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Health and Environmental Hazard of Plastic Waste in The Communities of Niger Delta

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ABSTRACT: *The purpose of this research was to investigate the possible adverse effects on human health that are caused by the presence of plastic rubbish in the villages that are situated in the Niger Delta area. The samples of water, fish, sediment, and human blood that were collected and analysed for their physico-chemical characteristics included temperature, pH, electrical conductivity, total dissolved solids, biochemical oxygen demand, dissolved oxygen, nitrate, and phosphate. Sulphate, nitrate, and sulphate were also determined to be present in the samples. In addition, the samples were analysed to determine whether or not they included any trace elements of metals such as lead, arsenic, cadmium, copper, chromium, and zinc. The samples were analysed for heavy metals using atomic absorption spectrometry (AAS). These techniques were used to determine the composition of the samples. Further research was conducted to develop ecological and human health risk indicators in order to evaluate the presence of heavy metals in water and fish. Statistical Package for the Social Sciences, Version 25.0, was used for the analysis of the data that was obtained. In order to evaluate the nature of the connections between the various variables, descriptive statistical measures such as percentage, mean, and standard deviation were used. In addition, inferential statistical approaches such as Analysis of Variance (ANOVA) and Turkey's Test were applied in order to ascertain the existence of this link within a confidence interval of 0.05. According to the results of the research, heavy metals were found in water, fish, and human blood, respectively. The degrees of contamination, cancer risk, hazard quotient, prospective contamination index, degree of contamination, and contamination factor were all significantly increased due to the presence of heavy metals in the fish and the water. As a result, it is very necessary to carry out regular monitoring in order to evaluate the impact that waste plastic is having on the aquatic resources and the human population in the vicinity of the Niger Delta. This will assist assess the current state of these environmental dangers and their impact on the health of the general people.*
KEYWORDS: Human, Health, Environment, Natural, Plastic.

INTRODUCTION

The name "plastic" has its origins in the Greek word "plastikos," which denotes suitability for the process of moulding. The term "malleability" or "plasticity" is commonly employed to describe the properties of these materials in the manufacturing process, allowing them to be moulded, pressed, or extruded into various forms such as films, fibres, plates, tubes, bottles, boxes, and so on (Olotahand Arts, 2020). These chemicals may be classified as synthetic organic polymers and are widely utilised across several industries worldwide. Plastic is extensively utilised in several domains of human existence, encompassing water bottles, apparel, food packaging, medicinal provisions, electrical devices, constructing components, and numerous more applications. According to Yermak (2019), plastics have a historical presence dating back to 1869, when John Hyatt developed the initial synthetic polymer as a replacement for ivory (Science History Institute, 2021). The initial instance of a mass-producible and entirely synthetic plastic material, known as Bakelite, was developed in 1907 by Leo Baekeland (Our World in Data, 2021). The material was promoted as possessing a wide range of applications, characterised by its exceptional durability, resistance to heat, and insulating qualities. Moreover, it shown an optimal compatibility with mass production techniques, resulting in reduced expenses and ample availability of resources. The introduction of this innovation sparked a significant research and development focus on synthetic polymers, generating considerable interest in their applications across several sectors. World War II had a significant impact on the development and utilisation of plastics. The necessity for synthetic replacements to limited natural resources has spurred a significant effort to explore all possible applications for plastics. Plastic has the advantage of being more cost-effective, less complex to manufacture, and more readily accessible in terms of sourcing raw resources. The invention of Nylon by Wallace Carothers in 1935 led to its use in a wide range of military supplies, including parachutes, ropes, helmet liners and other plastic applications such as plexiglass, which found utility in aeroplane windows (Science History Institute, 2021). Following the conclusion of the war, there was a significant increase in expenditure, leading to the proliferation of plastics across several industries. Plastics gradually replaced steel in automobile manufacturing, paper and glass in packaging, and wood in furniture production (Science History Institute, 2021). The majority of bottling and consumer goods companies have transitioned to using high-density polyethylene (HDPE) as the primary material for manufacturing milk jugs, juice bottles, children's toys, and several other commonly used items (Plastics Industry, 2021). The manufacturers and consumers were highly attracted to the cost-effectiveness and ease associated with the disposal of plastic materials. However, the initial enthusiasm surrounding plastics eventually waned. The observation of ocean pollution started in the 1960s, coinciding with the emergence of concerns over the hazardous nature of chemicals employed in plastic production. Plastic exhibits an exceptionally long lifespan throughout the environment. The substance in question does not undergo decomposition, breakdown, or natural reintegration into the environment. Plastics derived from hydrocarbon-based resources have been in existence for little more than a century. The post-World War II era witnessed a significant surge in the production and advancement of several plastic commodities, therefore catalysing a transformative impact on contemporary society to such an extent that the absence of plastics would render the present-day world unidentifiable. Plastics have had a profound impact on the field of medicine by introducing life-saving devices, enabling space exploration, reducing the weight of vehicles to conserve fuel and minimise pollution, and contributing to the preservation of lives through the development of helmets, incubators, and equipment for ensuring clean drinking water. However, it is important to acknowledge that the predominant focus of plastic production centres around the disposable nature of these materials, as highlighte

