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# EVALUATING THE SOIL SAMPLES AND DISTRIBUTION OF ARTHROPOD SPECIES IN THE UNIVERSITY OF UYO, AKWA IBOM STATE, NIGERIA

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## ABSTRACT

This study was conducted to evaluate soil samples and the distribution of soil arthropods at the University of Uyo. The following physicochemical parameters and inorganic loads of the soil were measured for arthropod species obtained with the Berlese-Tullgren extractor: pH, temperature (°C), electrical conductivity (mg/L), BOD (mg/L), Chloride (mg/L), Nitrate (mg/L), Phosphate (mg/L), Sulphate (mg/L) and Nitrite (mg/L). Soil arthropod samples were collected from four (4) sampling sites: the Faculties of Science, Agriculture, Engineering, and Postgraduate School (PGS) using pitfall trap and Berlese-Tullgren extraction funnel techniques. The results of the soil physicochemical parameters and inorganic contents revealed that variables differed significantly between sampling sites at $p < 0.05$. Fifty-two species of soil-dwelling arthropods were collected and classified into four (4) classes; Insecta, Hexapoda, Arachnida, and Diplopoda, fourteen orders with 2310 individual species. The number of individuals of Hymenoptera 989 (42.81%), Coleoptera 455 (19.70%), Orthoptera 422 (18.27%), Polydesmida 94 (4.07%), Arachnida 92 (3.98%) and Hemiptera 71 (3.07%) was widely collected across both seasons, using pitfall and Berlese-Tullgren extractor funnel method. The dominant species were *Formica* sp. (390; 16.88%), *Camponotus vagus* (313; 13.55%), and *Teleogryllus emma* (296; 12.81%). The collection of soil arthropods during the wet season (1673; 72.42%) had a higher abundance than the dry season (637; 27.58%) across all sampling sites. It was evidence that the pitfall trap expressed more effectiveness in the collection of soil-dwelling arthropods (1693; 73.29%) than the Berlese-Tullgren extractor funnel method (617: 26.71%). Results of the soil samples show that the soil's physicochemical parameters and inorganic loads fell within the Environmental Protection Agency (EPA) recommended range. The composition, individual, and relative abundance recorded in this study suggest that the University of Uyo has high soil arthropod species diversity, more research should be carried out to close the gap in the species of this wonderful group in the University.

KEYWORDS: Soil sample, physico-chemical parameters, inorganic loads, *Camponotus vagus*

## INTRODUCTION

Arthropods are the largest and most special group of animals on the planet. They are classified into five primary classes: Crustacea, Myriapoda, Insecta, Arachnida, and Onychophora. Arthropods occupy every possible environment, even the soil. Some soil arthropods, such as spiders (Araneae: Salticidae), grasshoppers (Orthoptera: Acrididae), and bees (Hymenoptera: Apidae), live on the soil's upper surface layer. Some are located in the mid-layer of the soil e.g. Ants (Hymenoptera: Formicidae) and dung beetles (Coleoptera: Scarabaeidae). Some are accustomed to living underground. Examples are mole cricket (Orthoptera: Gryllotalpidae), millipedes (Polydesmida: Eurymerodesmidae). The soil is a component of the biosphere consisting of mineral particles and organic compounds. It is inhabited by bacteria, fungi, and macro-organisms (Lakshmi and Joseph, 2016). Soil arthropods contribute to delivering ecosystem services, maintaining soil quality, and minimising environmental pollutants, as well as forming key components of the soil food webs. Soil arthropods are also involved in the breakdown of organic materials in the soil (Lavelle *et al*., 2016; Orgiazzi *et al.*, 2016; Menta and Remelli, 2020; Fauzi *et al*., 2023; Akpan *et al*., 2024). The distribution and variety of soil arthropods depend mainly on the physical structure of the soil, the kind and quantity of organic matter, interactions between species, human intervention, and climate. High biodiversity is synonymous with ecosystem health (Paudel and Tiwari, 2022). The health of the soil ecosystem is therefore proportional to its productivity and sustainability which is based on the changing state of its physicochemical and biological qualities (Somasundaram *et al*., 2013; Bufebo and Elias, 2020, Akpan *et al*., 2024).

Intensive agricultural systems that incorporate the use of chemicals such as nitrogenous fertilizer can generate detrimental effects on soils, including loss of biodiversity. Soil arthropods are also sensitive to land deterioration. Indiscriminate use of cheap but persistent pesticides by farmers exerts negative effects on soil arthropods. Leaching of wastes from landfills or direct discharge of industrial effluents have detrimental effects on the natural environment including soil arthropods. The ensuing decrease in the natural population of arthropods is deplorable in itself and could impair agricultural activities, notably through the absence of vital pollinators and lack of nutrients for recycling as a result of soil contamination. Several studies have shown that distribution, diversity, and abundance of soil arthropods are influenced by the availability of substrate quality, organic matter, the concentration of nutrients and age, and the biological diversity of rehabilitating habitat, as well as rapid climatic changes (Agwunobi and Ugwumba, 2013; Esenowo *et al*., 2014; Abah *et al.*, 2017; Nargis *et al*., 2021; Ado and Rabiu, 2022). Conversely, studies on the diversity and abundance of soil arthropods (macroinvertebrates) in some locations in Uyo, Akwa Ibom state have been carried out by Esenowo *et al*. (2014), Udo *et al*. (2019), Akpan *et al*. (2020), Akpan *et al*. (2021), Udofia *et al*. (2021), Akpan *et al.* (2024), Oboho *et al*. (2024); but

there was gap on the comprehensive information on soil sample analysis in the Main Campus of University of Uyo. Hence, there is need for this study to evaluate soil samples and the distribution of soil arthropods at the University of Uyo.

