



Microbial Diversity Metrics: An Insight into the Ecological Status of Different Water Resources in Anambra State Central Senatorial Zone, Nigeria



Idu, P. N.¹, Chukwura, E. I.¹, Okonkwo, I. F.¹, Uba, B. O.^{2*} and Oghonim, P. A. N.³

¹Department of Applied Microbiology and Brewing, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria.

²Department of Microbiology, Chukwuemeka Odumegwu Ojukwu University, P.M.B. 02 Uli, Anambra State, Nigeria.

³Department of Biological Sciences (Microbiology), University of Delta, Agbor, Delta State, Nigeria.

*Corresponding author e-mail address: nkemalfred5050@gmail.com; +2348164549395

| Abstract | Article History |
|--|---|
| <p>This study evaluated the cumulative biodiversity patterns across selected seven Local Government Areas (LGAs) using multiple ecological diversity indices to determine variations in community structure and dominance. Standardized procedures were strictly adhered to during the sampling and bacteriological examination of the water samples from 21 different sampling sites. The structure of the bacterial communities was subsequently evaluated using established ecological metrics, including species richness, evenness, diversity and dominance indices. The results revealed marked spatial differences among the study areas. Awka North recorded the highest Margalef's richness index (1.19), indicating relatively greater species richness. In contrast, Njikoka exhibited the lowest Margalef's richness (1.05), suggesting reduced species representation. Awka South showed the lowest Simpson's diversity index (0.45) and Simpson's reciprocal index (1.82), reflecting lower overall diversity and higher dominance. Dunukofia had the lowest Pielou's evenness (0.49), indicating uneven species distribution. Anaocha recorded the highest Berger–Parker dominance index (0.69) and the lowest Shannon equitability (0.46), demonstrating strong dominance by a few taxa and reduced community balance. Conversely, Idemili South exhibited the highest Simpson's reciprocal index (3.24) and lowest Simpson's index (0.31), suggesting comparatively higher effective diversity and lower dominance, while Idemili North and South showed the lowest Berger–Parker dominance (0.51), indicative of more evenly distributed communities. Overall, the application of multiple biodiversity indices revealed significant differences in richness, dominance, and evenness across the LGAs, underscoring the importance of multidimensional ecological assessment. The findings provide valuable insight into spatial variations in community structure and serve as a baseline for environmental monitoring and sustainable ecosystem management in the study area.</p> <p>Keywords: Anambra Central Senatorial Zone, Diversity Metrics, Ecological assessment, Ecological Status, Environmental monitoring</p> | <p>Received: 05 Jan 2026 Accepted: 20 Feb 2026 Published: 28 Feb 2026</p> |
| | <p>Scan QR code to view*</p>  |
| | <p>License: CC BY 4.0</p>  <p>Open Access article.</p> |
| <p>How to cite this paper: Idu, P. N., Chukwura, E. I., Okonkwo, I. F., Uba, B. O., & Oghonim, P. A. N. (2026). Microbial Diversity Metrics: An Insight into the Ecological Status of Different Water Resources in Anambra State Central Senatorial Zone, Nigeria. <i>IPS Interdisciplinary Journal of Biological Sciences</i>, 6(1), 257–271. https://doi.org/10.54117/ijbs.v6i1.143</p> | |

Introduction

Biodiversity is a multidimensional concept that encompasses the variability and complexity of life across different levels of biological organization. Broadly defined, it refers to the variety of living organisms and ecological complexes of which they are part, spanning genetic variation within species, species diversity within communities, and ecosystem diversity across landscapes (Daly *et al.*, 2018; Convention on Biological Diversity [CBD], 2022). Contemporary ecological discourse further recognizes functional diversity (variation in species' ecological roles), phylogenetic diversity (evolutionary relatedness among taxa), and even chemical and microbial diversity as integral components of biodiversity (Cardinale *et al.*, 2012; Díaz *et al.*, 2020). This integrative perspective

highlights biodiversity not merely as a count of species, but as a dynamic network of biological interactions that underpin ecosystem resilience, productivity, and stability in the face of environmental change worldwide (Uba, 2019a; 2019b; 2019c; Uba *et al.* 2019b; 2019c).

In ecological research and environmental monitoring, biodiversity is commonly quantified using diversity indices that summarize species composition and relative abundance within communities. Among the most widely applied metrics are species richness, the Shannon diversity index, and the Simpson diversity index (Pallmann *et al.*, 2012; Daly *et al.*, 2018). Although these indices are often used comparatively to evaluate ecological differences among habitats, they capture

distinct attributes of community structure and are therefore not directly interchangeable. Species richness simply represents the total number of species present in a given assemblage and provides a basic measure of taxonomic diversity. In contrast, the Simpson index quantifies the probability that two individuals randomly selected from a sample belong to the same species, thereby emphasizing dominance and evenness within the community. The Shannon index, derived from information theory, measures the entropy or uncertainty in predicting species identity, integrating both richness and evenness into a single metric expressed in units of information (Pallmann *et al.*, 2012). Because these indices differ conceptually and mathematically—richness being a count, Simpson a probability, and Shannon an entropy measure—they offer complementary insights into biodiversity patterns rather than equivalent assessments.

Beyond simple diversity quantification, bio-indices have become indispensable tools in evaluating ecological integrity, particularly in aquatic ecosystems. Czenlawska-Kusza (2005) emphasized that biological indices provide quantitative expressions of species composition while incorporating qualitative information regarding taxa sensitivity to environmental stressors. Such indices are widely employed in riverine and freshwater assessments to detect anthropogenic disturbances, monitor ecological status, and guide water resource management strategies (Sandhya & Laxmi, 2016; Bonada *et al.*, 2021). Microbial and macroinvertebrate diversity metrics, in particular, are increasingly recognized as sensitive indicators of pollution, eutrophication, and habitat degradation, as changes in community composition often precede detectable physicochemical alterations (Bolyen *et al.*, 2019; Orji and Oghonim, 2023; UNEP, 2023). Consequently, biodiversity indices serve as reliable proxies for assessing the ecological health of freshwater systems and the cumulative impacts of environmental stress.

Freshwater ecosystems in rapidly urbanizing regions are especially vulnerable to biodiversity loss due to industrial discharge, agricultural runoff, domestic waste input, and land-use changes. The 21 streams in seven Local Government Areas of Anambra Central Senatorial Zone, of Anambra State, Nigeria, represent important freshwater reservoirs that sustain diverse biological communities while simultaneously serving as primary water sources for domestic and agricultural activities. Despite their ecological and socio-economic significance, these streams are increasingly exposed to anthropogenic pressures, including effluent discharge and unregulated waste disposal, which environmentalists identify as significant threats to aquatic biodiversity and ecosystem functionality (Uba *et al.*, 2017; Uba *et al.*, 2020a; 2020b; 2020c; 2020d; 2020e; 2020f; 2020g; Otene *et al.*, 2019; IPBES, 2019; ; Umeh *et al.*, 2020; 2021; Dokubo *et al.*, 2022a; 2022b; Anidu *et al.*, 2023; Obiefoka *et al.*, 2023; Uba and Obiefuna, 2023; Ubajekwe *et al.*, 2025; Ekwenze *et al.*, 2025).

Although several studies have examined the physicochemical characteristics of water bodies within Anambra Central Senatorial Zone metropolis, there remains a paucity of comprehensive investigations focusing on bacteriological diversity in relation to biodiversity indices in these peri-urban

streams (Ike *et al.*, 2021; Egrefa *et al.* 2020a; 2020b; Okafor *et al.*, 2023; Ubani *et al.*, 2024a; 2024b; 2025; Okolo *et al.*, 2025; Okpalaunegbu *et al.*, 2025; Obiefuna *et al.* 2025). Given that bacterial communities play crucial roles in nutrient cycling, organic matter decomposition, and overall ecosystem functioning, understanding their diversity patterns is essential for evaluating freshwater ecological health (Bolyen *et al.*, 2019; Díaz *et al.*, 2020; Uba *et al.*, 2025).

Therefore, the present study was undertaken to assess the bacterial community structure of twenty- one freshwater streams in Anambra Central Senatorial Zone, Anambra State, Nigeria, using established biodiversity indices. By integrating microbial diversity metrics with ecological assessment tools, this research seeks to provide insight into the ecological status of these streams and contribute to evidence-based freshwater management and conservation strategies in South - Eastern Nigeria.

Materials and Methods

Description of Study Area

The studied areas include: Mmiri St John Alor, Mmiri Mgbo Nnobi, Oba Stream in Idemili South Local Government Area, Ukwu Apku Stream Eziowelle, Mmiri Oraukwu Oraukwu, Mbuda Spring Water Abacha in Idemili North, Otti Spring Enugu Ukwu, Abagana Stream, Ogbujilekwe Stream Nimo in Njikoka Local Government Area Umudioka Stream, Ali Ukpo Stream Ukpo, Onyekwena Spring Water Ifitedunu, in Dunukofia Local Government Area, Agulu Lake Agulu, Adazi Nnukwu Stream, Nri Stream in Anaocha Local Government Area, Nkwelle Awka Stream, Abor River in Umuawulu, Umuaba River Nibo in Awka South Local Government Area and Umuife Iyiohia Urum Stream, Araka Stream Mgbakwu, Ogbanabo Stream Isuaniocha in Awka North Local Government Area all located in Anambra Central Senatorial Zone, Anambra State Nigeria. Their geological and anthropogenic characteristics have been described in our previous publications (Alfred *et al.* 2023; 2025; Idu *et al.*, 2026).

Collection of Water Sample

Samples of Spring and Lake water were aseptically collected in triplicates from each of the four towns in four local government areas (Njikoka (Enugu Ukwu), Idemili North (Abacha), Anaocha (Agulu) and Dunukofia (Ifitedunu) using sterile sample bottles. The sampling method used for the rivers and stream water collection was the grab method as described by Oghonim *et al.* (2023); (2026); Dokubo *et al.* (2024); Uba and Okonkwo *et al.* (2025); Okwonkwo *et al.* (2026) and Uba *et al.* (2026a). Also, streams and rivers water samples were collected from Alor stream, Nnobi stream, Oba stream, Eziowelle stream, Oraukwu river, Abacha Spring Water, Otti Spring Enugu Ukwu, Abagana Stream, Ogbujilekwe Stream Nimo, Ali Ukpo Stream, Onyekwena Spring Water Ifitedunu, Agulu Lake, Adazi Nnukwu Stream, Nri Stream, Nkwelle Awka Stream, Abor River Umuawulu, Umuaba River Nibo, Umuife Iyiohia Urum, Araka Stream Mgbakwu and Ogbanabo Stream Isuaniocha respectively (Alfred *et al.* 2025; Okolo *et al.* 2025). The river and stream water samples were collected in triplicates from different sampling points; downstream, middle stream and upstream using sterile 5 L cylindrical

plastic containers, labeled, placed in a cooler and immediately were transported to the laboratory for analysis as described by Dibua *et al.* (2020), Ibo *et al.* (2020); Ibe *et al.* (2023), Alfred *et al.* (2023), Chukwura *et al.* (2025); and Dibua *et al.* (2025a); (2025b); (2025c).

Culture Media

The following media namely Nutrient agar, Chromocult Coliform Agar (CCA), Bile Aesculin Azide Agar (BAA), Thiosulfate Citrate Bile Salt Sucrose Agar (TCBS), Mannitol Salt Agar (MSA) and Salmonella - Shigella Agar (SSA), Cetrinide Milk Agar (CMA), Bacillus Selective agar (BSA) Buffered Peptone Water and Nutrient Broth were used and prepared according to the manufacturer's specification (Ofunwa *et al.* 2024; Njoku *et al.*, 2019a; 2019b; Anameze *et al.*, 2023; ; Ele *et al.*, 2025; Ezeamama *et al.*, 2025a; 2025b).