Plastic garbage has emerged as a formidable challenge in developing countries, with its proliferation evident in the form of litter on streets, waterways, and various public spaces such as parks and roadways. Additionally, they give rise to environmental concerns, provide hurdles to socio-economic development, and have an influence on biodiversity, infrastructure, tourism, and fishery livelihoods (Jambecket al., 2018). Plastics have emerged as a burgeoning commodity of significant economic importance in Nigeria. According to Okoro et al. (2020), it is a by-product derived from the process of petroleum refining. Polyethylene terephthalate (PET) finds extensive application in the manufacturing of various household appliances, cooking utensils, packaging materials, garbage bins, water bottles, as well as in the fabrication of some components for electronic devices (Yermak, 2019).The escalating presence of plastic in several environmental compartments in Nigeria can be attributed to inadequate legislation governing the disposal of plastic waste, indiscriminate dumping practises, and inappropriate management of plastic products and trash. In the Nigerian context, it has been seen that these compounds are being introduced into our aquatic ecosystems, deposited in sedimentary layers, and emitted into the atmosphere, occasionally through uncontrolled combustion, in the form of nanoplastics (Chen et al., 2020). It is evident that plastics possess non-biodegradable properties, leading to their potential bioaccumulation within the tissues of organisms and the surrounding environment, thereby resulting in detrimental consequences (Owamah et al., 2017; Zabbey et al., 2021). These factors ultimately lead to the exposure of individuals through skin contact, ingestion, and inhalation, thereby resulting in environmental pollution and posing diverse health hazards to the communities residing in the Niger Delta region. Plastics are considered essential due to its advantageous properties such as lightweight, flexibility, affordability, and durability, resulting in a significant global output of more than 360 million tonnes in 2018 (Plastics Europe, 2018). Microplastics are commonly defined as plastic particles that have a size of less than 5 mm (Arthur et al., 2009). The existence of microplastics in the environment has been documented as early as the 1970s (Carpenter, 2002), and subsequent research has consistently demonstrated their widespread occurrence. The majority of research has mostly concentrated on the examination of microplastics in marine environments, whereas a small proportion, less than 4% of published studies, have addressed the presence of microplastics in freshwater systems (Lambert and Wagner, 2018). Microplastics are introduced into freshwater ecosystems through multiple pathways, such as the release of domestic wastewater (Murphy, 2016), the utilisation of sludge derived from wastewater treatment plants in agricultural practises (Nizzetto et al., 2016), the leaching of landfills, the runoff from surfaces (with limited knowledge on the transportation mechanism), and the deposition from the atmosphere (Dris, 2016).Nevertheless, the presence of microplastic pollution has a detrimental impact on several aspects such as water quality, sediment composition, and the overall well-being of aquatic organisms. Boris (2017) asserts that the presence of micro- and nanoplastics in aquatic ecosystems emerged within the previous century, and these particles exhibit distinct attributes that have the potential to impact fish in many manners. The bulk of plastic production involves the inclusion of various additives, resulting in plastic products that are not solely constituted of plastic polymers. Various additives may be found in materials, such as reinforcing fibres, fillers, coupling agents, plasticizers, colourants, stabilisers (including halogen stabilisers, antioxidants, UV absorbers, and biological preservatives), lubricants, and flame-retardants. It is possible for these additives to leak out when consumed. The potential impact of these substances on fish may be detrimental. Moreover, once entering an aquatic habitat, microplastics demonstrate a high degree of efficacy in the adsorption of persistent organic pollutants that are already present in the water. When a fish ingests a microplastic particle, it concurrently ingests the toxicant. There is evidence to suggest that some chemicals have the potential to cause direct harm to fish when they are ingested. Furthermore, these chemicals may also be transported and accumulated along a food chain, as shown by studies conducted by Oliveira et al. (2013), Koelmans (2015), and Batel et al. (2016). Nevertheless, it is important to note that the potential danger posed by consuming microplastics that are contaminated may not necessarily exceed the risk associated with consuming natural prey that is also contaminated (Koelmans et al., 2016). This is due to the fact that the concentration of toxic substances linked to microplastics is significantly lower compared to the concentration already present in the prey item, either through absorption or adsorption. Moreover, it is improbable that the ingestion of microplastics will lead to an increase in exposure (and subsequently risk) to fish, particularly when considering hydrophobic organic toxicants linked with microplastics. The information presented in this statement is derived from a study conducted by Koelmans et al. (2016), which focuses on the transfer rate of hydrophobic organic compounds from microplastics to organisms, the rates of desorption mimicked in artificial gut fluids, and the possibility for bioaccumulation. However, despite being improbable, it is plausible that additional substances, including metals, which are linked to microplastics, might potentially have an accumulative impact when consumed by fish, hence increasing the related danger.Phthalates are compounds that are widely present and generated in significant quantities, mostly serving as plasticizers in various consumer goods. The extensive utilisation and prevalence of phthalates have generated great apprehension regarding their impact on human health. Numerous studies have demonstrated a correlation between exposure to phthalates and the development of numerous illnesses, with reproductive problems being particularly noteworthy. According to the study conducted by Benjamin et al. in 2017, it was found that... There exists a global phenomenon characterised by a rising prevalence of reproductive problems, including hormone-dependent malignancies, infertility, and diminished fecundity. According to data from 2015, a notable proportion of couples globally, ranging from 8% to 12%, experienced infertility or a reduction in their ability to conceive. According to a study conducted by Kumar et al. in 2015, it was shown that 6.7% of females had infertility (CDC, 2019). The observed decline in sperm concentration among males during the past five decades, amounting to a reduction of 32.5%, has been a notable phenomenon. Environmental pollutants, including phthalates, have been identified as a potential contributing factor to the prevalence of contemporary reproductive problems (Sengupt et al., 2018).The Niger Delta region is considered the focal point for oil and gas development in Nigeria due to its significant reserves of crude oil (Atubi, 2015; Chikere and Fenibo, 2018). The Niger Delta has been identified as the third biggest mangrove forest globally, as supported by Anejionu et al. (2015) and Kuenzer et al. (2014). The Niger Delta is characterised by its fan-shaped landmass, spanning around 70,000 km2. The location of the area is in the southern part of Nigeria. The region consists of two major rivers, namely the Benue River and the Niger River, which mostly discharge their waters into the Atlantic Ocean. The biological characteristics of the area are defined by the presence of a substantial floodplain resulting from the deposition and buildup of sediments carried downstream by the Benue and Niger rivers (Ayanlade, 2012). The Niger Delta region encompasses a coastal stretch spanning around 450 km, as documented by Awosika in 1995. According to the United Nations Development Programme (UNDP, 2006), the region is home to an approximate population of about 30 million individuals. According to Chinweze and Abiola-Oloke (2009), the wetland in question is not only the biggest in Africa, but also ranks among the largest globally. The Niger Delta area, which comprises the states of Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Ondo, Imo, and Rivers, serves as the primary centre for oil production in Nigeria (Otu & Oloidi, 2018). The geographical area under question encompasses around 7.5% of Nigeria's overall land area. According to Ordinioha and Brisibe (2013), the region under consideration encompasses nine southern states of Nigeria and has a total of 186 Local Government Areas, with a population over 25 million individuals. The region in question is widely recognised as being among the most ecologically damaged areas globally, mostly due to extensive oil and gas development activities. According to the findings of Kuenzer et al. (2014), the primary concern for the Niger Delta region and its residents revolves around the detrimental impact of hydrocarbon pollution.