## MATERIALS AND METHOD

Study Area

This study was done in the University of Uyo Main Campus, Uyo, Akwa Ibom State from May 2023 to December 2023. Four (4) sampling sites were chosen at random: The Faculties of Science, Agriculture, Engineering, and Postgraduate School (PGS) (Figure 1). Faculty of Science (FOS) sits between Latitude 5.0395647°N and Longitude 7.9818198°E. Here, the site was forested, and vegetative covers within this site were principally trees, herbs, shrubs, and under storey runners. Faculty of Agriculture (FOA) is located between Latitude 5.0490367°N and Longitude 7.9772044°E. The site was forested and vegetative covers within this zone were densely more distributed than site 3. Faculty of Engineering (FOE) is located between Latitude 5.0425779°N and Longitude 7.9661550°E. There were scarce plant coverings on this site and much grassland. Due to construction and industrial activity, trees, bushes, and herbs were rarely scattered in this zone. Post Graduate School (PGS) is located between Latitude 5.0360224°N and Longitude 7.93375119°E. There were limited vegetal covers on this site compared to site 3. In this place, urbanisation and more human/economic activities were carried out, with the persistent movement of people.

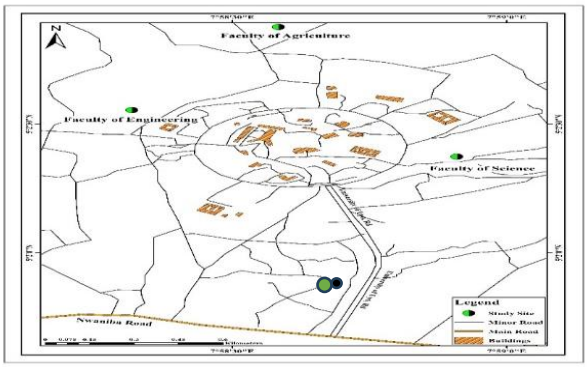


Fig. 1: Map showing sampling sites in the University of Uyo main campus, Uyo, Akwa Ibom State. Source: Cartography studio, Department of Geography and Natural Resources Management, University of Uyo, Uyo (2023).

### Sampling method

This investigation used the standard sample procedures described by Esenowo *et al*. (2014), Triyogo *et al*. (2020), Akpan *et al*. (2021), Knapp *et al*. (2022), and Akpan *et al*. (2024). These approaches involved the employment of Pitfall traps and Berlese-Tullgren extractors.

### Analysis of soil physicochemical parameters

The soil pH and temperature were measured in situ with a buffered electronic pH meter (Model H18314 HANNA) and mercury in glass thermometer, while both conductivity and biological oxygen demand (BOD) were assessed using a K120 digital duet electronic conduction meter. A quantity of 50 g each of soil samples was collected from different areas using a hand towel and placed individually in a beaker of 150 ml of distilled water. It was swirled with a glass rod for 15 - 25 seconds before inserting the mercury-in-glass thermometer, which is done by placing the bulb end of the thermometer to take the temperature reading. The reading was allowed to acquire a constant value before each reading was recorded, and this was done repeatedly to collect three (3) readings (used as replicates).

### Analysis of soil inorganic content

Soil samples were collected from the sampling sites using a sterilised hand towel for analysis of the following soil inorganic contents: Chloride, Nitrate, Sulphate, Phosphate, and Nitrite, in the laboratory of the Department of Chemistry, University of Uyo using standard protocols (Jamel, 2017). Nitrate, Sulphate, Phosphate, and Nitrite were found using the procedure in equation 1 below, whereas Chloride was calculated with equation 2:

$NO_3^-$ (mg/L) = (Absorbance of Test × Dilution Factor ×Concentration of Standard) / (Absorbance of Standard × Weight of Sample) (1)

Cl (mg/l) = ([(A – B) × M × 70900]) / ([Volumes (ml) of Sample]) (2)

Where: A is the volume (ml) of AgNO3 used for titrating the sample, B is the volume (ml) of AgNO3 used for titrating the blank, M is the molarity of AgNO3 utilised.

### Sampling of Soil Arthropods

The sampling of the Arthropods was done utilising two (2) methods of collection viz: Pitfall Trap and Berlese-Tullgren Extractor Funnel.

Pitfall Trap Method

A total of 16 pitfall traps made of plastic containers measuring 27cm deep with a mouth diameter of 30cm containing 4 - 5% formalin (Esenowo *et al*., 2014; Triyogo *et al*., 2020; Knapp *et al*., 2022, Akpan *et al*., 2024) were buried in 30cm deep excavated soil with the rims flush with the soil in all sampling sites. The caught arthropods were taken to the Laboratory of the Department of Animal and Environmental Biology, University of Uyo, for sorting and stored in 5% formalin. Identification of soil arthropod samples to genus/species was conducted using morphological and graphical keys provided by McGavin, 2002; Villet 2003; Picker, 2012; Villet and Picker 2012; Menta *et al*., 2018). Berlese-Tullgren Extractor Funnel Method.

The Berlese-Tullgren approach was used to capture soil arthropods as well. Four (4) Berlese-Tullgren extractor funnels were fabricated as described by Akpan *et al*. (2024), using 20 L C-way plastic water containers screened with a 1 mm mesh net. The soil samples utilised for the Berlese–Tullgren extractor were gathered from the sampling sites with the aid of the soil auger.

## DATA ANALYSIS

Data generated were entered into Microsoft Excel and analysed using SPSS version 20. Paleontological Statistics (PAST) 3.0 versions.

## RESULTS

### Soil physicochemical characteristics and inorganic contents

The mean and standard error results of soil physicochemical parameters and inorganic contents evaluated revealed soil pH concentrations measured during the dry and wet seasons in the Post-Graduate School (PGS) were 5.28 ± 0.14 and 4.81±0.11; whereas sample sites of the Faculty of Engineering (FOE) recorded pH values of 7.02±0.13 and 7.04±0.87, followed by Faculty of Agriculture (FOA) and Faculty of Science (FOS) with pH values of 8.03±0.15; 8.99±0.08 and 8.09±0.14; 8.03±0.28 respectively (Table 1). The soil temperature (ºC) results indicated that in the sampling site of the Faculty of Science temperature for the dry season was recorded 27.15 ± 0.13ºC whereas for the rainy season, the soil temperature was recorded 26.53 ± 0.80 ºC (Table 1). The results of the other physicochemical parameters are also presented on Table 1.