Sterilization

As stated in Willey *et al.* (2008), conical flasks (Pyrex), prepared media and other plastic materials were sterilized by autoclaving at 121 °C for 15 min at a pressure of 15 psi. Glass wares such as pipettes, glass spreader, Petri dishes, measuring cylinder, and other glass materials were sterilized in the laboratory hot air oven at a temperature of 160°C for 1 hr before use (Nkamigbo *et al.* 2020a; 2020b; Uba, 2019; Okafor *et al.* 2021a; 2021b).

Bacterial Isolation Technique

A direct spread plate with volumes of 0.1ml of aliquot was used. A ten-fold serial dilution method was used. Then, 0.1 mL from dilutions 10⁻³ were inoculated onto a Nutrient agar, Chromocult Coliform Agar (CCA), Bile Aesculin Azide Agar (BAA), Thiosulfate Citrate Bile Salt Sucrose Agar (TCBS), Mannitol Salt Agar (MSA) and Salmonella - Shigella Agar (SSA), Cetrinide Milk Agar (CMA) and Bacillus Selective agar (BSA) respectively. The inoculated plates were incubated inverted at 37 °C for 24 hr. The respective counts were determined after incubation using an electric colony counter and colonies counted were expressed at CFU/mL (APHA, 2012; Iheukwumere *et al.*, 2012a; 2012b; Mundi *et al.*, 2013; 2014; Okoye *et al.*, 2014; 2020a; 2020b; 2020c; ; Uba *et al.*, 2024; Dokubo and Uba, 2023; Nwigwe *et al.* 2022, Nwigwe *et al.* 2023, Ifediegwu *et al.* 2023a; 2023b; Ifediegwu *et al.* 2024a, 2024b; 2024c; Nnaka *et al.* 2024).

Classical Microbial Diversity Study

Species richness, diversity, and evenness indices were used to measure bacterial diversity in accordance with Daly *et al.* (2018)'s description.

Index of Species Richness

This study used the Margalef index (d) as measure of species richness (number of isolated species).

Index of Margalef

It is denoted by equation:

Margalef index (d) = (S - 1)/log N

where N stands for the total number of bacteria and S for the number of species.

Index of Species Diversity

This study used the Simpson index (D), the reciprocal of Simpson's index (1/D), and the Shannon – Wiener index as measures of species diversity.

Index of Simpson

It is represented by the following formula:

$$\text{Simpson index, } D' = \frac{1}{\sum (P_i)^2}$$

$$P_i = \frac{n_i}{N},$$

where n_i stands for the number of bacteria that make up i, i² etc and N for the total number of individuals.

Index of Reciprocal of Simpson

It is represented by the following formula:

Reciprocal Simpson index = 1/D

The following equation represents the Shannon-Weiner index:

$$\text{Shannon-Wiener Index, } H' = \sum_{i=1}^S P_i \log_2 P_i$$

Here, S stands for the total number of species and P_i for the number of members in the ith species. Also, P_i represents the likelihood that a sampling plot will contain a given species, i (Das *et al.* 2006).

Shannon Equitability Index

The Shannon Equitability Index (EH), also called Shannon Evenness, measures how evenly individuals are distributed among the species present in a community.

$$EH = \frac{H'}{\ln(S)}$$

Where: EH = Shannon equitability (evenness) index; H' = Shannon–Wiener diversity index; S = Total number of species (species richness); ln(S) = Natural logarithm of species richness.

Index of Species Evenness

The following equation represents the Pielou's evenness (J') index:

$$\text{Pielou's evenness, } J' = \frac{H'}{H'_{\max}}$$

In this case, H'_{max} stands for the highest diversity value relative to the total number of species and the Shannon-Wiener diversity index is represented by H'.

Berger–Parker Dominance Index (d)

The Berger–Parker dominance index (d) measures the proportional importance of the most abundant species in a community. It emphasizes dominance rather than overall diversity.

d = N_{max}/N

Where d = Berger–Parker dominance index; N_{max} = Number of individuals in the most abundant species and N = Total number of individuals

Statistical Analysis

The results of the data generated were expressed as mean \pm standard deviation (SD) using GraphPad Prism version 8.0.2. The data means were analyzed by two-way Analysis of Variance (ANOVA) followed by Tukey's post hoc test to compare differences in the diversity of the pathogen composition of the three sampling sites and different sampling points. The values less than $p < 0.05$ were considered statistically significant at 95 % confidence interval (Emmy – Egbe *et al.*, 2015; Uba and Chukwura, 2016; Uba *et al.* 2016; 2018a; 2018b; 2018c; 2019d; 2019e; Alisa *et al.*, 2020; Anukam *et al.*, 2020a; 2020b; Uba *et al.*, 2021a; 2021b; Enemchukwu *et al.*, 2026a; 2026b; Afulukwe *et al.*, 2025; 2026; Umezulora *et al.*, 2026).

Results

The results of species diversity profile of the sampling sites are presented in Table 1 - 7, respectively. From the Table 1 result, the diversity profile of Awka North LGA, Urum had the highest Margalef's richness of 1.16, highest Shannon - Wiener index of 1.43, Mgbakwu had the lowest Simpson's index of 0.36, Isuaniocha had the highest Berger-Parketers Dominance of 0.57 respectively.

The diversity profile of Awka South LGA sampling site is presented in Table 2. From the result Nkwelle Awka had the highest Berger-Parketers Dominance of 0.64, Nibo had the highest Shannon Equitability index of 0.75 and highest reciprocal of Simpson's index of 3.05, Umuawulu had the highest Simpson's index of 0.51 respectively.

The diversity profile of Dunukofia LGA sampling site is presented in Table 3. From the result, Ukpo had the highest Simpson's index of 0.70, Ifitedunu had the highest Margalef's index of 1.57 and Umudioka had the highest Pielou's evenness and reciprocal of Simpson's index of 0.63 and 1.80 respectively.

The diversity profile of Anaocha LGA sampling site is presented in Table 4. From the result, Nri had the highest Margalef's richness and Shannon - Wiener Index of 1.23 and 1.06, Agulu had the lowest Pielou's evenness and Berger-Parketers Dominance of 0.53 and 0.67, Adazi- Nnukwu had the highest Simpson's index of 0.72 respectively.

The diversity profile of Njikoka LGA sampling site is presented in Table 5. From the result, Abagana had the highest Shannon Wiener index and Simpson's reciprocal index of 1.56 and 3.90, Enugu Ukwu had the highest Shannon equitability index of 0.77, Nimo had the highest Berger-Parketers dominance of 0.83 and lowest Simpson's diversity index of 0.30 respectively.

The diversity profile of Idemili South LGA sampling site is presented in Table 6. From the result, Oba had the highest Margalef's richness and Shannon Wiener index Of 1.21 and 1.61, Nnobi had the highest Berger-Parketers dominance of 0.68, Alor had the highest Pielou's evenness and Simpson's reciprocal index of 0.87 and 4.07 respectively. Cumulatively, Idemili South had the highest Simpson's reciprocal index of 3.24 and lowest Simpson's index of 0.31 respectively (Figures 6 and 8).

The diversity profile of Idemili North LGA sampling site is presented in Table 7. From the result, Abacha had the highest Shannon equitability index and Simpson's diversity index of 0.77 and 0.69, Eziowelle had the highest Berger-Parketers dominance of 0.68 and lowest Pielou's evenness of 0.57, Oraukwu had the highest Margalef's richness and Simpson's index of 1.42 and 0.39 respectively. Statistically, there were significant ($p < 0.05$, $F = 5.07$, $p < 0.0001$) differences detected among the community indices but non - significant ($p > 0.05$, $F = 0.9481$, $p = 0.5278$) differences detected among the sampling sites.

Cumulatively, Awka North had the highest Margalef's richness of 1.19 (Figure 1). Awka South had the lowest Simpson's diversity index of 0.45 and lowest Simpson's reciprocal index of 1.82 respectively (Figures 7 and 8). Dunukofia had the lowest Pielou's evenness of 0.49 (Figure 4). Anaocha had the highest Berger-Parketers dominance of 0.69 and lowest Shannon equitability index of 0.46 respectively (Figures 3 and 5). Njikoka had the lowest Margalef's richness of 1.05 (Figure 1). Idemili South had the highest Simpson's reciprocal index of 3.24 and lowest Simpson's index of 0.31 respectively (Figures 6 and 8). Idemili North had the lowest Berger-Parketers dominance of Idemili South and North had the lowest Berger-Parketers dominance of 0.51, respectively (Figure 4.5). Statistically, there were significant ($p < 0.05$, $F = 631.14$, $p < 0.0001$) differences detected among the community indices but non-significant ($p > 0.05$, $F = 2.125$, $p = 0.0675$) differences detected among the sampling sites.

Table 1: Diversity profile of Awka North LGA sampling sites

| Species group | Urum | Mgbakwu | Isuaniocha | Mean \pm SD |
|----------------------------------|------|---------|------------|------------------|
| Species richness | 7.00 | 7.00 | 5.00 | 6.33 \pm 1.15 |
| Margalef's richness (Dmg) | 1.16 | 0.96 | 0.86 | 0.99 \pm 0.15 |
| Shannon-Wiener index (H') | 1.43 | 1.30 | 0.99 | 1.24 \pm 0.226 |
| Shannon Equitability index (EH) | 0.71 | 0.64 | 0.63 | 0.66 \pm 0.04 |
| Pielou's Evenness (J') | 0.74 | 0.67 | 0.62 | 0.67 \pm 0.06 |
| Berger-Parketers Dominance (d) | 0.40 | 0.54 | 0.57 | 0.50 \pm 0.09 |
| Simpson's index (D) | 0.28 | 0.36 | 0.49 | 0.38 \pm 0.11 |
| Simpson's Diversity index (1-D) | 0.72 | 0.64 | 0.51 | 0.63 \pm 0.11 |
| Simpson's Reciprocal index (1/D) | 3.58 | 2.81 | 2.06 | 2.82 \pm 0.76 |

Table 2: Diversity profile of Awka South LGA sampling sites

| Species group | Nkwelle -Awka | Nibo | Umuawulu | Mean±SD |
|----------------------------------|---------------|------|----------|-----------|
| Species richness | 7.00 | 6.00 | 6.00 | 6.33±0.58 |
| Margalef's richness (Dmg) | 1.14 | 1.01 | 0.97 | 1.04±0.09 |
| Shannon-Wiener index (H') | 1.20 | 1.36 | 1.13 | 1.23±0.12 |
| Shannon Equitability index (EH) | 0.61 | 0.75 | 0.64 | 0.67±0.07 |
| Pielou's Evenness (J') | 0.61 | 0.76 | 0.63 | 0.67±0.08 |
| Berger-Parkers Dominance (d) | 0.64 | 0.54 | 0.49 | 0.56±0.08 |
| Simpson's index (D) | 0.5 | 0.33 | 0.51 | 0.45±0.10 |
| Simpson's Diversity index (1-D) | 0.5 | 0.67 | 0.49 | 0.55±0.10 |
| Simpson's Reciprocal index (1/D) | 2.02 | 3.05 | 1.98 | 2.35±0.61 |

Table 3: Diversity profile of Dunukofia LGA sampling sites

| Species group | Ukpo | Ifitedunu | Umudioka | Mean±SD |
|----------------------------------|------|-----------|----------|------------|
| Species richness | 7.00 | 7.00 | 6.00 | 6.67±0.56 |
| Margalef's richness (Dmg) | 1.11 | 1.57 | 0.91 | 1.20±0.34 |
| Shannon-Wiener index (H') | 0.66 | 0.97 | 1.14 | 0.92±0.24 |
| Shannon Equitability index (EH) | 0.34 | 0.49 | 0.64 | 0.49±0.15 |
| Pielou's Evenness (J') | 0.34 | 0.50 | 0.63 | 0.49±0.15 |
| Berger-Parkers Dominance (d) | 0.83 | 0.76 | 0.53 | 0.71±0.16 |
| Simpson's index (D) | 0.70 | 0.58 | 0.55 | 18.76±1.39 |
| Simpson's Diversity index (1-D) | 0.30 | 0.42 | 0.45 | 0.39±0.08 |
| Simpson's Reciprocal index (1/D) | 1.42 | 1.72 | 1.80 | 1.65±0.20 |

