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Identification and Characterization of Endocrine Disrupting Compounds in Ikpa River, Southern Nigeria

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ABSTRACT: This study aims to identify and characterize the types and concentrations of Endocrine Disrupting Compounds (EDCs) present in the Ikpa River, Southern Nigeria. In this study, the accessible population comprised two hundred and eighty (280) respondents and samples in the locality. The sample size was determined using the Taro Yamane formula and calculated as 147 respondents. The samples were analyzed using Gas Chromatography–Mass Spectrometry (GC–MS) to identify and quantify selected Bisphenols (A, S, F, P, Z) and Nonylphenols. Physicochemical parameters were measured to assess general water quality, while a community-based questionnaire captured public awareness and potential exposure pathways. Results indicated that water quality parameters, such as pH (6.8–6.9), dissolved oxygen (8.5 mg/L), and total dissolved solids (24–28 mg/L), were within the limits set by the WHO and NESREA. However, trace concentrations of bisphenols and nonylphenols (0.20–2.20

ppb) were detected across all sampling sites. Primary data were analysed using Statistical Package on Social Science (SPSS Version 25), Analysis of Variance (ANOVA), and Pearson Correlation methods. The result of the research hypotheses showed the type and concentration of EDCs in the Ikpa River. The study recommends that eco-friendly alternative products be used in place of EDC-containing products. This prevents harmful compounds from entering the environment, thereby reducing water contamination and the need for costly water treatment or remediation measures in the future.

Keywords: *Ecological Risk Assessment, Endocrine Disrupting Compounds (EDCs), Environmental Pollution, Ikpa River, Water Quality.*

1. Introduction

The sustainability of freshwater ecosystems is crucial to human survival and biodiversity conservation. Rivers serve as vital natural resources for domestic, agricultural, industrial, and ecological functions. The global environment, particularly water bodies, is increasingly burdened by an array of anthropogenic chemicals, released as a consequence of rapid industrialization, burgeoning urbanization, and widespread consumerism. Among these pollutants, Endocrine Disrupting Compounds (EDCs) have garnered significant scientific and public health concern due to their insidious ability to interfere with the delicate balance of hormonal systems in living organisms (IPCS, 2002; Encarnação et al., 2019).

Among the diverse classes of EDCs, EDCs represent a group of particular concern. Chemically defined by a hydroxyl group directly attached to an aromatic hydrocarbon ring, these compounds encompass a wide array of industrial chemicals and their derivatives. Key examples include Bisphenol A (BPA), Alkylphenols and other specific compounds like triclosan. These compounds enter the aquatic environment primarily through the leaching from discarded consumer products in solid waste, the direct discharge of domestic and industrial wastewater, and agricultural runoff. Due to their persistence, bioaccumulation potential, and estrogenic activity, they have been detected in aquatic ecosystems globally, raising concerns about ecological and human health risks (WHO, 2022; Rochester, 2015; Jobling et al., 1998).

Nigeria, like many developing countries, faces several challenges in managing chemical pollution, including poor wastewater treatment infrastructure resulting in the direct discharge of untreated effluents, inadequate regulatory enforcement, especially concerning unmonitored and emerging pollutants, limited environmental monitoring frameworks that do not account for EDCs or other micropollutants, and a lack of public awareness about the potential hazards of consumer products containing EDCs (Asonye et al., 2007; Udebuana et al., 2015; Nwaneri et al., 2018).

The need for this research is underscored by a critical knowledge gap. Despite the global and regional concerns surrounding EDCs and the documented general pollution of Nigerian aquatic systems (Ibor et al., 2023; Monday et al., 2025; Olayinka et al., 2022; Onyekachi et al., 2019), there is a significant lack of specific empirical data on the occurrence, distribution, and comprehensive ecological and pollution risks of EDCs within the Ikpa River, Southern Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

The materials and resources used for this study included the following; Water Sampling Bottles, Sediment Sampler, GPS Device, Coolers with Ice Pack, Aluminum Foil, Ziplock Bags, Gloves, lab coats, goggles, masks, Field Notebooks & Data Sheets, Laptops and Statistical Software. All items were obtained from standard lab suppliers or the university's environmental science department.

2.2 Methods

2.2.1 Study Area

The Ikpa River is a significant freshwater body within Akwa Ibom State, a coastal state in the Niger Delta region, Southern Nigeria and spans roughly **501 km²** covering local government areas including Ibiono-Ibom, Itu, Uruan, and Uyo as shown in figure 1. Overall Basin of the river is located between Latitude 5°11′ N and 5°16′ N, and Longitude 7°55′ E and 8°07′ E (Etteokon, et al., 2021).