The results of the inorganic loads of the soil of the four sampling sites are presented in Table 2. The inorganic contents of the soil were significantly difference at $p < 0.05$ between sampling sites.

Table 1: Physicochemical parameters of the soil sample from the study area.

| Sites | pH | Temperature (ºC) | Elect Cond (mg/l) | BOD (mg/l) |
|---|---|---|---|---|
| **Dry** | | | | |
| FOS | 8.09±0.14a | 29.50±0.40a | 187.00±3.10a | 1.61±0.03a |
| FOE | 7.02±0.13b | 28.48±0.51b | 96.57±3.06c | 1.60±0.04a |
| FOA | 8.03±0.15a | 27.15±0.13c | 151.50±5.66b | 1.48±0.03b |
| PGS | 5.28±0.14c | 28.33±0.16b | 92.67±2.34c | 1.51±0.03b |
| **Total** | 7.11±0.11 | 28.37±0.24 | 131.93±6.03 | 1.55±0.02 |
| **p Value** | <0.001* | <0.001* | <0.001* | 0.029* |
| **Wet** | | | | |
| FOS | 8.03±0.28a | 26.53±0.80c | 46.75±7.08a | 0.43±0.06ab |
| FOE | 7.04±0.87b | 29.24±0.14a | 49.67±5.00a | 0.36±0.03b |
| FOA | 8.99±0.08a | 27.89±0.16b | 58.33±2.50a | 0.53±0.04a |
| PGS | 4.81±0.11c | 28.56±0.33b | 58.50±5.05a | 0.48±0.03ab |
| **Total** | 7.47±0.26 | 28.06±0.29 | 53.31±2.61 | 0.45±0.02 |
| **p Value** | 0.004* | <0.001* | 0.269ns | 0.032* |
| **Overall** | | | | |
| FOS | 8.56±0.19 | 28.02±0.60 | 116.88±15.10 | 1.02±0.12 |
| FOE | 7.03±0.43 | 28.86±0.32 | 73.12±5.67 | 0.98±0.13 |
| FOA | 8.51±0.14 | 27.52±0.13 | 104.92±10.17 | 1.00±0.10 |
| PGS | 5.04±0.10 | 28.44±0.18 | 75.58±4.48 | 0.99±0.11 |
| **Total** | 7.29±0.14 | 28.21±0.19 | 92.62±5.19 | 0.998±0.06 |
| **p Value** | <0.001* | 0.006* | 0.003* | 0.998ns |
| **Both seasons** | | | | |
| Dry | 7.11±0.11 | 28.37±0.24 | 131.93±6.03 | 1.55±0.02 |
| Wet | 7.47±0.26 | 28.06±0.29 | 53.31±2.61 | 0.45±0.02 |
| **Total** | **7.29±0.14** | **28.21±0.19** | **92.62±5.19** | **1.00±0.06** |
| **p Value** | **0.027*** | **0.419ns** | **<0.001*** | **<0.001*** |

ns – Not significant at p>0.05, * - Significant at p<0.05

Table 2: Soil inorganic content from study area.

| Sites | Chloride | Nitrate | Sulphate | Phosphate | Nitrite |
|---|---|---|---|---|---|
| **Dry** | | | | | |
| FOS | 4.68±0.06d | 2.32±0.04d | 5.20±0.03d | 1.50±0.09b | 0.09±0.00a |
| FOE | 5.74±0.12b | 3.89±0.10b | 7.16±0.02b | 1.36±0.27b | 0.05±0.01c |
| FOA | 5.21±0.03c | 3.10±0.04c | 6.18±0.02c | 1.43±0.13b | 0.07±0.00b |
| PGS | 6.25±0.22a | 4.66±0.16a | 8.17±0.04a | 2.33±0.22a | 0.04±0.01c |
| **Total** | **5.47±0.11** | **3.49±0.14** | **6.68±0.16** | **1.65±0.11** | **0.06±0.00** |
| p Value | <0.001* | <0.001* | <0.001* | 0.002* | <0.001* |
| **Wet** | | | | | |
| FOS | 6.66±0.18a | 3.08±0.04a | 7.48±0.20a | 2.15±0.03a | 0.72±0.04a |
| FOE | 6.70±0.18a | 3.13±0.03a | 7.58±0.21a | 2.22±0.03a | 0.69±0.03a |
| FOA | 6.70±0.18a | 3.10±0.04a | 7.53±0.21a | 2.19±0.04a | 0.68±0.03a |
| PGS | 6.71±0.18a | 3.17±0.05a | 7.61±0.21a | 2.25±0.03a | 0.68±0.03a |
| **Total** | **6.69±0.09** | **3.12±0.02** | **7.55±0.10** | **2.20±0.02** | **0.69±0.02** |

| | | | | | |
|---|---|---|---|---|---|
| p Value | 0.996ns | 0.456ns | 0.973ns | 0.213ns | 0.869ns |
| **Overall** | | | | | |
| FOS | 5.67±0.23c | 2.70±0.08d | 6.34±0.26d | 1.82±0.08b | 0.40±0.07a |
| FOE | 6.22±0.15ab | 3.51±0.09b | 7.37±0.11b | 1.79±0.16b | 0.37±0.07a |
| FOA | 5.96±0.18bc | 3.10±0.03c | 6.85±0.17c | 1.81±0.10b | 0.38±0.06a |
| PGS | 6.48±0.14a | 3.92±0.18a | 7.89±0.12a | 2.29±0.11a | 0.36±0.07a |
| **Total** | **6.08±0.09** | **3.31±0.07** | **7.11±0.10** | **1.93±0.06** | **0.38±0.03** |
| p Value | 0.011* | <0.001* | <0.001* | 0.008* | 0.975ns |
| **Both seasons** | | | | | |
| Dry | 5.47±0.11 | 3.49±0.14 | 6.68±0.16 | 1.65±0.11 | 0.06±0.00 |
| Wet | 6.69±0.09 | 3.12±0.02 | 7.55±0.10 | 2.20±0.02 | 0.69±0.02 |
| **Total** | **6.08±0.09** | **3.31±0.07** | **7.11±0.10** | **1.93±0.06** | **0.38±0.03** |
| p Value | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** |