Table 4: Diversity profile of Anaocha LGA sampling sites

| Species group | Nri | Agulu | Adazi-Nnukwu | Mean±SD |
|----------------------------------|------|-------|--------------|-----------|
| Species richness | 7.00 | 6.00 | 6.00 | 6.33±0.58 |
| Margalef's richness (Dmg) | 1.23 | 1.08 | 0.95 | 1.09±0.14 |
| Shannon-Wiener index (H') | 1.06 | 0.94 | 0.99 | 1.00±0.06 |
| Shannon Equitability index (EH) | 0.54 | 0.52 | 0.55 | 0.54±0.02 |
| Pielou's Evenness (J') | 0.54 | 0.53 | 0.56 | 0.54±0.02 |
| Berger-Parkers Dominance (d) | 0.70 | 0.67 | 0.69 | 0.69±0.02 |
| Simpson's index (D) | 0.51 | 0.51 | 0.72 | 0.58±0.12 |
| Simpson's Diversity index (1-D) | 0.49 | 0.49 | 0.28 | 0.42±0.12 |
| Simpson's Reciprocal index (1/D) | 1.96 | 1.96 | 1.39 | 1.77±0.33 |

Table 5: Diversity profile of Njikoka LGA sampling sites

| Species group | Abagana | Enugu-Ukwu | Nimo | Mean±SD |
|----------------------------------|---------|------------|------|-----------|
| Species richness | 8.00 | 6.00 | 6.00 | 6.67±1.16 |
| Margalef's richness (Dmg) | 1.15 | 1.03 | 0.92 | 1.03±0.16 |
| Shannon-Wiener index (H') | 1.56 | 1.37 | 0.70 | 1.21±0.45 |
| Shannon Equitability index (EH) | 0.75 | 0.77 | 0.39 | 0.64±0.21 |
| Pielou's Evenness (J') | 0.75 | 0.77 | 0.39 | 0.64±0.21 |
| Berger-Parkers Dominance (d) | 0.41 | 0.53 | 0.83 | 0.59±0.22 |
| Simpson's index (D) | 0.26 | 0.34 | 0.70 | 0.43±0.23 |
| Simpson's Diversity index (1-D) | 0.74 | 0.66 | 0.30 | 0.57±0.23 |
| Simpson's Reciprocal index (1/D) | 3.9 | 2.96 | 1.44 | 2.77±0.24 |

Table 6: Diversity profile of Idemili South LGA sampling sites

| Species group | Oba | Nnobi | Alor | Mean±SD |
|-----------------------------------|------|-------|------|-----------|
| Species richness | 8.00 | 5.00 | 6.00 | 6.33±1.53 |
| Margalef's richness (Dmg) | 1.21 | 0.75 | 0.96 | 0.97±0.23 |
| Shannon-Wiener index (H') | 1.61 | 0.91 | 1.56 | 1.36±0.39 |
| Shannon Equitability index (EH) | 0.77 | 0.56 | 0.87 | 0.73±0.16 |
| Pielou's Evenness (J') | 0.77 | 0.57 | 0.87 | 0.74±0.15 |
| Berger-Parkers Dominance (d) | 0.47 | 0.68 | 0.39 | 0.51±0.15 |
| Simpson's index (D) | 0.27 | 0.52 | 0.25 | 0.35±0.15 |
| Simpson's Diversity index (1 - D) | 0.73 | 0.48 | 0.75 | 0.65±0.15 |
| Simpson's Reciprocal index (1/D) | 3.67 | 1.98 | 4.08 | 3.24±1.11 |

Table 7: Diversity profile of Idemili North LGA sampling sites

| Species group | Abacha | Eziowelle | Oraukwu | Mean±SD |
|----------------------------------|--------|-----------|---------|------------|
| Species richness | 8.00 | 5.00 | 8.00 | 7.00± 1.73 |
| Margalef's richness (Dmg) | 1.21 | 0.75 | 1.42 | 1.13±0.34 |
| Shannon-Wiener index (H') | 1.61 | 0.91 | 1.30 | 1.27±0.35 |
| Shannon Equitability index (EH) | 0.77 | 0.56 | 0.87 | 0.73±0.16 |
| Pielou's Evenness (J') | 0.77 | 0.57 | 0.63 | 0.66±0.10 |
| Berger-Parkers Dominance (d) | 0.47 | 0.68 | 0.59 | 0.58±0.11 |
| Simpson's index (D) | 0.31 | 0.33 | 0.39 | 0.34±0.04 |
| Simpson's Diversity index (1-D) | 0.69 | 0.67 | 0.61 | 0.66±0.04 |
| Simpson's Reciprocal index (1/D) | 3.26 | 3.04 | 2.56 | 2.95±0.36 |

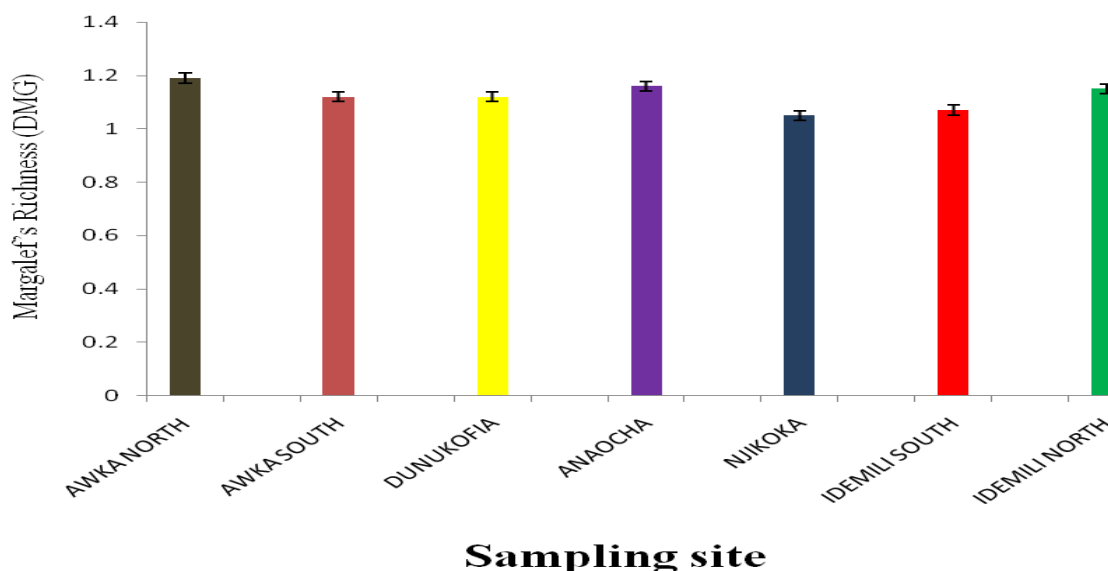


Figure 1: Cumulative Margalef's richness of the seven Local Government Areas of Anambra State sampling sites. N. B: Error bar = mean standard deviation.

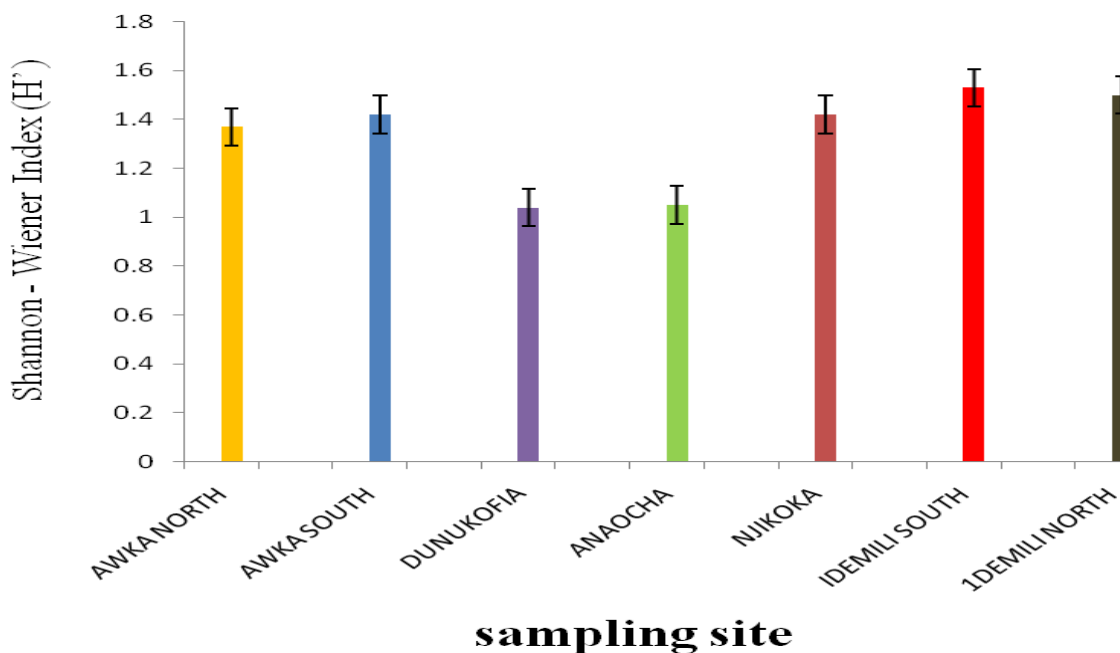


Figure 2: Cumulative Shannon - Wiener index of the seven Local Government Areas of Anambra State sampling sites. N. B: Error bar = mean standard deviation

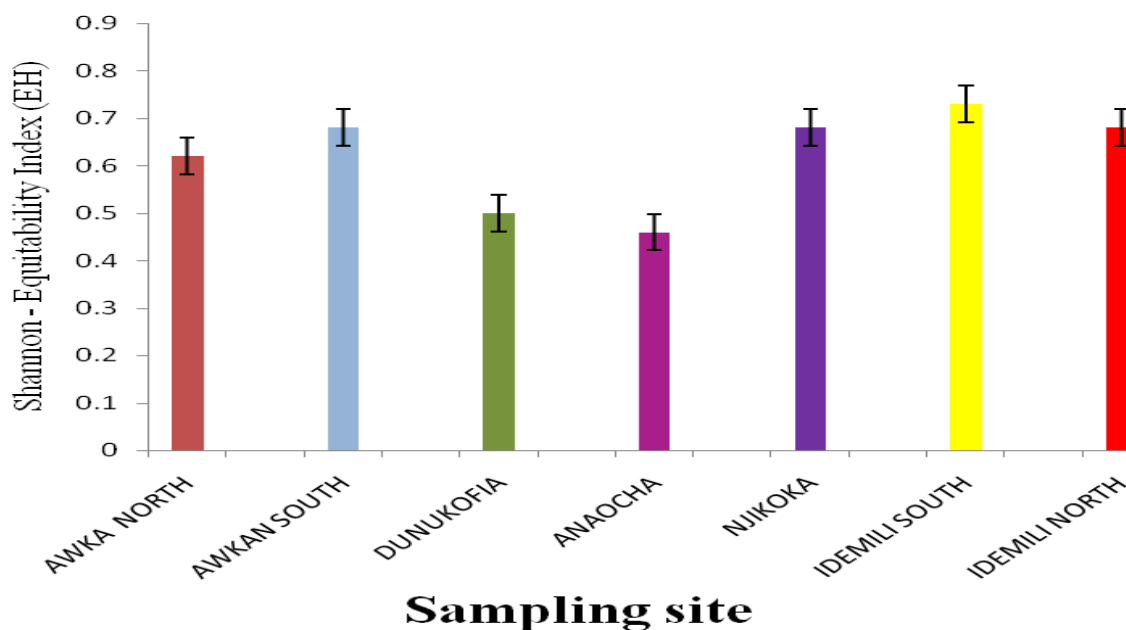


Figure 3:

Cumulative Shannon – equitability index of the seven Local Government Areas of Anambra State sampling sites
 N. B: Error bar = mean standard deviation.