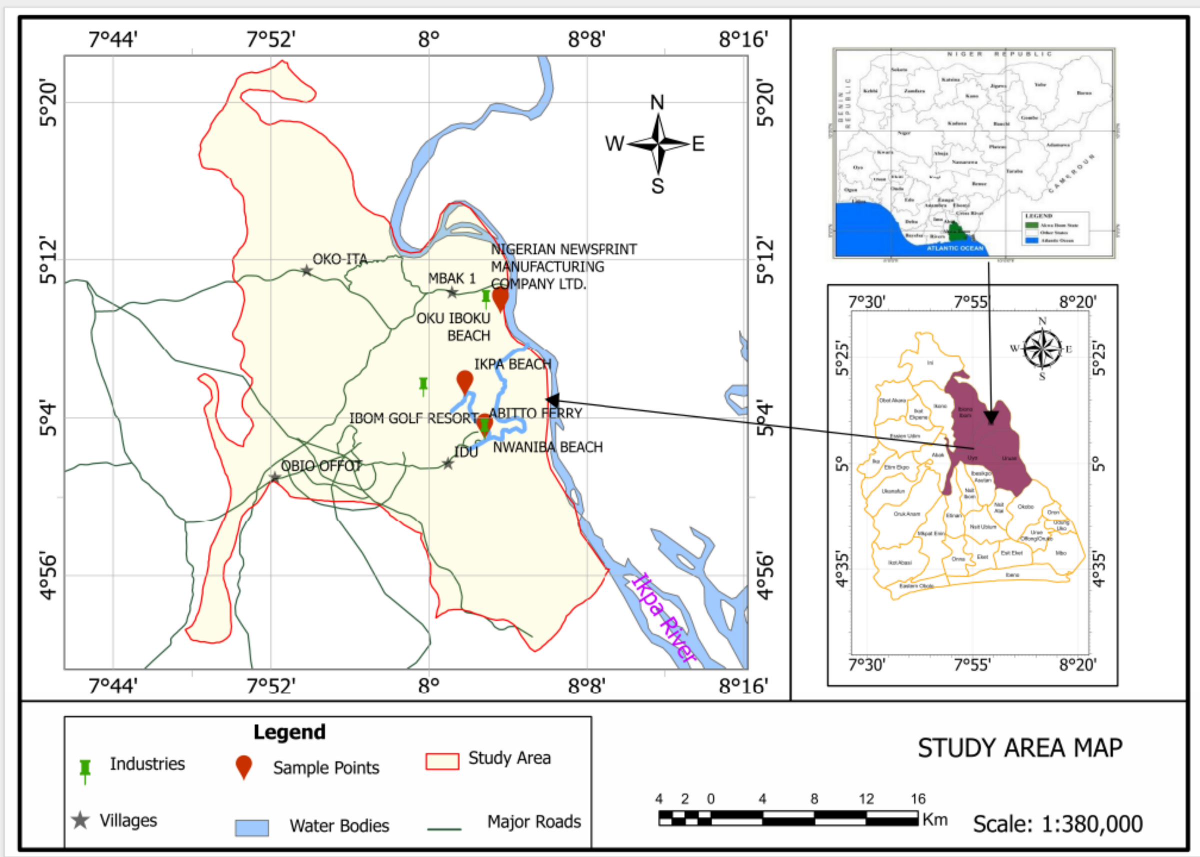

Figure 1: Map showing the Study Area in Nigeria.

2.2.2 Sample Collection and Preservation

Surface water samples were collected in polyethylene bottles from each station for physicochemical analyses. The sampling containers were previously washed with detergent, deionised water, 10 % (v/v) HNO_3, and with deionised water again. The containers were pre-rinsed with the surface water to be collected before samples were taken. The samples were collected just below the surface of water with the bottle pointing downward, filled gradually and then capped under water when full. The sediment samples, at depth of 0 – 5.0 cm, were collected using a stainless steel hand trowel from each point where water sample was taken. Samples were stored in pre-labelled polythene bags to indicate the code, date and time of collection, kept in an ice-chest and taken to the laboratory. In the laboratory, the samples were air dried for four days at ambient temperature. Coarse materials – small stones, wood, and other large materials were removed by hand picking, and the samples then pulverized using an agate mortar and pestle. The homogenized sediment samples were sieved with nets of mesh sizes 0.5, 1 and 2 mm respectively and then stored in clean labelled paper bags until analysis.