ns – Not significant at p>0.05, * - Significant at p<0.05. FOS – Faculty of Science, FOA – Faculty of Agriculture, FOE – Faculty of Engineering, PGS – Post-Graduate School.

**Soil-dwelling arthropod species composition.**

The composition of soil-dwelling arthropod species found utilising the pitfall trap and the Berlese-Tullgren extractor funnel revealed that fifty-two soil arthropod species were gathered and identified. These were grouped into four groups (Insecta, Hexapoda, Arachnida, and Diplopoda) and fourteen orders (Table 3).

Table 3: Composition of the soil arthropod species in the University of Uyo

| S/N | Phylum | Class | Order | Scientific name | Common names |
|---|---|---|---|---|---|
| 1 | Arthropoda | Insecta | Hymenoptera | *Formica* sp | Field ant |
| 2 | | | | *Pachycondyla* sp | Big black ant |
| 3 | | | | *Camponotus vagus* | Carpenter ant |
| 4 | | | | *Lasuis niger* | Black garden ant |
| 5 | | | | *Camponotus africeps* | Carpenter ant |
| 6 | | | | *Harpegnathos venator* | Small ant |
| 7 | | | | *Odontomachus baun* | Trap jaw ant |
| 8 | | | | *Apis melifera* | Honey bee |
| 9 | | | | *Paraponera clavata* | Bullet ant |
| 10 | | | | *Monomorium minimum* | Little black ant |
| 11 | | | Coleoptera | *Platynus* sp | Ground beetle |
| 12 | | | | *Harpalus rufipes* | Ground beetle |
| 13 | | | | *Calathus* sp | Beetle |
| 14 | | | | *Leistus* sp | Ground beetle |
| 15 | | | | *Anomala cuprea* | Leaf beetle |
| 16 | | | | *Maladera castanea* | Garden beetle |
| 17 | | | | *Tenebrio molitor* | Yellow mealworm beetle |
| 18 | | | | *Aphodius rufipes* | Dung beetle |
| 19 | | | | *Listronotus bonariensis* | Stem weevil |
| 20 | | | | *Pyrophorus* sp | Click beetle |
| 21 | | | | *Dysticus marginalis* | Predatory Diving beetle |
| 22 | | | | *Pheropsophus jessoensis* | Ground beetle |
| 23 | | | | *Onitis* sp | Dung beetle |
| 24 | | | | *Tenebrio obscurus* | Dark mealworm beetle |
| 25 | | | | *Zophobas morio* | Superworm darkling beetle |
| 26 | | | | *Calosoma scrutator* | Field searcher |
| 27 | | | | *Titanus giganteus* | Titan beetle |
| 28 | | | Orthoptera | *Teleogryllus emma* | Field cricket |
| 29 | | | | *Gryllus bimaculatus* | Field cricket |
| 30 | | | Orthoptera | *Velarifictous micado* | Burrowing cricket |
| 31 | | | | *Grylliodes sigillatus* | Tropical cricket |
| 32 | | | | *Califera* sp | Grasshopper |
| 33 | | | Hemiptera | *Authenta* sp | African assassin bug |
| 34 | | | | *Reduvis personatus* | Masked hunter |
| 35 | | | | *Halymorpha halys* | Brown stink bug |
| 36 | | | | *Acanthaspis* sp | Assassin bug |

| | | | | |
|---|---|---|---|---|
| 37 | | | *Triatoma infestans* | Kissing bug |
| 38 | | Lepidoptera | *Chrysopoloma similis* | African Slug moth |
| 39 | | | *Ascalapha odorata* | Black witch moth |
| 40 | | Blattodea | *Blatta orientalis* | Oriental roach |
| 41 | | | *Parcoblatta* sp | Wood cockroach |
| 42 | | Dermaptera | *Forficula smyrnesis* | Earwig |
| 43 | | Diptera | *Cuterebra* sp | Rodent bot |
| 44 | Hexapoda | Collembola | *Lepidocyrtus* sp | Spring tail |
| 45 | | Thysanura | *Lepisma saccharina* | Silverfish |
| 46 | Arachnida | Araneae | *Lycosa* sp | Wolf spider |
| 47 | | | *Heteropoda venatoria* | Huntsman spider |
| 48 | | | *Araneus ventricosus* | Large nocturnal spider |
| 49 | | | *Badumna insignis* | Tube dwelling spider |
| 50 | | | *Erastigena agrestis* | Hobo spider |
| 51 | Diplopoda | Spirostreptida | *Archispirostreptus gigas* | Giant African millipede |
| 52 | | Polydesmida | *Polydesmus* sp | Millipede |

Note: + Presence, - Not presence

**Seasonal distribution of soil-dwelling arthropods species**

The results on the seasonal distribution of the soil-dwelling arthropod species (Figure 2) revealed that in the wet season more of the soil-dwelling arthropod species were collected with sampling location Faculty of Science recoding 644 individuals of the soil-dwelling arthropod species.