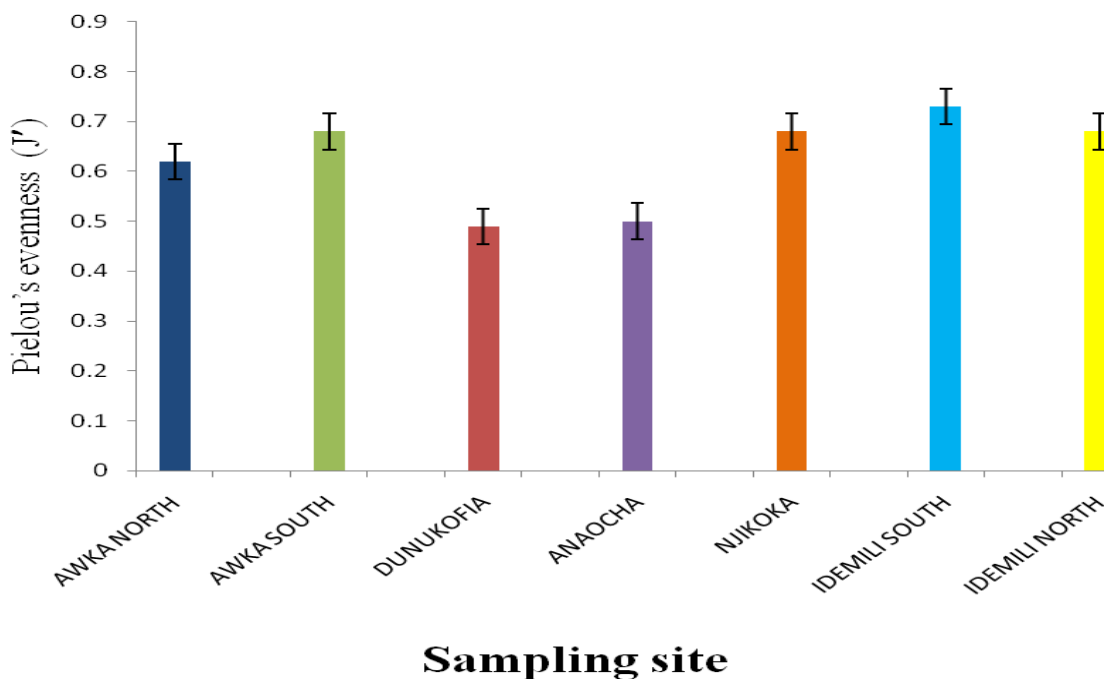


Figure 4: Cumulative Pielou's evenness of the seven Local Government Areas of Anambra State sampling sites
 N. B: Error bar = mean standard deviation

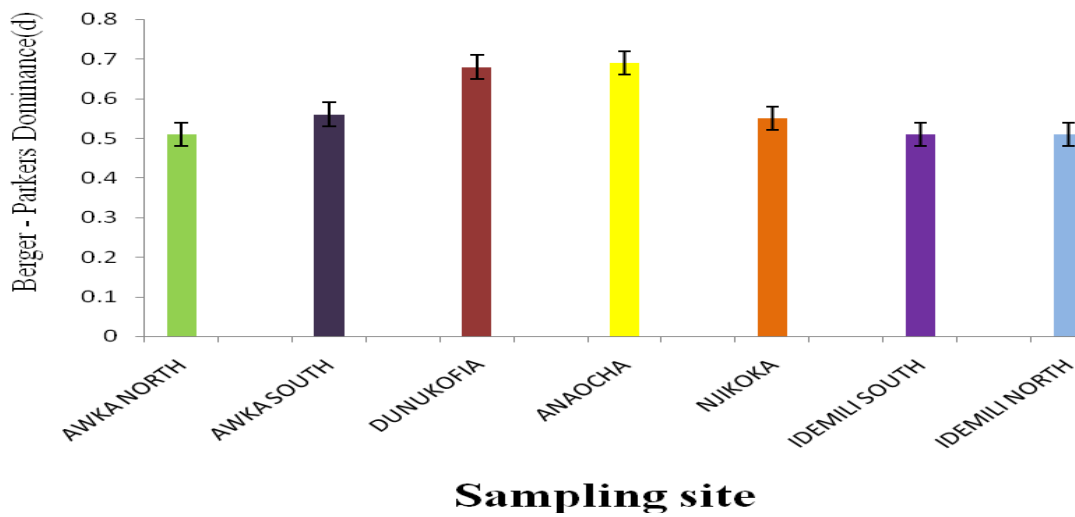


Figure 5: Cumulative Berger – parkers dominance of the seven Local Government Areas of Anambra State sampling sites
 N. B: Error bar = mean standard deviation

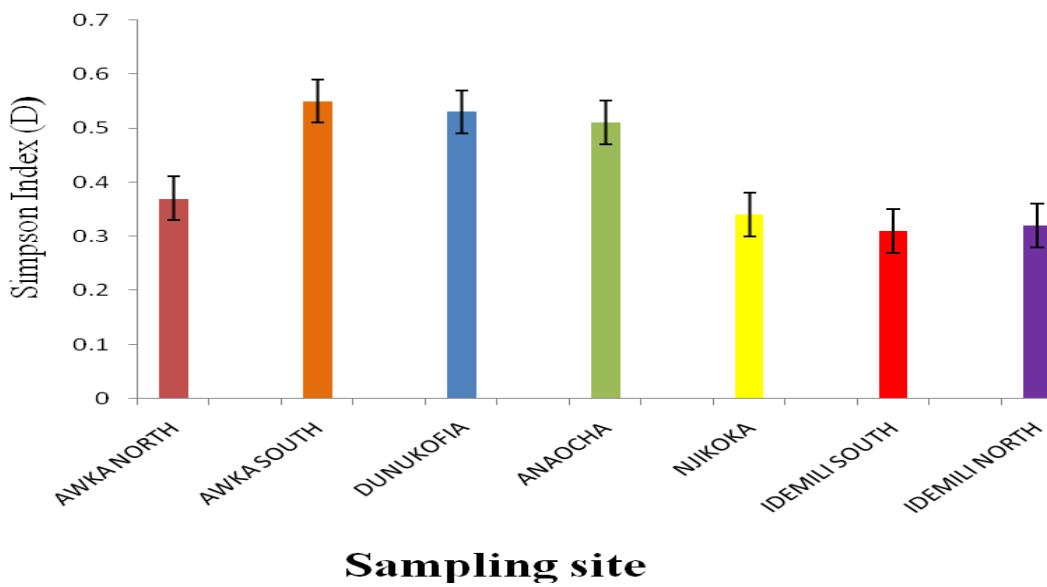


Figure 6: Cumulative Simpson index of the seven Local Government Areas of Anambra State sampling sites
 N. B: Error bar = mean standard deviation

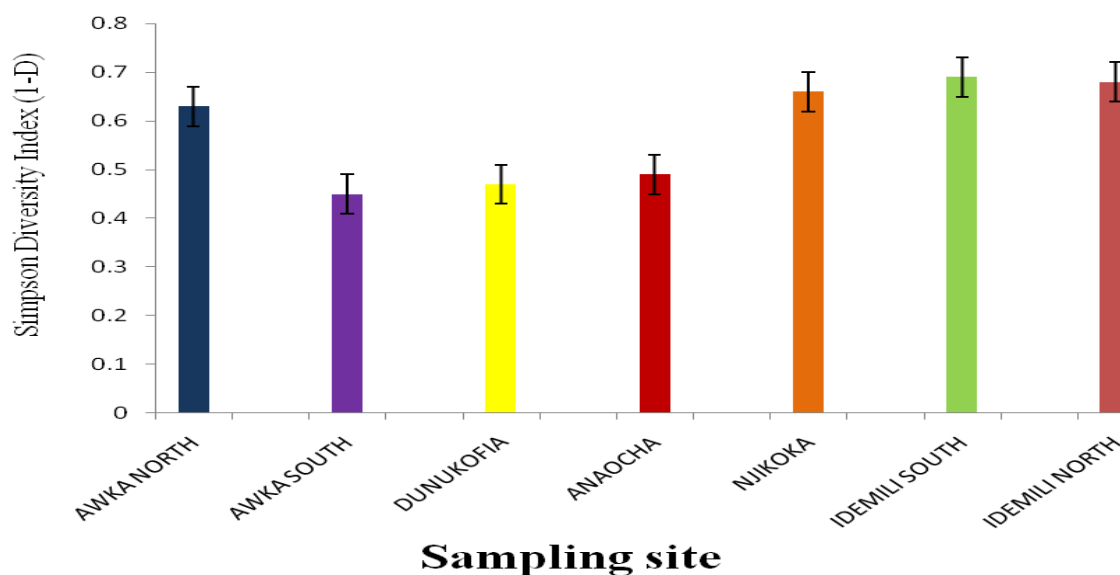


Figure 7: Cumulative of Simpson diversity index the seven Local Government Areas of Anambra State sampling sites
N. B: Error bar = mean standard deviation

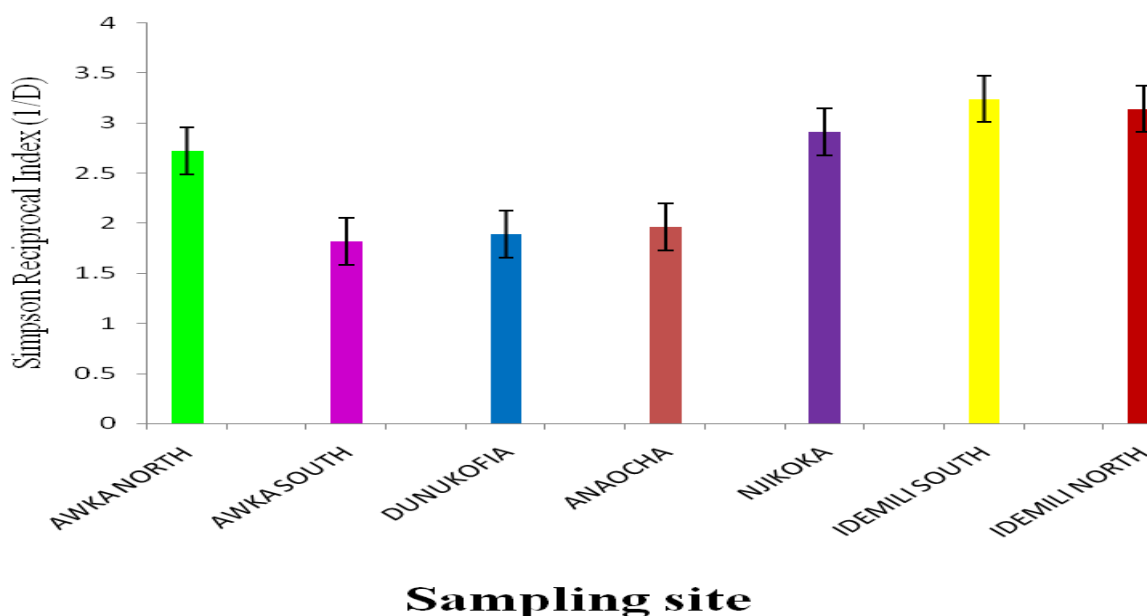


Figure 8: Cumulative of Simpson reciprocal diversity index of the seven Local Government Areas of Anambra State sampling sites
N. B: Error bar = mean standard deviation

Discussion

A diversity index is a quantitative measure that reflects how many different types (such as species) that are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among these types (Otene *et al.*, 2020). Ecological indices such as Margalef measure richness of species in an ecosystem. Margalef index has no limit value and it shows a variation depending upon the number of species hence used for comparison of sites and takes only one component of diversity (species richness) into consideration reflecting sensitivity to sample size (Otene *et al.*,

2020). Margalef's index estimate species richness but at the same time it is independent on the sample size. Margalef's richness ranged from 0.86 to 1.57 (Figure 1) and suggests low richness and contradicted with the study titled diversity of the bacterial communities of three selected streams in Anambra State, Nigeria carried out by Uba *et al.* (2025) who reported that Obibia had the highest Magarlef index of 11.703 while Mgbakwu had the lowest Magarlef index of 11.275.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as

the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4 (Otene *et al.*, 2020). This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Otene *et al.* (2020) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted. Shannon- Wiener ranged from 0.66 to 1.61 (Figure 2) based on the above classification the freshwater bodies are considered to be heavily and moderately polluted since their values were below one (1) and range of 1-3 respectively as confirmed by Davies and Otene (2009).