2.2.3 Sampling and Data Analyses

Some parameters were determined *in situ* using Extech meter probe (Exstick II), flow velocity was determined by floatation method, while phosphate, nitrate and biochemical oxygen demand were analyzed *ex-situ*. All parameters were determined according to standard methods of water and wastewater (APHA 2017). BPA, OP and NP were determined using a gas chromatograph equipped with a mass spectrometer. Separation of all targeted compounds was achieved by injecting about 1 μL of each extract into the GC system (in a splitless mode) through a capillary column (3.0 m length, 0.2 mm internal diameter, 0.2 μm film thickness). Helium gas was used as the carrier gas. Statistical Package for Social Science (SPSS) Version 25 was employed to compute the mean, variance and standard error in the data collected. Also, one-way analysis of variance (ANOVA) and least significant difference (LSD) test were used to separate significance in mean values computed for stations. The probability level was set at $p=0.05$

3.0 Results

3.1 Physicochemical Characteristics of the Samples

Results of the physicochemical assessment of samples collected from the Ikpa river are presented in Tables 1 and 2. The measured temperature range (27–28 °C) aligns with tropical ambient conditions and supports metabolic activity of aquatic organisms. pH (6.8–6.9) indicates slightly acidic but stable water chemistry, suggesting little anthropogenic interference. Many aquatic species thrive in this range. Dissolved Oxygen (DO) levels (~8.5 mg/L) reflect healthy oxygen balance, essential for aerobic decomposition and aquatic life survival while BOD values (~2.8 mg/L) suggest low levels of biodegradable organic matter — the river is not heavily loaded with sewage or organic pollutants.

Table 1: Physicochemical properties of water samples

Parameter	Range / Values Observed	Interpretation
Temperature (°C)	27.6 – 27.9 °C	Within normal tropical surface water range; stable and suitable for aquatic life.
pH	6.8 – 6.9	Slightly acidic but within WHO permissible range (6.5 – 8.5) — good for aquatic organisms.
Total Dissolved Solids (TDS)	~24.5 mg/L	Very low, confirming fresh and relatively unpolluted water.
Nitrate (NO_3^-)	0.02 – 0.07 mg/L	Far below WHO limit (50 mg/L) — suggests minimal agricultural runoff or sewage impact.
Turbidity (NTU)	3.0 NTU	Slightly above ideal (1 NTU), but acceptable for natural surface water.

Table 2: Descriptive Statistics for Water Quality Parameters

Parameter	Mean ± SD	Minimum	Maximum	Guideline (e.g., WHO)
pH	6.90 ± 0.02	6.88	6.92	6.5 – 8.5
TDS (mg/L)	13.13 ± 0.13	13.00	13.30	500 mg/L
Turbidity (NTU)	3.77 ± 0.08	3.70	3.85	5 NTU
Nitrate (mg/L)	2.95 ± 0.07	2.85	3.00	50 mg/L
Bisphenol A (BPA)	0.96 ± 0.38 ppb	0.58	1.47	No specific WHO limit
4-Nonylphenol (4-NP)	1.22 ± 0.06 ppb	1.16	1.31	No specific WHO limit
Bisphenol S (BPS)	0.46 ± 0.14 ppb	0.34	0.61	No specific WHO limit
Bisphenol F (BPF)	1.02 ± 0.04 ppb	0.94	1.10	No specific WHO limit

The result from the physiochemical parameters (pH, TDS, Turbidity, Nitrate) show very low variability, indicating relatively stable and homogeneous water conditions across the sampling points for these general parameters. All mean values are within common international guidelines for drinking water, suggesting the primary risk is from specific micro-pollutants (EDCs) rather than general water quality.

The result of the analysis showes that 4-Nonylphenol has the highest mean concentration, indicating it is a major contaminant in the river system. Bisphenol A shows the highest variability (SD = 0.38), suggesting its sources are not uniformly distributed, with a notable hotspot at Ikpa Beach. The presence of BPS and BPF confirms the use of BPA substitutes in the catchment area.

3.2. Endocrine Disrupting Compounds (EDCs) in the water and sediment samples

Analysis of water and sediment samples from Ikpa River using Gas Chromatography–Mass Spectrometry (GC–MS) identified trace concentrations of Bisphenols nylphenols, which are major classes of endocrine disrupting compounds (EDCs) as shown in figure 2