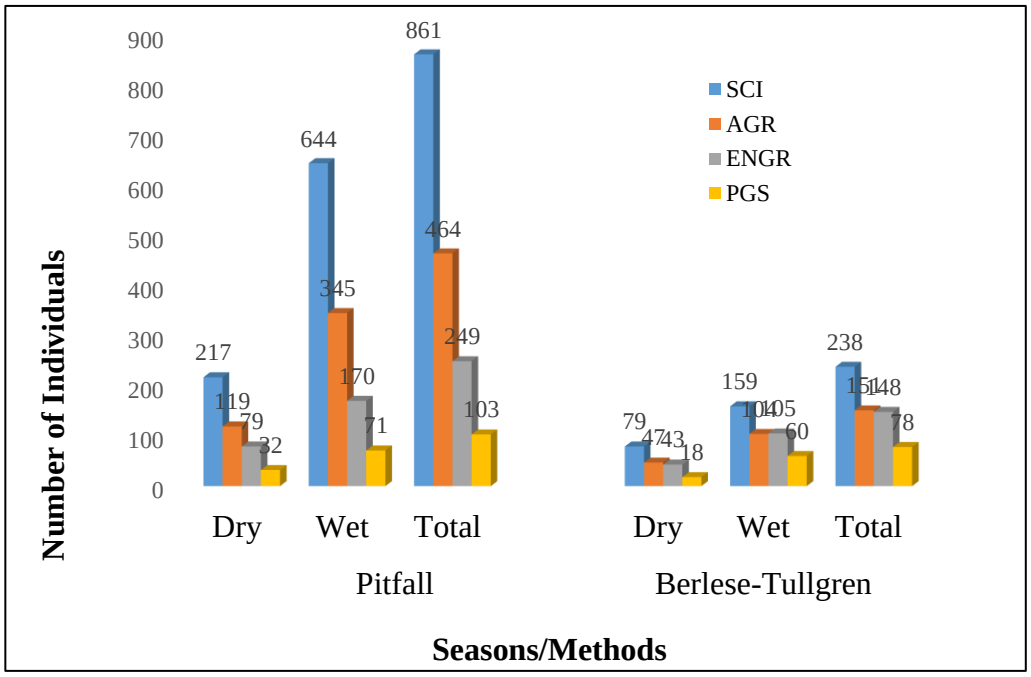


Fig. 2: Seasonal distribution of soil arthropods for both trapping methods. SCI – Science, AGR – Agriculture, ENGR – Engineering, PGS – Post Graduate School
Source: Field data (2023).

**Univariate correlation of soil arthropod species.**

The univariate correlation relationship results of the soil physico-chemical parameters and inorganic contents for the pitfall trap sampling method revealed that BOD (mg/L), Nitrate (mg/L) and Sulphate (mg/L) linked inversely with Formica sp. ($r = -0.79$, $p < 0.05$); *O. baun, Calathus* sp., *G. bimaculatus, V. micado, G. sigillatus, Authenta* sp., *R. personatus, A. ventricosus, B. insignis and E. agrestis* ($r = -0.77$, $p < 0.05$) (Table 3). The univariate correlation relationship results of the soil physicochemical parameters and inorganic contents for the Berlese-Tullgren extractor funnel sampling method in Table 10, revealed that BOD (mg/L), Nitrate (mg/L), and Sulphate (mg/L) linked inversely with Rodent bot; *Cuterebra* sp. ($r = -0.77$, $p < 0.05$). The correlation relationship status of soil-dwelling arthropod species with various soil physicochemical parameters and inorganic concentrations is also presented in Tables 3 and 4.

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Table 3: Univariate correlation of soil arthropod species with soil physiochemical parameters and inorganic contents for pitfall method

