental variables using CanoDraw

Discussion, Conclusions and Policy Implications

The significant relationships found in this study are listed below;

- the factor of objects in the soil and mercury level in the soil with higher mercuryconcentrations in soils with the presence of unusual objects;
- the presence of plant roots in the soil and earthworm population with greater earthworm population in soils containing plant roots;

- the population of earthworm species *L. rubellus* and pH value with population high in pH 6.0.

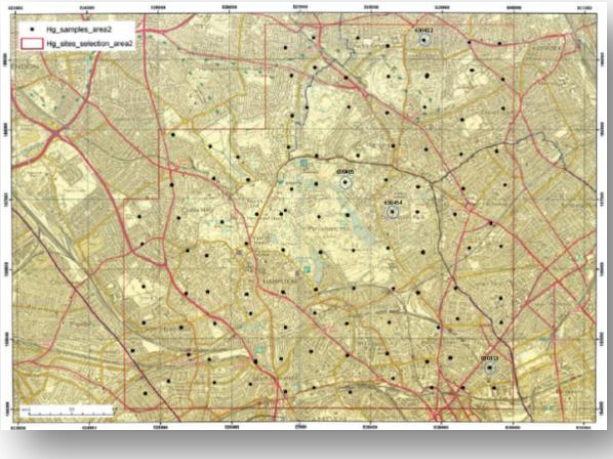
The findings suggest that the main sources of mercury pollution in the sampling soils may come from these unusual objects. This study also strengthens the findings in the literature that plant roots in the soils are positively correlated to earthworm population. However, the analysis on the earthworm species in this study seems not to be very convincing due to the low number of adult earthworms encountered in the sampling. This study also found that earthworm species *A. caliginosa*, *L. terrestris* and *A. longa* in the field can still survive in soils with unfavourable conditions. And earthworms also existed in field soils with higher mercy concentrations than the lethal levels reported by literatures. Thus this study further demonstrated the differences in the relationships between soil, earthworms and soil pollution under confounding field conditions and controlled laboratory conditions.

It is also noted that there are some limitations in this study. The number and frequency of earthworms encountered in the field were affected by the temperature and weather which may result in bias in the data. The method of hand-sorting earthworms may also lead to underestimation of earthworm population. Furthermore, the descriptive questions in the OPAL Soil and Earthworm Survey inevitably result in subjectivity in the data.

The links between soil, earthworms and soil pollution studied in this work has implications on earthworms serve as bio-indicator of soil condition and pollution in future regulation and policy. Future studies should try to exclude the limitations above and include more quantitative data. As the links between soil, earthworms and pollution are not very clear yet, further studies are still needed.

Project Sampling areas:

Camden area, North London



Hammersmith area, West London.