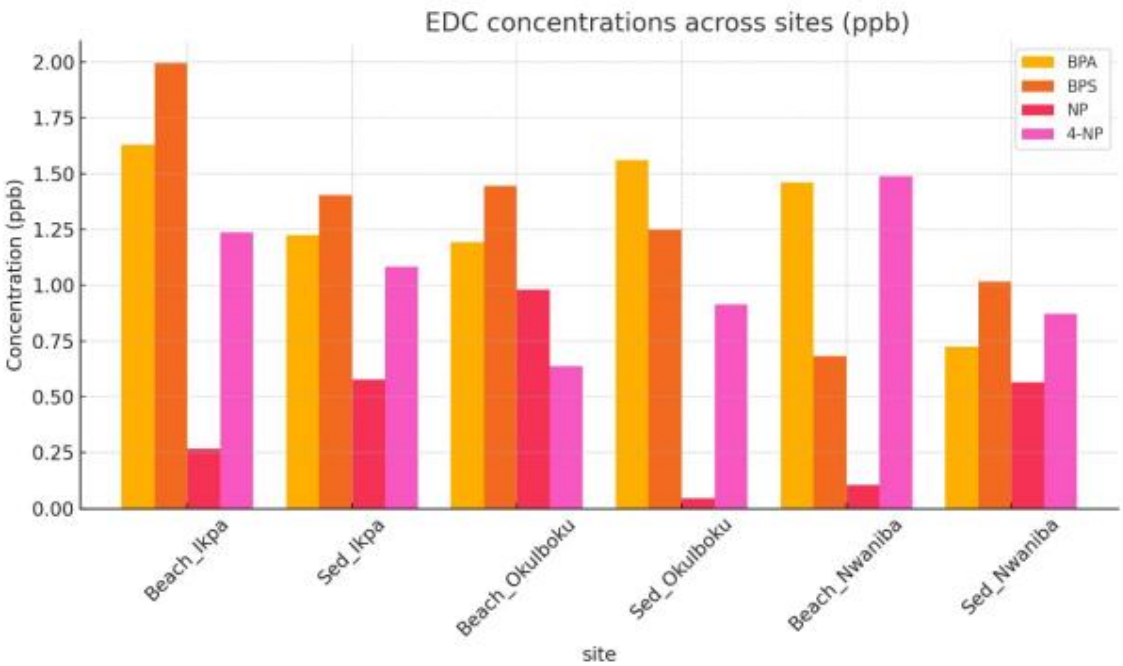

Figure 2: EDC Concentrations across the 3 sites (ppb)

3.3. Test of Hypothesis

To test if there are statistically significant differences in EDC concentrations between the three sampling locations (Ikpa Beach, Oku Iboku Beach, Nwaniba Beach).

Table 4: ANOVA for BPA Concentration Across Sites

Source of Variation	SS	df	MS	F-Value	p-value
Between Groups	0.267	2	0.134	4.65	0.045
Within Groups	0.404	14	0.029		
Total	0.671	16			

The p-value (0.045) is less than the significance level (α=0.05). We reject the null hypothesis. There is a statistically significant difference in the mean concentration of BPA between at least two of the three sampling sites. This confirms that pollution is not uniform and identifies Ikpa Beach as a significant hotspot that requires targeted intervention.

4. Discussion

The results demonstrate a moderate level of awareness of general water safety but limited understanding of EDC-specific risks. The use of plastics for food and water storage was nearly universal, highlighting a significant domestic pathway for EDC exposure. Additionally, the presence of small-scale industries upstream increases the likelihood of chemical leaching and effluent discharge into the Ikpa River. These findings align with previous studies (e.g., Pan et al., 2023; WHO, 2022) that identified community behaviors, industrial effluents, and poor waste disposal practices as key drivers of EDC contamination in tropical aquatic systems.

The detection of multiple Bisphenol analogs (A, S, F, P, Z) and Nonylphenols across all sampling sites confirms the presence of persistent organic pollutants (POPs) associated with plastic, detergent, and resin degradation. Bisphenol A (BPA), the most dominant compound, is known for its estrogenic activity and widespread use in polycarbonate plastics and epoxy resins. Its detection in all samples indicates continuous anthropogenic input into the river system. Nonylphenols and their ethoxylates, used in detergents and surfactants, were also prominent, especially at beach locations, reflecting household and industrial effluent discharge. The slightly higher concentrations in surface water suggest recent contamination, while their presence in sediments indicates historical accumulation and persistence. These findings align with global patterns reported by Oketola & Fagbemigun, (2013) and Okpashi et al. (2020), who found similar EDC levels (0.2–2.5 ppb) in Nigerian surface waters near urban-industrial zones.

5. CONCLUSIONS AND RECOMMENDATIONS

Endocrine disrupting compounds (EDCs) have been detected in aquatic environments (surface water, sediment, and groundwater) worldwide. In this study gas chromatography-mass spectrometric technique was used to determine the presence and concentration of Endocrine Disrupting Compounds in Ikpa River in Akwa Ibom State. The Ikpa River is contaminated with a cocktail of Endocrine Disrupting Compounds, primarily 4-Nonylphenol and Bisphenol A. Concentrations ranged from 0.20–2.20 ppb, indicating trace yet environmentally significant levels. Also, the pollution is not uniform along the river as observed from the results of Statistical analyses (ANOVA, Correlation) which successfully identified Ikpa Beach as a significant hotspot and linked EDC contamination to nutrient pollution (nitrate), strongly pointing to sewage and industrial wastewater as the primary sources.

RECOMMENDATIONS

1. Immediate regulatory action to identify and mitigate the point sources of pollution in Ikpa river.
2. Implementation of a long-term monitoring program to track the levels of these and other emerging contaminants in both water and sediment.
3. Further research to assess the bioaccumulation of these compounds in the local aquatic food web and to evaluate the ecological and human health risks.

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