| Scientific names | pH | Temp (°C) | Elect Cond (mg/l) | BOD (mg/l) | Nitrate | Sulphate | Phosphate | Nitrite |
|---|---|---|---|---|---|---|---|---|
| *Formica sp* | -0.13 | 0.03 | 0.74* | -0.79* | -0.79* | -0.79* | -0.34 | 0.89* |
| *Pachycondyla sp* | -0.02 | 0.08 | 0.81* | -0.74* | -0.89* | -0.89* | -0.52* | 0.96* |
| *Camponotus vagus* | -0.03 | 0.08 | 0.81* | -0.74* | -0.88* | -0.88* | -0.51* | 0.96* |
| *Camponotus africeps* | -0.42 | 0.05 | 0.58* | -0.72* | -0.50* | -0.50* | 0.09 | 0.65* |
| *Odontomachus baun* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Apis melifera* | -0.25 | 0.81* | 0.36 | 0.80* | -0.23 | -0.23 | -0.28 | 0.06 |
| *Paraponera clavata* | -0.88* | 0.95* | 0.45 | 0.64* | -0.10 | -0.10 | 0.34 | 0.06 |
| *Monomorium minimum* | -0.77* | 0.38 | -0.30 | 0.57* | 0.64* | 0.64* | 0.92* | -0.60* |
| *Platynus sp* | 0.78* | -0.75* | 0.00 | -0.83* | -0.34 | -0.34 | -0.59* | 0.39 |
| *Harpalus rufipes* | 0.22 | -0.15 | 0.66* | -0.84 | -0.83* | -0.83* | -0.61* | 0.90* |
| *Calathus sp* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Leistus sp* | 0.89* | -0.33 | -0.04 | -0.08 | -0.28 | -0.28 | -0.85* | 0.16 |
| *Anomala cuprea* | -0.82* | 0.89* | 0.82* | 0.18 | -0.55* | -0.55* | 0.05 | 0.55* |
| *Tenebrio molitor* | 0.82* | -0.70* | 0.03 | -0.78* | -0.39 | -0.39 | -0.67* | 0.42 |
| *Aphodius rufipes* | 0.87* | -0.49 | -0.53 | 0.18 | 0.25 | 0.25 | -0.46 | -0.37 |
| *Listronotus bonariensis* | -0.39 | 0.91* | 0.58* | 0.66* | -0.42 | -0.42 | -0.30 | 0.28 |
| *Pyrophorus sp* | -0.23 | 0.82* | 0.46 | 0.72* | -0.34 | -0.34 | -0.36 | 0.18 |
| *Dysticus marginalis* | 0.97* | -0.86* | -0.47 | -0.43 | 0.11 | 0.11 | -0.46 | -0.12 |
| *Pheropsophus jessoensis* | 0.96* | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Onitis sp* | 0.92* | -0.87* | -0.70* | -0.23 | 0.38 | 0.38 | -0.25 | -0.41 |
| *Tenebrio obscurus* | 0.96* | -0.67* | -0.53* | -0.07 | 0.20 | 0.20 | -0.49 | -0.28 |
| *Zophobas morio* | 0.97* | -0.85* | -0.54* | -0.35 | 0.19 | 0.19 | -0.42 | -0.21 |
| *Calosoma scrutator* | 0.96* | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Titanus giganteus* | 0.97* | -0.85* | -0.55* | -0.34 | 0.19 | 0.19 | -0.42 | -0.22 |
| *Teleogryllus emma* | 0.46* | -0.48 | 0.36 | -0.94* | -0.61* | -0.62* | -0.55* | 0.70* |
| *Gryllus bimaculatus* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Velarifictous micado* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Grylliodes sigillatus* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Califera sp* | 0.96* | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Authenta sp* | -0.17 | 0.05 | 0.75 | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Reduvis personatus* | -0.17 | 0.05 | 0.75 | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Halymorpha halys* | 0.96* | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Acanthaspis sp* | -0.43 | 0.84* | 0.22 | 0.91 | 0.00 | 0.00 | 0.01 | -0.14 |
| *Chrysopoloma similis* | -0.96* | 0.83* | 0.60* | 0.26 | -0.26 | -0.26 | 0.38 | 0.29 |
| *Ascalapha odorata* | 0.96* | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Blatta orientalis* | -0.26 | 0.85* | 0.54* | 0.66* | -0.42 | -0.42 | -0.40 | 0.27 |
| *Parcoblatta sp* | 0.96 | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Forficula smyrnesis* | 0.96 | -0.83* | -0.60* | -0.26 | 0.26 | 0.26 | -0.38 | -0.29 |
| *Lepidocyrtus sp* | -0.01 | -0.09 | 0.67* | -0.85* | -0.76* | -0.76* | -0.38 | 0.87* |
| *Lepisma saccharina* | -0.52* | 0.82* | 0.12 | 0.94* | 0.13 | 0.13 | 0.18 | -0.25 |
| *Lycosa sp* | 0.65* | -0.63* | 0.19 | -0.90* | -0.50* | -0.50* | -0.60* | 0.56* |
| *Heteropoda venatoria* | 0.93* | -0.85* | -0.28 | -0.63* | -0.09 | -0.09 | -0.54 | 0.10 |
| *Araneus ventricosus* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Badumna insignis* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Erastigena agrestis* | -0.17 | 0.05 | 0.75* | -0.77* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Archispirostreptus gigas* | 0.88* | -0.64* | 0.05 | -0.66* | -0.42 | -0.42 | -0.77* | 0.41 |
| *Polydesmus sp* | 0.93* | -0.68* | -0.06 | -0.60* | -0.32 | -0.32 | -0.74* | 0.30 |

* - Strong negative or positive correlation.

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Table 4: Univariate correlation of soil arthropod species with soil physiochemical parameters and inorganic for Berlese – Tullgren extractor funnel method.

| Scientific names | pH | Temp. (ºC) | Elect Cond (mg/l) | BOD (mg/l) | Chloride | Nitrate | Sulphate | Phosphate | Nitrite |
|---|---|---|---|---|---|---|---|---|---|
| *Camponotus vagus* | -0.16 | 0.05 | 0.75* | -0.77* | -0.81* | -0.79* | -0.79* | -0.32 | 0.89* |
| *Lasuis niger* | -0.08 | -0.03 | 0.71* | -0.82* | -0.79* | -0.77* | -0.77* | -0.34 | 0.87* |
| *Pachycondyla* sp | -0.14 | -0.06 | 0.65* | -0.84* | -0.72* | -0.69* | -0.70* | -0.24 | 0.82* |
| *Harpegnathos venator* | -0.54* | 0.59* | 0.95* | -0.30 | -0.83* | -0.82* | -0.82* | -0.23 | 0.87* |
| *Formica* sp | 0.83* | -0.79* | -0.07 | -0.79* | -0.29 | -0.28 | -0.28 | -0.58* | 0.32 |
| *Pheropsophus jessoensis* | -0.88* | 0.72* | 0.04 | 0.70* | 0.33 | 0.33 | 0.33 | 0.69* | -0.34 |
| *Anomala cuprea* | -0.37 | 0.90* | 0.56* | 0.68* | -0.38 | -0.40 | -0.40 | -0.30 | 0.26 |
| *Maladera castanea* | 0.10 | 0.45 | 0.86* | -0.13 | -0.93* | -0.95* | -0.95* | -0.85* | 0.87* |
| *Tenebrio molitor* | -0.30 | 0.87* | 0.74* | 0.47 | -0.61* | -0.63* | -0.63* | -0.48 | 0.50* |
| *Pyrophorus* sp | 0.70* | -0.63* | 0.18 | -0.86* | -0.51* | -0.50* | -0.50* | -0.66* | 0.55* |
| *Onitis* sp | -0.30 | 0.87* | 0.72* | 0.49 | -0.58* | -0.60* | -0.60* | -0.47 | 0.47 |
| *Leistus* sp | -0.21 | 0.80* | 0.38 | 0.77* | -0.24 | -0.26 | -0.26 | -0.32 | 0.10 |
| *Aphodius rufipes* | -0.31 | 0.85* | 0.43 | 0.77* | -0.25 | -0.28 | -0.28 | -0.27 | 0.12 |
| *Teleogryllus emma* | 0.86* | -0.71* | -0.75* | 0.05 | 0.49 | 0.48 | 0.48 | -0.21 | -0.54* |
| *Velarifictous micado* | -0.14 | -0.06 | 0.65* | -0.84* | -0.72* | -0.69* | -0.70* | -0.24 | 0.82* |
| *Triatoma infestans* | -0.06 | -0.05 | 0.69* | -0.84* | -0.79* | -0.77* | -0.77* | -0.36 | 0.87* |
| *Acanthaspis* sp | -0.61* | 0.99* | 0.64* | 0.62* | -0.38 | -0.40 | -0.40 | -0.12 | 0.30 |
| *Forficula smyrnesis* | 0.93* | -0.58* | 0 | -0.5 | -0.37 | -0.37 | -0.37 | -0.82* | 0.33 |
| *Parcoblatta* sp | -0.33 | 0.83* | 0.88* | 0.26 | -0.76* | -0.78* | -0.78* | -0.52* | 0.68* |
| *Lepisma saccharina* | 0.60* | -0.61* | 0.21 | -0.92* | -0.52* | -0.51* | -0.51* | -0.58* | 0.58* |
| *Lepidocyrtus* sp | 0.72* | -0.76* | 0.01 | -0.89* | -0.35 | -0.34 | -0.34 | -0.52* | 0.40 |
| *Dysticus marginalis* | -0.78* | 0.63* | 0.80* | -0.19 | -0.58* | -0.56* | -0.56* | 0.13 | 0.64* |
| *Cuterebra* sp | -0.17 | 0.05 | 0.75* | -0.77* | -0.79* | -0.77* | -0.77* | -0.30 | 0.88* |
| *Lycosa* sp | -0.21 | 0.80* | 0.38 | 0.77* | -0.24 | -0.26 | -0.26 | -0.32 | 0.10 |
| *Heteropoda venatoria* | -0.37 | 0.89* | 0.46 | 0.76* | -0.27 | -0.29 | -0.29 | -0.23 | 0.14 |
| *Polydesmus* sp | -0.10 | -0.07 | 0.66* | -0.85* | -0.73* | -0.71* | -0.71 | -0.27 | 0.83* |
| *Archipirostreptus gigas* | 0.68* | -0.68* | 0.13 | -0.89* | -0.46 | -0.45 | -0.45 | -0.58* | 0.51* |