The higher values of Shannon-Wiener index in this study with respect to bacterial load in water sample satisfied the assertion by Davies and Otene (2009) that they are indicators of environmental pollution. Shannon-Wiener index obtained in this study is lower than the value (3.90) reported by Antal and Josph (2015) in great Kwa River, Cross River State which was attributed to difference in environmental factors. The index when applied to the present study indicates that individuals of the community are not evenly distributed with values ranging from 0.34 to 0.87, respectively from the studied area. Statistically, there were significant ($p < 0.05$, $F = 5.07$, $p < 0.0001$) differences detected among the community indices but non-significant ($p > 0.05$, $F = 0.9481$, $p = 0.5278$) differences detected among the 21 sampling sites.

The cumulative biodiversity assessment across the selected seven Local Government Areas (LGAs) revealed marked spatial variations in community structure and ecological stability (Figure 8). Awka North recorded the highest Margalef's richness (1.19), indicating comparatively greater species richness relative to sample size. Margalef's index primarily reflects the number of taxa present and is particularly sensitive to the occurrence of rare species (Magurran, 2013). This suggests that Awka North may provide relatively favorable environmental conditions that support a broader range of taxa, possibly due to habitat heterogeneity or lower anthropogenic disturbance. Conversely, Awka South exhibited the lowest Simpson's diversity index (0.45) and lowest Simpson's reciprocal index (1.82), indicating reduced overall diversity and greater dominance by fewer species. Simpson's index is weighted toward dominant taxa and reflects the probability that two randomly selected individuals belong to the same species (Uba *et al.* 2025). Lower Simpson's reciprocal values therefore imply reduced effective species diversity, often associated with ecological stress or environmental perturbation (Tuomisto, 2012). Such patterns may reflect anthropogenic pressures, including urban runoff or pollution inputs, which selectively favor tolerant species over sensitive ones. Dunokofia showed the lowest Pielou's evenness (0.49), suggesting uneven distribution of individuals among species. Evenness indices provide insight into community balance; low values indicate that a few taxa dominate the assemblage while others are poorly represented. This uneven structure may signal environmental filtering

processes or competitive exclusion mechanisms influencing species distribution (Uba *et al.* 2025). Anaocha demonstrated the highest Berger-Parker dominance (0.69) and lowest Shannon equitability (0.46), reinforcing evidence of strong dominance by one or few taxa. The Berger-Parker index specifically emphasizes the proportional abundance of the most dominant species, making it a sensitive indicator of ecological imbalance (Magurran & McGill, 2011). The concurrent low Shannon equitability further confirms limited distributional uniformity, as Shannon-based measures integrate both richness and evenness components (Uba *et al.* 2025). Such dominance-driven patterns are frequently observed in ecosystems exposed to nutrient enrichment or pollution stress (Shade *et al.*, 2012). Njikoka recorded the lowest Margalef's richness (1.05), implying comparatively reduced species presence. Lower richness may reflect habitat simplification, environmental degradation, or limited niche availability (Chase & Myers, 2011). In contrast, Idemili South exhibited the highest Simpson's reciprocal index (3.24) and lowest Simpson's index (0.31), indicating comparatively higher diversity and lower dominance. High reciprocal Simpson values correspond to greater effective species numbers and suggest a more balanced and stable ecological community (Uba *et al.* 2025). Additionally, Idemili North and South recorded the lowest Berger-Parker dominance (0.51), further supporting reduced dominance pressure and improved community distribution relative to other LGAs. Also, statistically, there were significant ($p < 0.05$, $F = 631.14$, $p < 0.0001$) differences detected among the community indices but non-significant ($p > 0.05$, $F = 2.125$, $p = 0.0675$) differences detected among the seven local government sampling sites.

Conclusion

Overall, the multidimensional biodiversity metrics demonstrate that community structure varies considerably across the study areas. Also, while some LGAs like Idemili South and Awka North) displayed characteristics of relatively stable and diverse communities, others like Anaocha and Awka South) showed patterns consistent with dominance and reduced evenness. These findings underscore the importance of applying multiple diversity indices, as each capture different ecological attributes—richness, dominance, and evenness—and together provide a more comprehensive evaluation of ecosystem health. Such integrative biodiversity assessment is essential for understanding anthropogenic impacts and guiding freshwater ecosystem management strategies.

References

- Afulukwe, S. C., Emmy-Egbe, I. O., Anyaegbulam, L. C., Uba, B. O., Obi-Ezeani, C. N., Akulue, J. C., Egbe, P. A., & Nnoruka, O. E. (2026). Evaluation of Biochemical Indices of Liver and Kidney Tissues of Albino Wistar Rats Treated with Anthelmintic Drug (Albendazole). *IPS Interdisciplinary Journal of Biological Sciences*, 6(1): 211 – 220. <https://doi.org/10.54117/ijjbs.v6i1.120>.
- Afulukwe, S. C., Uba, B. O., Okemadu, O. C., Akulue, J. C., Akudu, L. S., & Anaebonam, E. C. (2025). Histopathological Examination of Liver and Kidney Tissues of Albino Wistar Rats Treated with Albendazole Drug. *Health Science Research International*, 2(1): 10 – 22. <https://doi.org/10.54117/hsri.v2i1.54>.
- Alfred, P. N., Mbachu, I. A. C., Uba, B. O., Iweriolor, S.N. and Okemadu, O.C. (2025). Bacterial Pathogen Community Profiling

- of Three Freshwater Bodies in Akwa North and South Local Government Areas, Anambra State, Nigeria. *IPS Journal of Public Health*, 5 (3): 302 – 309. <https://doi.org/10.54117/rrrmk019>.
- Alfred, P.N., Mbachu, I.A.C. and Uba, B.O. (2023). Water Quality Indices and Potability Assessment of Three Streams in Akwa North and South Local Government Areas, Anambra State, Nigeria. *Journal of Applied Sciences and Environmental Management* 27 (2):223 – 228. <https://dx.doi.org/10.4314/jasem.v27i2.6>.
- Alisa, O. C., Anukam, N. B., Ogukwe, N. C., Chinwuba, J. A. and Uba, B. O. (2020). Determination of compost humification and other constituents that can be used as stability index. *International Research Journal of Modernization in Engineering Technology and Science*, 2 (12): 139 – 147. <https://www.irjmets.com/paperdetail.php?paperId=47fd0a18a604b911124f7def72690f1c>.
- American Public Health Association (APHA) (2012). Standard methods for examination of water and wastewater. (22nd edn.). American Public Health Association, Washington, DC: P. 1360.
- Anameze, C.I., Emmy-Egbe, I.O., Anyaegbunam, L.C., Ogomaka, I.J., Uba, B.O., Odumodu, O.A., Ezeigwe, C., Kamalu, N.L., Chukwubude, C.B., Akogu, O., Ezekwueme, E., Emmy-Egbe, C.C., Obiefoka, O.S., Ezenwata, S.I. and Ilechukwu, C.C. (2023). Qualitative and quantitative phytochemical analysis of *Gongronema latifolium* leaf extract. *IPS Journal of Applied Microbiology and Biotechnology* 2 (1): 16 – 19. <https://doi.org/10.54117/ijamb.v2i1.10>.
- Anidu, F.N., Uba, B.O., Ezemba, C.C., Okoye, E.L. and Dokubo, C.U. (2023). Study on optimization, degreasing and destaining potentials of glycophospholipid biosurfactant produced by *Bacillus anthracis* S62A. *Dutse Journal of Pure and Applied Sciences* 9 (1a): 29 – 43. <https://dx.doi.org/10.4314/dujopas.v9i1a.4>.
- Antai, E. E. & Joseph, A. P. (2015). Planktonic abundance and diversity in Great KWA River, Cross River State, Nigeria. *International Journal of Innovative Science, Engineering & Technology*, 2 (9): 141 – 154.
- Anukam, N. B., Alisa, O. C., Ogukwe, N. C., Chinwuba, J. A., Uba, B. O. and Ogukwe, E. C. (2020a). Phyto – toxicity evaluation of agro – waste formulated compost on five different plant seeds. *The International Journal of Engineering and Science*, 9 (12): 21 -26. [C0912012126.pdf](https://doi.org/10.54117/ijamb.v2i1.10) Or <https://dx.doi.org/10.9790/1813-0912012126>.
- Anukam, N. B., Alisa, O. C., Ogukwe, N. C., Chinwuba, J. A., Uba, B. O. and Ogukwe, E. C. (2020b). Physico–chemical evaluation of agro–waste formulated compost from five different waste source. *American Journal of Applied Chemistry*, 8(6): 130 – 134. [oi: https://dx.doi.org/10.11648/j.ajac.20200806.11](https://dx.doi.org/10.11648/j.ajac.20200806.11).
- Bolyen, E., Rideout, J. R., Dillon, M. R., Bokulich, N. A., Abnet, C. C., Al-Ghalith, G. A., ... Caporaso, J. G. (2019). Reproducible, interactive, scalable and extensible microbiome data science using QIIME 2. *Nature Biotechnology*, 37(8), 852–857. <https://doi.org/10.1038/s41587-019-0209-9>
- Bonada, N., Prat, N., Resh, V. H., & Statzner, B. (2021). Developments in aquatic insect biomonitoring: A comparative analysis of recent approaches. *Annual Review of Entomology*, 66, 249–270.
- Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., ... Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature*, 486(7401), 59–67. <https://doi.org/10.1038/nature11148>
- Chase, J. M., & Myers, J. A. (2011). Disentangling the importance of ecological niches from stochastic processes across scales. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1576), 235–2363.
- Chukwura, E. I. and Udogu, N. A. (2017) Evaluation of Bacterial Biofilm from Selected Surface Water and Borehole Water Samples in Anambra State, Nigeria. *Analytical Science Journal (ASJ)*. 2(1): 36 – 47.
- Chukwura, E. I., Uba, B. O., Dibua, N. A., Chude, C. O., Okoye, E. C. S., Ubajekwe, C.C., Eleanya, L. C., Agbo, B. C. and Nwajiobi, F. O. (2025). Physicochemical and bacteriological quality assessment of Ogbunike abattoir wastewater Anambra State, Nigeria for irrigation purpose. *Journal of Global Ecology and Environment* 21 (3): 378 – 385. [doi.10.56557/jogee/2025/v21i39625](https://doi.org/10.56557/jogee/2025/v21i39625).
- Convention on Biological Diversity. (2022). *Global biodiversity outlook 5*. Secretariat of the Convention on Biological Diversity.
- Czeniawska-Kusza, I. (2005). Comparing modified biological monitoring working party score system and several biological indices based on macroinvertebrates for water quality assessment. *Limnology*, 35: 169 – 176.
- Daly, A.J., Baetens, J.M. & De Baets, B. (2018). Review on ecological diversity: Measuring the unmeasurable. *Mathematics*, 6: 119. [doi:10.3390/math6070119](https://doi.org/10.3390/math6070119).
- Das, S., Lyla, P. S. & Khan, S.A. (2006). Marine microbial biodiversity: present status and advanced statistical paradigms. Chapter 25. *In: Conservation Biology in Asia* (2006) McNeely, J.A., T. M. McCarthy, A. Smith, L. Olsvig-Whittaker, and E.D. Wikramanayake (Eds. Pp. 455). Society for Conservation Biology Asia Section and Resources. Kathmandu, Nepal: Himalaya.
- Davies, O. A., & Otene, B. B. (2009). Environmental pollution studies in freshwater ecosystems: Implications of biodiversity indices as indicators of ecological disturbance. *African Journal of Environmental Science and Technology*, 3(11), 346–352
- Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneeth, A., ... Zayas, C. N. (2020). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, 366(6471), eaax3100.
- Dibua N. A., Chukwura E.I & Chude C.O. (2020) Evaluation of Different salts and Heavy Metal Concentrations on Bacterial Biofilm from Selected Surface and Borehole Water Samples. *Frontiers in Environmental Microbiology*. 6 (2): 11-17.
- Dibua, N. A., Okoye, E. C. S., Egudu, N. A., Chibueze, C. B., Azuka, C. P., Ojeh, I. K., & Nwosu, O. K. (2025c). Assessment of physicochemical parameters and heavy metals concentration of leachates from dumpsite around Idemili River, Obosi Nigeria. *Archives of Agriculture and Environmental Science*, 10(2), 364 - 373.
- Dibua, N.A., Ezeanwu, B. A., Chude, C. O., Eleanya, L. C., Okoye, E. C., Adamu, J. E., Agbo, B. C., Okpala, V. C., Oradubanya, O., K. and Ngonadi, U. J. (2025b). Heavy Metal Assessment of *Claris Angullaris* and *Tilapia Zilli* from Omambala River, Anambra State, Nigeria. *Journal of Global Agriculture and Ecology* 17 (3):19-30.
- Dibua, N.A., Nwose, C. V., Chude, C. O., Eleanya, L. C., Okoye, E. C.S., Agbo, B. C. & Nwerekem, O. S. (2025a). Physicochemical and Bacteriological Quality of Borehole Water Near Dumpsites in Student Hostels, Uli Campus, Nigeria. *Asian Journal of Microbiology and Biotechnology* 10 (2):1-10.
- Dokubo, C. U., Uba B. O. and Nnaji, I. G. (2022b). Combined coagulation and disinfection efficiencies of *Mangifera indica*, *Carica papaya* and solar disinfection on synthetic agro - waste water. *International Journal of Advanced Multidisciplinary Research and Studies* 2 (4):789 - 793. <https://www.multiresearchjournal.com/arlist/list-2022.2.4/id-437>.
- Dokubo, C. U., Uba B. O., Nnubia, C.P. and Akaun, I.P. (2022a). Evaluation of toxicity and resistant effects of heavy metals and antibiotics on the growth of marine bioluminescent bacteria. *International Journal of Frontline Research in Science and Technology* 01 (02): 030 – 037. <https://doi.org/10.56355/ijfrst.2022.1.2.0041>.
- Dokubo, C.U. and Uba, B.O. (2023). Assessment of the decontamination and disinfecting potentials of *Ocimum*