* - Strong negative or positive correlation.

EPA Standard Recommended Range for Soil Physicochemical parameters and Inorganic contents

The results obtained from the physicochemical parameters and inorganic contents of soil (Table 5) were all subjected to standard quality criteria as recommended by the Environmental Protection Agency (2014). Observations shows that those that falls within the range are moderate, those values less than are low, and more than normal values are termed high. For instance, when pH is < 6.5, it is acidic, neutral when it falls within the required range and alkaline when pH > 7.5.

Table 5: EPA Standard Recommended Range for Soil Physicochemical parameters and Inorganic contents.

| | EPA Recommended Range | Sites | | | |
|---|---|---|---|---|---|
| | | FOS | FOA | FOE | PGS |
| **Physicochemical parameters** | | | | | |
| pH | 6.5 – 7.5 | 8.56** | 8.51** | 7.03* | 5.04 |
| Temperature (ºC) | 20 – 30 | 28.02* | 27.52* | 28.86** | 28.44** |
| Conductivity (mg/L) | 110 – 570 | 116.88* | 104.92* | 73.12 | 75.58 |
| BOD (mg/L) | 2 – 140 | 1.02 | 1.00 | 0.98 | 0.99 |
| **Soil Inorganic content** | | | | | |
| Chloride | 5 – 200 | 5.67* | 5.96* | 6.22* | 6.48* |
| Nitrate | 0 – 50 | 2.70* | 3.51* | 3.10* | 3.92* |
| Sulphate | 5 – 200 | 6.34* | 7.37* | 6.85* | 7.89* |
| Phosphate | 0 – 50 | 1.82* | 1.79* | 1.81* | 2.29* |
| Nitrite | 0 – 50 | 0.40* | 0.37* | 0.38* | 0.36* |

-Low, * - Moderate, **- High

Source: EPA - Environmental Protection Agency (2014).

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## DISCUSSION

The sustainability of an ecosystem is greatly impacted by the species richness, abundance, and population distribution of soil arthropods because these organisms play important roles in agro-ecosystems as prey, predators, pollinators, decomposers, etc. (Bagchi *et al*., 2014; Rana *et al*., 2019; Maqsood *et al*., 2020). As a result, preserving and improving richness and biodiversity is critical in establishing solutions for sustainable agroecosystems (Jacobsen *et al*., 2019; Torma *et al*., 2019). The variance in soil pH reported in this study could be related to changes in environmental effects such as leaching and evaporation to mention but a few. Soil samples from the Faculties of Science and Agriculture were alkaline, whereas soil pH values from the Faculty of Engineering and Postgraduate School were within permissible norms of the EPA, 2014. The BOD content of the FOS and FOA samples, together with other physicochemical properties and inorganic contents, increased species diversity at this site. This coincides with the research findings of Akpan *et al*. (2020). The observed mean temperature in the four sampling sites falls within the EPA-recommended standard. This also corroborates the report of Agwunobi and Ugwumba (2013) that temperatures ranging from 26.52 ºC to 30.24 ºC were beneficial for the thriving of soil arthropods.

In this study, greater temperatures reported in the dry season compared to wet season temperatures explained the increased species diversity and abundance of soil arthropods in the rainy season. This corresponds with past findings that when temperature is exceedingly high, there is a drop in arthropod variety and abundance (Samuel, 2000; Popoola and Amusat, 2015). The distribution of arthropod fauna during the wet season supports the findings of Leekey *et al*. (2014), who reported that precipitation had a major impact on the richness and quantity of arthropods. Mcglynn *et al*. (2019) revealed in their investigations that the population of arthropods reduces in the hot and xeric climatic zone, emphasising further that moderate temperature is crucial for better growth and reproduction of soil arthropod species.