- gratissimum* synthesized silver nanoparticles on water and wastewater samples. *IPS Journal of Public Health* 3 (2): 58 – 65. <https://doi.org/10.54117/ijph.v3i2.20>.
- Dokubo, C.U., Mbachui, I.A.C., Umeaku, C.N. and Uba, B.O. (2024). Isolation, screening and identification of multi – metal resistant fungi isolated from biogas slurry sample. *Tropical Journal of Applied Natural Sciences*, 2 (2): 140 – 159.
- Egurefa, S.O., Orji, M.U. and Uba, B.O. (2020a). Toxic effect of refinery industrial effluent using three toxicity bioassays. *South Asian Journal of Research in Microbiology*, 6 (2): 10 – 23.
- Egurefa, S.O., Orji, M.U. and Uba, B.O. (2020b). Toxicological evaluation of two Nigerian refinery effluents using natural biomarkers. *Research & Reviews: A Journal of Toxicology*, 10 (2): 22 – 31.
- Ekwenzee, T. N., Uba, B. O., Dibua, N. A., Ike, V. E., Mere, C. A., & Chikwendu, J. C. (2025). Effect of Biosynthesized Nanoparticles on the Germination Profile of Zea mays Under Salinity Stress. *IPS Journal of Agriculture, Food Technology and Security*, 2(1), 53–59. <https://doi.org/10.54117/ijafts.v2i1.72>.
- Ele, E.E., Okoye, E.L., Uba, B.O., Aniekwu, C.C., Iheukwumere, C.M., Obumseli, H. and Okoye, P.A. (2024). Antibacterial effects of phytosynthesized silver nanoparticles against some selected bacteria. *International Journal of Research and Innovation in Applied Science* 9 (10): 460 – 467. <https://doi.org/10.51584/IJRIAS>.
- Emmy-Egbe, I.O., Umeaku, C.N. and Umeti, C.T. (2015): Prevalence of Urinary Tract Infections among pregnant women in Anambra State Nigeria. *Journal of Public Allied Health Sciences*, 1: 1 – 5.
- Enemchukwu, C. N., Lukong, C. B., Nwaka, A. C., & Uba, B. O. (2026b). Isolation of Lipase from Soyabean Seeds and Its Immobilization in Calcium Alginate Beads. *IPS Journal of Biotechnology and Applied Biochemistry*, 2(1), 93–100. <https://doi.org/10.54117/ijbab.v2i1.118>.
- Enemchukwu, C. N., Lukong, C. B., Nwaka, A. C., Uba, B. O., Ifemeje, J. C., Mere, C. A., & Igiri, V. C. (2026a). Green synthesis of eco-friendly potassium nanoparticles immobilized lipase enzyme and its potentials in biodiesel production. *International Journal of Global Trends and Research*, 3 (1): 66 – 76. <https://doi.org/10.54117/n3bqr651>.
- Ezeamama, M. M. C., Chukwura, E. I., Uba, B. O., Chikwendu, J. C., Ubajekwe, C. C., Ike, V. E., & Egbe, P. A. (2025a). Evaluation of the Urease Inhibitory, Antiulcer and Acute Toxicity Effects of Ethanolic Seed Extracts of *Garcinia Kola* against Chemically Induced Ulcers. *IPS Journal of Phytochemistry and Medicinal Plant Research*, 1(2): 20 – 26. <https://doi.org/10.54117/ijpmpr.v1i2.4>.
- Ezeamama, M. M. C., Chukwura, E. I., Uba, B. O., Iheukwumere, I. H., Awari, V. G., Ike, V. E., & Agu, K. C. (2025b). Assessment of the Phytochemical and Antibacterial Profiles of Aqueous and Ethanolic Extracts of *Garcinia Kola* Seed. *IPS Journal of Drug Discovery Research and Reviews*, 3(2): 51 – 56. <https://doi.org/10.54117/ijddr.v3i2.39>.
- Ibe, C.O., Mbachui, I.A.C. and Uba, B.O. (2023). Analysis and characterization of untreated greywater obtained from Enugu Metropolis. *Tropical Journal of Applied Natural Sciences* 1 (1): 1 – 17. <https://tjansonline.org/view-paper.php?id=20>.
- Ibo, E.M., Umeh, O.R., Uba, B.O. and Ekwuatu, P.I. (2020). Bacteriological assessment of some borehole water samples in Mile 50, Abakaliki, Ebonyi State, Nigeria. *Archives of Agriculture and Environmental Science* 5 (2): 179 – 189. <https://doi.org/10.26832/24566632.2020.0502015>.
- Idu, P. N., Chukwura, E. I., Uba, B. O., Okoli, F. A., & Oghonim, P. A. N. (2026). Assessment of the bacteriological quality of selected surface water resources in Anambra Central Senatorial Zone, Anambra State. *Journal of Public Health, Policy, and Society*, 3(1), 87–100. <https://doi.org/10.54117/b8kkjp54>.
- Ifediegwu, M. C., Onuora, S. C., Uba, B.O., Okoye, E. L., Egurefa, S. O. and Awari, V. G. (2023b). Assessment of the plasmid mediated biodegradation of crude oil under optimal growth conditions. *IPS Interdisciplinary Journal of Biological Sciences*, 2(1): 32 – 44.
- Ifediegwu, M. C., Uba, B.O., Awari, V., Chukwujekwu, A. G. and Akaun, I. P. (2023a). Post-reclamation evaluation of residual hydrocarbons in crude oil contaminated soil using gas chromatographic techniques and plant growth indices. *Journal of Pollution Monitoring, Evaluation Studies and Control*, 2 (1): 15 - 29.
- Ifediegwu, M.C., Orji, M.U., Onuora, S.C. and Uba, B.O. (2024b). Evaluation of the degrading potentials of plasmid and non-plasmid borne soil bacterial strains on Bonny light crude oil. *Archives of Agriculture and Environmental Science* 9(1): 14 – 22.
- Ifediegwu, M.C., Orji, M.U., Onuora, S.C. and Uba, B.O. (2024c). Exploration of the catabolic plasmid genes profile of crude oil degrading bacteria isolated from aged oil contaminated soils of Anambra State. *Scientia Africana*, 23 (1): 11 – 30.
- Ifediegwu, M.C., Uba, B.O., Awari, V.G. and Okongwu, D.J. (2024a). Biodegradation of bonny light crude oil by plasmid and non-plasmid borne soil bacterial strains using biostimulation and bioaugmentation techniques. *Science World Journal*, 19 (1): 178 – 188.
- Iheukwumere, I., Uba, B.O. and Ubajekwe, C.C (2012). Antibacterial activity of *Annoria muricata* and *Persca americana* leaves extracts against ampicillin resistant *S. aureus*. *Journal of Science, Engineering Technology*, 19(2): 10786-10798.
- Iheukwumere, I., Uba, B.O. and Ubajekwe, C.C (2012). Anti-fungal, haematological and wound healing activity of *Mucuna pruriens* leaves extracts. *Journal of Applied Science*, 15(2): 10541-10550.
- Ike, G.C., Odibo, F.J.C. and Okeke, J.J. (2021). Bacteriological examination of Obibia stream during wet and dry seasons in Awka, Anambra State, Nigeria. *Multidisciplinary Science Journal*, 3: e2021005, doi:10.29327/multiscience.2021005.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2019). *Global assessment report on biodiversity and ecosystem services*. IPBES Secretariat.
- Magurran, A. E. (2013). *Measuring biological diversity* (2nd ed.). Wiley-Blackwell.
- Magurran, A. E., & McGill, B. J. (Eds.). (2011). *Biological diversity: Frontiers in measurement and assessment*. Oxford University Press.
- Mundi, K.S., Okoye, E.L., Uba, B.O., Esimone, C.O. and Attama, A.A. (2013). Evaluation of the antibacterial activity of some commercial disinfectants against methicillin-resistant *Staphylococcus aureus*. *International Journal of Applied Science and Engineering* 1 (1): 19 – 22. <http://dx.doi.org/10.2139/ssrn.3448993>.
- Mundi, S.K; Okoye, E.L., Uba, B.O., Esimone, C.O, and Attama, A.A. (2014). The combined antibacterial activity of face cleaning agent and *Psidium guajava* leaf extract on methicillin resistant *Staphylococcus aureus*. *International Journal of Agriculture and Biosciences* 3 (2): 77 – 81. <https://www.ijagbio.com/pdf-files/volume-3-no-2-2014/77-81.pdf>.
- Njoku, N.O., Mbachui, I.A.C. and Uba, B.O. (2019a). Impact of cow dung on the physicochemical and metabolic indicators during composting of agro wastes. *Tropical Journal of Applied Natural Sciences*, 2 (3): 59 – 70.
- Njoku, N.O., Mbachui, I.A.C. and Uba, B.O. (2019b). Influence of physicochemical and microbiological properties on the composting of agro wastes using cow dung as a booster. *Animal Research International*, 16 (1): 3238 – 3246.
- Nkamigbo, P.N., Machu, I.A.C. and Uba, B.O. (2020b). Influence of glyphosate and 2, 4 - D amine herbicides on soil metabolic processes. *Research & Reviews: A Journal of Biotechnology*, 10 (1): 1 – 11.
- Nkamigbo, P.N., Mbachui, I.A.C. and Uba, B.O. (2020a). Investigation of the toxic effects of herbicides on some selected

- microbial populations from soil. *World Journal of Advanced Research and Reviews*, 06 (01): 40 – 49.
- Nnaka, O. B., Umeaku, C.N., Uba, B.O., Anyene, C. C. and Nkachukwu, M. B. (2024). Determination of the effect of mycoremediation on the physicochemical properties of hydrocarbon polluted soils of the Niger Delta region of Nigeria. *Tropical Journal of Applied Natural Sciences*, 2 (1): 1 – 18.
- Nwigwe, V. N., Nwigwe, H. C., Okereke, J. N., Uba, B.O. and Dokubo, C.U. (2023). Potential of agro-based industrial wastewater as an alternative substrate for bioelectricity. *Animal Research International* 20 (1): 4741 – 4747. <https://www.ajol.info/index.php/ari/article/view/246974>.
- Nwigwe, V.N. and Uba, B.O. (2022). Role of electrochemically active bacteria in the treatment of piggery and poultry wastewaters from Umuagwo in Ohaji Egbema Local Government Area of Imo State, Nigeria. *Journal Applied Science and Environmental Management* 26 (12): 2085 – 2093. <https://dx.doi.org/10.4314/jasem.v26i12.24>.
- Obiefoka, S.O., Emmy-Egbe, I.O., Anyaegbunam, L.C., Uba, B.O., Anameze, C.I., Ogoamaka, I.J., Kamala, N.L., Ezeigwe, C., Akaogu, O., Odumodu, O.A., Emmy-Egbe, C.C., Ezenwata, O.S. and Chukwubude, C.B. (2023). The Prevalence of Lymphatic Filariasis Infection among Primary School Children (5-9 Years) of Infected Adults in Ihiala Local Government Area of Anambra State, Nigeria. *IPS Journal of Public Health*, 3 (2): 66 – 72.
- Obiefuna, O. H., Nzekwe, C. M., Onuorah, S. C., Uba, B. O., Ubajakwe, C. C., Okey-Ndeche, N. F., and Ike, V. E. (2025). Assessment of the seasonal impact on physicochemical quality of borehole water samples in Emene, Enugu State, Nigeria. *IPS Journal of Public Health* 5 (4): 422 – 430. <https://doi.org/10.54117/8rr3ms81>
- Ofunwa, J.O., Mbachu, I.A.C., Umeaku, C.N. and Uba, B.O. (2024). Impact of composting on the physical factors of municipal solid waste materials with organic additives in Ihiala Anambra State. *Tropical Journal of Applied Natural Sciences*, 2 (2): 94 – 112.
- Oghonim, P. A. N. (2023). Evaluation of the bacteriological characteristics of selected borehole water samples in Agbor, Delta State, Nigeria. *Newport International Journal of Scientific and Experimental Sciences (NIJSES)*, 3(3), 168 – 185.
- Oghonim, P. A. N., Onuorah, S. C., Onyima, C. S., Idu, P. N., Uba, B. O., Onyekpeze, C. E., Agbakhamon, E., Alari, E. J., Osunde, G., & Ottah, F. (2026). Public health risk assessment of heavy metal contamination in abattoir wastewater-irrigated soil and edible crops in Agbor, Delta State, Nigeria. *INOSR Applied Sciences*, 14(1), 9 – 17.
- Oghonim, P. A. N., Ugwu, O. P.-C., & Godwin, V. C. (2023). Evaluation of the average values of the chemical parameters of selected borehole water samples in Agbor, Delta State, Nigeria. *IDOSR Journal of Applied Sciences*, 8(3), 118–139.
- Okafor, C. A., Uba, B.O. and Dokubo, C.U. (2023). Application of myco-fabricated silver nanoparticle in the adsorption malachite green and trypan blue from aqueous solution. *Nigerian Journal of Life Sciences* 12 (2): 8 – 15. <https://doi.org/10.52417/njls.v12i2.354>.
- Okafor, F.N., Orji, M.U., Nweke, C. O., Onuorah, S.C., Uba, B.O. and Dokubo, C.U. (2021b). Toxicity of Quaternary Mixture of Formulated Glyphosate and Phenols on *Providencia vermicola* Dehydrogenase Activity. *Archives of Current Research International* 21(4): 1 – 10. <https://dx.doi.org/10.9734/ACRI/2021/v21i430239>.
- Okafor, F.N., Orji, M.U., Onuorah, S.C., Uba, B.O., Dokubo, C.U. and Ofunnwa, J.O. (2021a). In vitro Interactive Toxicity of Binary Mixtures of Selected Herbicides on *Lysinibacillus fusiformis*. *Asian Journal of Biology* 12(3): 30-41. <https://dx.doi.org/10.9734/AJOB/2021/v12i330165>.
- Okolo, O.C., Uba, B. O. and Ike, V.O. (2025). Influence of untreated noodle wastewater on physicochemical, enzymatic and bacteriological dynamics of soil. (2025). *Journal of Pollution Monitoring, Evaluation Studies and Control* 4 (2): 110 –119. <https://doi.org/10.54117/jpmesc.v4i2.20.2025>.
- Okonkwo, O. P., Uba, B. O., Ifemeje, J. C., Ozochi, C. A., Okongwu, D. J., & Anaebonam, E. C. (2026). Green Synthesis of Silver Nanoparticles from Aqueous Seed Extract of *C. papaya* and its Application in Surface Water Resources Decontamination. *IPS Journal of Plant, Animal, and Environmental Sciences*, 2(1): 22–31. <https://doi.org/10.54117/ijpae.v2i1.121>.
- Okoye, E. L., Uba, B. O. and Onwunyili, C. E. (2020c). Antibacterial activity and protein sequences of actinomycetes isolated from coastal area of Niger Delta against human and fish pathogens. *International Journal of Biosciences and Technology*, 13 (1): 1 – 17.
- Okoye, E. L., Uba, B. O. and Ugwuoke, C. J. (2020b). Determination of the growth rate and susceptibility pattern of fungi using agro-waste formulated media. *Nigerian Journal of Microbiology*, 34(2): - 5258 – 5268.
- Okoye, E. L., Uba, B. O., Dike, U. C. and Eziefule, U. J. (2020a). Growth rate and antifungal activities of acetone extracts of *Ocimum gratissimum* (Scent Leaf) and *Allium sativum* (Garlic) on cassava and banana peels formulated media. *Journal of Advances in Microbiology*, 20 (4): 19 – 29.
- Okoye, E.L., Uba, B.O., Uhobo, P.C., Oli, A.N. and Ikegbunam, M.N. (2014). Evaluation of the antibacterial activity of methanol and chloroform extracts of *Alchornea cordifolia* leaves. *Journal of Scientific Research and Report* 3 (1):255 – 262. <https://journaljsrr.com/index.php/JSRR/article/view/1692/3353>.
- Okpalaunegbu, C.A., Chinweuba, A.J., Ojiako, E.N., Uba, B.O. and Okafoanyali, J.O. (2025). Physicochemical properties and heavy metal analysis of sewage and leachate wastewater collected from the Sewage Tank at the University of Nigeria, Nsukka and the First Market Municipal Dumpsite, Ifite-Awka, Anambra State. *Journal of Global Ecology and Environment* 21 (3): 320 – 332. <https://doi.org/10.56557/jogee/2025/v21i39583>.
- Orji, M. U., & Oghonim, P. A. N. (2023). Evaluation of the average physical parameters of selected borehole water samples in Agbor, Delta State, Nigeria. *IDOSR Journal of Scientific Research*, 8(3), 125–138.
- Otene, B.B., Alfred – Ockiya, J.F. & Ejiko, E.O. (2020). Bio-Indices of bacteria loads in water and mangrove Oyster (*Crassostrea Gasar*) of Woji/ Trans-Amadi Creek, Port Harcourt, Nigeria. *International Journal of Research and Innovation in Applied Science*, 5 (3): 104 – 110.
- Otene, B.B., Alfred-Ockiya, J.F. & Amadi, F. (2019). Physicochemical properties and zooplankton community structure of Okamini Stream, Port Harcourt, Nigeria. *International Journal of Research and Innovation in Applied Science*, 4 (10): 2454 – 6194.
- Pallmann, P., Hothorn, L. A., & Futschik, A. (2012). Testing for equality of biodiversity indices. *Computational Statistics & Data Analysis*, 56(10), 3073–3085.
- Sandhya, D.D. and Laxmi, K. S. (2016). Bioindices of bacterial communities. *International Journal of Current Microbiology and Applied Science*, 5 (12): 219 – 233.
- Shade, A., Caporaso, J. G., Handelsman, J., Knight, R., & Fierer, N. (2012). A meta-analysis of changes in bacterial and archaeal communities with time. *The ISME Journal*, 6(8), 1493–1506.
- Tuomisto, H. (2012). A diversity of beta diversities: Straightening up a concept gone awry. *Ecography*, 35(1), 23 – 33.
- Uba, B. O., Alfred, P. N., Ukpai, E. G., Ike, V. E. & Chikwendu, J. C. (2025). Diversity Of The Bacterial Communities Of Three Selected Streams In Anambra State, Nigeria. *Open Journals of Environmental Research*, 6 (2): 59 – 72. DOI: <https://doi.org/10.52417/ojer.v6i2.453>.
- Uba, B. O. (2018a). Effect of aromatic hydrocarbons and marine sediments from Niger Delta on the growth of microalga *Phaeodactylum tricorutum*. *Biotechnology Journal International*, 22 (4): 1 – 18.