The capture of major soil-dwelling arthropod taxa varies utilising the two sampling approaches. The pitfall trap captured more soil arthropods (73.29%) than the Berlese-Tullgren extractor funnel (26.71%). This percentage difference demonstrated that the pitfall trap was a more efficient means of sampling soil-dwelling arthropods than the Berlese-Tullgren extractor funnel. Again, this coincides with the report of Sabu and Shiju (2010). Regardless of the success of the pitfall trap sample technique, a few individuals of the soil-dwelling arthropod orders Diptera and Spirostreptida that were not captured with the pitfall traps were captured with the Berlese-Tullgren extractor funnel. The use of Berlese-Tullgren certainly favoured the catch of the aforementioned species and corresponds with other studies (Vineesh, 2007; Anu *et al*., 2009). The collection of fewer taxonomic groups of soil-dwelling arthropods using the Berlese-Tullgren extractor funnel may also be attributed to the fact that most of the soil-dwelling arthropods sampled in this study were unable to burrow through the 10 – 25 cm depth of soil from which soil samples were collected for arthropod extraction. Pitfall trap catching of soil-dwelling arthropods is visible in the taxonomic richness and assemblage composition and abundance of individuals of taxa that were active and fast-moving at the topsoil and these were Hymenoptera, Orthoptera, Coleoptera, and Arachnida. Prasifka *et al*., 2007; Sabu and Shiju, 2010; and Leskona *et al*., 2019 observed similar taxonomic richness using pitfall traps. Also, species richness and abundance may be ascribed to the nature of vegetation found in the ecosystem of the University of Uyo and corresponds with the report of Corti *et al*. (2013) that species richness and abundance of an ecosystem is controlled by vegetation. The great abundance of the order Hymenoptera (Ants) particularly Formica sp. also corroborates the findings of Esenowo *et al.*, 2014; Apolinaria *et al*., 2019; Nsengimana *et al*., 2022. They attributed the great abundance of Formica sp. in their research area to the capacity of this species to adapt to varied settings. The prevalence of Hymenoptera in this study is further similar to the observation reported by Akpabio *et al*. (2015) that Hymenoptera was discovered on every sample site either foraging, prospecting for nectar, mating and even oviposition site. Leskona *et al.* (2017) additionally noted that the amount of food is a factor that influences the formation of colonies from the Formicidae because food is a fundamental requirement for ants.

The dominance of Orthoptera following Hymenoptera could be linked to the herbaceous nature of the insect which enables them to exploit a wide range of food sources including a group of angiosperm plants (Price *et al*., 2011; Leskona *et al*., 2019). The great abundance of the Gryllidae family is related to the adequacy of the habitat for the crickets. These are nocturnal insects that discovered acceptable hiding spots in the sampling sites. During the daylight, the crickets hid in their tunnel home, under tree detritus.

The order Coleoptera was the third abundant category with the biggest number of individual species, largely dominated by beetles of Family Scarabidae. Studies by Do *et al.* (2012) in South Korea indicated that these beetles are mostly influenced by litter, tree cover, shrub cover, and slope of the area and these were detected in the study area. Also, Viric *et al*. (2017) revealed that the higher distribution, abundance, and species richness of beetles could be linked to the leaf-litter covering the soil and shrubs variety which were well spread and numerous in their study regions. Besides, Blattodea, families under the order Spirostreptida, Diptera, Lepidoptera, and Collembola (Class Hexapoda) showed low abundance in this study, despite certain orders having more than one species. This validates the conclusion previously established by Nilsson *et al.* (2013) that the abundance of these arthropods is mostly governed by the environmental conditions of the area. Additionally, the modest abundance of order Polydesmida in this study, accords with studies carried out by Toth and Horning (2020) that the individuals under the order Polydesmida prefer a habitat rich in rotting wood and litter.

According to Southwood and Henderson (2000), Brown and Matthews (2016), the efficiency of the pitfall traps sampling technique over the Berlese-Tullgren extractor funnel sampling technique in this study could be attributed to the location of the trap, the size of the trap container, the nature of the container, the timing of trapped sample collection, the type of liquid preservative used, and the soil physico-chemical parameters. Some of the arthropod species may have died owing to dryness in the sand core before going through the heat gradient generated on the sand and did not fall into the collection jar. This corroborates the report of Sabu *et al*. (2012).

The univariate correlation relationship results revealed that soil physicochemical parameters and inorganic contents such as temperature, BOD, nitrate, sulphate, and phosphate had a strong inverse effect; while pH, electrical conductivity, and nitrite had a relatively positive effect on the taxonomic richness, assemblage abundance, and distribution of the arthropods collected using the two sampling techniques; pitfall trap and Berlese-Tullgren extractor funnel. However, both the physicochemical characteristics and inorganic contents of the soil either demonstrated a considerable positive or negative effect on the distribution pattern of these terrestrial arthropods within the study period. Nargis *et al*. (2021) emphasized that due to the fluctuations in season, each species may demonstrate a large response to the environmental elements and vegetation of the surrounding area.

## CONCLUSION

Activities in the University of Uyo have in one or another altered the distribution of arthropod species. Such activities highlighted are anthropogenic disturbances (intensive agricultural practices, construction of buildings, etc.) which tend to influence the population of these soil fauna and disrupt the ecological functions carried out by these arthropod species which include the provision of ecosystem services, as useful pollinators, and decomposition of organic matters. Studies on the soil samples demonstrate that the soil's physicochemical parameters and inorganic contents such as pH, temperature, Conductivity, chloride, nitrate, Sulphate, phosphate, and nitrite except BOD, fall within the Environmental Protection Agency (EPA) recommended range. The distribution patterns revealed in this study show that no one sampling strategy is appropriate for sampling all orders of arthropods and that more than two techniques may be required.

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