- Uba, B. O. (2018b). Growth profile and catabolic pathways involved in degradation of aromatic hydrocarbons by marine bacteria isolated from Niger Delta. *Microbiology Research Journal International*, 26 (5): 1 - 18.
- Uba, B. O. and Anidu, F. N. (2023). Evaluation of the characterization and heavy metals remediation potential of biosurfactant produced by *Aeromonas hydrophila* S62A. *Archives of Agriculture and Environmental Science*, 8 (2):116 – 124.
- Uba, B. O. and Obiefuna, G. O. (2023). Aerobically enhanced nanobioremediation of diesel oil contaminated soil and water using mycosynthesized silver nanoparticle as biostimulating agent. *Science World Journal* 18 (1): 75 – 82. <https://scienceworldjournal.org/article/view/23510>.
- Uba, B. O. and Udaba, P.I. (2026b). Evaluation of the Production of Biosurfactant by Yeast Strains Isolated from Fruit Pastes and their Biodegradative Potential on Waste Engine Oil. (2026). *Journal of Pollution Monitoring, Evaluation Studies and Control*, 5(1): 147 - 157. <https://doi.org/10.54117/ejmptp50>.
- Uba, B. O., Chukwura, E. I., Iheukwumere, I.H., Okeke, J.J. and Akaun, I.P. (2020f). Evaluation of marine waste water and aromatic hydrocarbons toxicity using a battery of assays. *Research & Reviews: A Journal of Toxicology*, 10 (2): 1 – 13.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Emmy-Egbe, I. O. and Ubani, O. (2021b). Assessment of Toxicity of Marine Sediment and Aromatic Hydrocarbon Samples using Marine Algal Toxicity and Phytotoxicity Tests. *Indian Journal of Environmental Protection*, 41 (2): 123
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Ubani, O. and Odibo, F.J.C. (2021a). Toxicological evaluation of aromatic hydrocarbons using toxi-chromo test and mice model. *Indian Journal of Ecology*, 48 (5): 1533 – 1541. <https://indianecologicalsociety.com/wp-content/themes/ecology/fullpdfs/1635504109.pdf>.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Ubani, O., Chude, C.O. and Akabueze, U. C. (2019c). *In vitro* degradation and reduction of aromatic hydrocarbons by marine bacteria isolated from contaminated marine environments of Niger Delta. *Advances in Research*, 18 (3): 1 - 17.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Ubani, O., Irabor, M. I., Onyekwulufe, N. V., Ajeh, J. E., Muogbo, C. S., Nwafor, M. C., Igboosorom, C. C., Nwodo, C. J., Okafor, J. C. and Nwachukwu, C. J. (2018a). Multiple degradation and resistant capabilities of marine bacteria isolated from Niger Delta, Nigeria on petroleum pollutants and heavy metals. *Journal of Advances in Biology and Biotechnology*, 20 (1): 1 -17.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Umebosi, A.A., Agbapulonwu, U. F., Muogbo, O. C., Okoye, C. L., Oranta, L.O., Odunukwe, A.M., Ndurue, C. P. and Ehirim, O. S. (2018c). Biofilm and biosurfactant mediated aromatic hydrocarbons degradation by marine bacteria isolated from contaminated marine environments of Niger Delta. *Journal of Applied Life Sciences International*, 19 (4): 1 -17.
- Uba, B. O., Obidike, K.N., Dokubo, C.U. and Nnaodi, I.D. (2020g). Bioelectricity generation using marine sediment and cow dung. *EC Microbiology*, 16 (10): 1 – 12.
- Uba, B. O., Okonkwo, O. P., Idigo, M. A., Igiri, V.C., Okongwu, D. J., Okemadu, O.C. & Anaebonam, E. C. (2026a). Disinfecting Potentials and Eco-Safety Evaluation of Nano-treated Surface Water Resources by Biogenic Silver Nanoparticles Using Bacterial and Phytotoxicity Indices. (2026). *African Journal of Applied Research & Sustainable Development*, 4(1): 47-58. <https://doi.org/10.54117/j2gae873>.
- Uba, B. O., Okoye, E. L., Anyaeji, O.J. and Ogonnaya, O.C. (2019a). Antagonistic Potentials of actinomycetes isolated from coastal area of Niger Delta against *Citrus sinensis* (Sweet Orange) and *Lycopersicon esculentum* (Tomato) fungal pathogens. *Research and Reviews: A Journal of Biotechnology*, 8 (3): 4 – 15.
- Uba, B. O., Okoye, E. L., Dokubo, C.U., Azuanichie, T. and Nworah, O.M. (2018b). Biostimulatory effect of organic and inorganic nutrients on soil biological indicators in diesel contaminated soil. *Journal of Bioscience and Biotechnology*, 3(6): 121 – 135.
- Uba, B. O., Okoye, E. L., Ekwueme, C., Azubike, T. C. and Ugoma, J.C. (2017). Heavy metals and antibiotics resistance pattern of bacteria isolated from brewery and plastic industries effluent waste. *African Journal of Education, Sciences and Technology*, 3(3): 43 – 50.
- Uba, B. O., Udaba, P.I., Dibua, N.A., Ubajakwe, C.C., Igiri, V.C., Okongwu, D. J., & Anaebonam, E. C. (2026c). Toxicity and Safety Evaluation of Glycolipid Biosurfactant Produced by Yeast Strains Isolated from Fruit Pastes. (2026). *IPS Journal of Toxicology*, 4(1): 100 - 109. <https://doi.org/10.54117/axm1gf40>
- Uba, B. O., Udeh, C.A., Nduneri, C. F. and Akaun, I. P. (2020e). Potentials of carrot (*Daucus carota*) and cocoyam (*Colocasia esculenta*) peels as suitable mycological culture media. *Research & Reviews: A Journal of Life Sciences*, 10 (3): 22 – 29.
- Uba, B.O. (2019a). Aromatic hydrocarbons degradation and plasmid profile of marine bacterial isolates obtained from petroleum contaminated marine environments of Niger Delta, Nigeria. *Microbiology Research Journal International*, 27 (1): 1 – 20.
- Uba, B.O. (2019b). Effects of aromatic hydrocarbons and marine water from Niger Delta on the β -galactosidase activity of mutant *Escherichia coli*. *Archives of Current Research International*, 16 (3): 1 – 16.
- Uba, B.O. (2019c). Phylogenetic framework and metabolic genes expression analysis of bacteria isolated from contaminated marine environments of Niger Delta. *Annual Research & Review in Biology*, 30 (5): 1 – 16.
- Uba, B.O. and Okonkwo, O.P. (2025). Surface water treatment potentials of silver nanoparticles biosynthesized from *Moringa oleifera* seed extract. *African Journal of Health, Safety and Environment*, 6(2): 01 - 18. <https://doi.org/10.52417/ajhse.v6i2.622>.
- Uba, B.O., Akunna, M.C., Okemadu, O. C. and Umeh, C. J. (2019b). Kinetics of Biodegradation of total petroleum hydrocarbon in diesel contaminated soil as mediated by organic and inorganic nutrients. *Animal Research International*, 16 (2): 3295 – 3307.
- Uba, B.O., Akunna, M.C., Okemadu, O. C. and Umeh, C. J. (2019e). Kinetics of Biodegradation of total petroleum hydrocarbon in diesel contaminated soil as mediated by organic and inorganic nutrients. *Animal Research International*, 16 (2): 3295 – 3307.
- Uba, B.O., Egbujor, J.C. and Umeh, O.R. (2020c). *Selenastrum capricornutum* Prinz, *Zea mays* L. and *Phaseolus vulgaris* L. biomonitors: Natural monitors of spent phone battery toxicity. *Asian Journal of Advanced Research and Reports*, 13 (1): 31 – 41. <https://doi.org/10.9734/AJARR/2020/v13i130300>.
- Uba, B.O., Okonkwo, C.J. and Umeh, O.R. (2020d). Experimental assessment of the toxicity effects of phone battery wastes on aquatic and terrestrial bioindicators. *Asian Journal of Biochemistry, Genetics and Molecular Biology*, 5(1): 17 – 27. <https://doi.org/10.9734/AJBGMB/2020/v5i130117>.
- Uba, B.O., Okoye, E.L. and Chukwura, E.I. (2016). Bioremediating potentials of marine mercury-resistant bacteria on polyaromatic hydrocarbons components of Bonny light crude oil. *Journal of Advances in Biology and Biotechnology*, 7 (4): 1 - 12.
- Uba, B.O., Okoye, E.L., Anyichie, J.C., Dokubo, C.U. and Ugwuoji, E.T. (2024). Synthesis, characterization and application of biogenic silver nanoparticles as antibacterial and antifungal agents. *Journal of Advances in Microbiology* 24 (3): 65 – 78. <https://doi.org/10.9734/JAMB/2024/v24i3809>.
- Uba, B.O., Okoye, E.L., Chude, C.O. and Ogamba, J.O. (2020a). Assessment of the toxicity potentials of spent laptop battery wastes on essential soil microbes and plant bioindicators. *Asian Journal of Biology*, 9(2): 33 – 46. <https://doi.org/10.9734/AJOB/2020/v9i230085>.

- Uba, B.O., Okoye, E.L., Ebodi-Henry, J.N. and Okoye, W.K. (2019d). Organic and inorganic nutrients mediated enhanced bioremediation of diesel contaminated soil. *Tropical Journal of Applied Natural Sciences*, 2 (3): 39-51.
- Uba, B.O., Okoye, E.L., Nweke, B.G. and Ibeneme, C.P. (2020b). Evaluation of the ecotoxicity potentials of e-waste using *Selenastrum capricornutum* (microalga), *Eisenia fetida* (earth worm) and *Allium cepa* (onion bulb) as bioindicators. *Asian Journal of Biotechnology and Genetic Engineering*, 3(2): 20 – 31. <https://journalajbge.com/index.php/AJBGE/article/view/24>.
- Uba, B.O., Uhobo, P.C., Oli, A.N. and Ikegunam, M.N. (2014). Evaluation of the antibacterial activity of methanol and chloroform extracts of *Alchornea cordifolia* leaves. *Journal of Scientific Research and Report*, 3 (1):255-262. <https://journaljsrr.com/index.php/JSRR/article/view/1692/3353>.
- Ubajekwe, C. C., Chukwura, E. N., Dimejesi, S. N., Uba, B. O., Eleanya, L., Ezendianafo, J. N., & Dibua, N. A. (2025). Screening for Lipase Enzyme Producing Potentials of *Bacillus* Species Isolated from Different Automobile Workshops in Anambra State. *IPS Journal of Advanced and Applied Biochemistry*, 1(2), 51–56. <https://doi.org/10.54117/ijaab.v1i2.71>.
- Ubani, O., Obiefuna, G.O., Uba, B.O., Dokubo, C.U., Mere, C. A. and Akaun, I.P. (2024a). Kinetic modelling and half-life study on bioremediation of diesel oil contaminated soil and water using nano - remediation strategy: kinetic modelling and half-life study on bioremediation of diesel oil. *Multidisciplinary Science Journal* 7: e2025182. <https://doi.org/10.31893/multiscience.2025182>.
- Ubani, O., Uba, B. O., Modise, S. J., Egunfa, S. O., Orji, M. U. and Dokubo, C. U. (2025). A characterization and evaluation of the ecotoxicity of petroleum refinery effluents using a battery of bioassays. *Multidisciplinary Science Journal* 8 (3): 2026159. <https://doi.org/10.31893/multiscience.2026159>.
- Ubani, O., Uba, B.O., Modise, S. J., Okoye, E. L., Omeazu, S. C., Ndibe, C.R., Umeh, O. R. and Dokubo, C. U. (2024b). Responses of *Selenastrum capricornutum*, *Eisenia fetida*, *Brassica nigra* and *Sorghum bicolor* to spent phone battery toxicity. *Multidisciplinary Science Journal*, 6 (7): 2024107 - 2024107.
- Umeh, O.R., Chukwura, E.I., Ibo, E.M. and Uba, B.O. (2020). Evaluation of physicochemical, bacteriological and parasitological quality of selected well water samples in Awka and its environment, Anambra State, Nigeria. *Archives of Agriculture and Environmental Science* 5 (2): 73 – 88. <https://doi.org/10.26832/24566632.2020.050201>.
- Umeh, O.R., Chukwura, E.I., Okoye, E.L., Ibo, E.M., Egwuatu, P. I. and Uba, B.O. (2021). Phytochemical Screening and Antibacterial Evaluation of Conventional Antibiotics, Garlic and Ginger on Isolates from Fish Pond Water Samples in Awka, Anambra State, Nigeria. *Journal of Pharmaceutical Research International* 33(30B): 118-132. <https://doi.org/10.9734/jpri/2021/v33i30B31646>.
- Umezulora, B. I., Okoye, E. L., & Uba, B. O. (2026). Phytochemical Profiling of Aqueous, Methanol and Hexane Leaf Extracts of *Jatropha curcas* using Chromatographic and Spectral Fingerprints. *IPS Journal of Phytochemistry and Medicinal Plant Research*, 2(1): 35 – 44. <https://doi.org/10.54117/ijpmpr.v2i1.37>.
- United Nations Environment Programme. (2023). *Global environment outlook 6: Healthy planet, healthy people – Updated findings*. UNEP.
- Willey, J. M., Sherwood, I. M. & Woolverton, C. J. (2008). Prescott, Harley and Kleins Microbiology. (7th ed. Pp. 537 - 813). New York: McGraw-Hill companies.



FEATURED PUBLICATIONS

Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour

The study found that adding banana peel flour to wheat flour can improve the nutritional value of noodles, such as increasing dietary fiber and antioxidant content, while reducing glycemic index.

DOI: <https://doi.org/10.54117/ijaab.v6i1.24>

Cite as: Oguntoyinbo, C. O., Ogunmurewa, J. A. V., & Onwoba, C. S. (2023). Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour. *IPS Journal of Nutrition and Food Science*, 2(2), 20-24.

Impact of Pre-Sowing Physical Treatments on The Seed Germination Behaviour of Sorghum (*Sorghum bicolor*)

The study found that ultrasound and microwave treatments can improve the germination of sorghum grains by breaking down the seed coat and increasing water diffusion, leading to faster and more effective germination.

Submit your manuscript for publication: [Home - IPS Intelligentsia Publishing Services](https://www.ips-journals.com)

• Thank you for publishing with us.