Aim of the Study

This research work is aimed at examining the health and environmental hazard of plastic waste in the communities of Niger Delta, Nigeria.

Objectives of the Study

The specific objectives of the study are to:

1 Assess the contamination of food and drinks (fish and water) by plastics (microplastics and phthalates) in Niger Delta communities.
2 Evaluate the importance of these contaminations to the public health of the Niger Delta communities.

MATERIALS AND METHODS

Experimental/Sampling Design

The research is an exposure research and a quantitative research. A total of four sampling stations in Port Harcourt, Niger Delta communities were used in the study.

Duration of the Study: This research was carried for six months, between January 2022 and June, 2022. Samples were collected once on monthly basis.

Data collection

Before commencing the sample process, a preliminary survey was undertaken at several study locations. The preliminary sample was carried out during the scouting visit with the purpose of acquainting ourselves with field methodology, familiarising ourselves with the sampling stations and equipment, and, of utmost importance, reducing any potential errors in sampling and handling. The process of collecting water samples was carried out for a duration of 6 months, adhering to the established methods specified by APHA (2005). The geographical coordinates of the sample sites were determined in situ using portable GPS technology, namely the Garmin Extrex device. The GPS device was initialised at each station and allowed a duration of around 2-3 minutes to achieve a level of stability. The measurements were subsequently acquired from the device and recorded in accordance with the study done by Wokoma and Njoku in 2017.

Water sampling

The sampling of surface water and sediment was carried out following a previously established approach, with some modifications included (Changbo et al., 2018). In order to conduct surface water sampling, a total volume of thirty litres of water samples were collected from the uppermost layer, namely within the depth interval of 0 to 30 cm. The data collection was conducted utilising a well cleaned big flow sampler prior to the commencement of the study. The collected water was subjected to filtration using a stainless steel sieve with a pore diameter of 45 µm. The sediments that were found on the sieve were carefully rinsed into a glass container with a volume of 1 litre, using water that had been deionized. The selection of a preservation solution comprised of a 5% formalin concentration was made for this specific objective. At each sampling location, three replicate samples were collected. In order to decrease the risk of cross-contamination, the sampler and stainless sieve were thoroughly cleaned using deionized water throughout each sampling interval.

Isolation of Microplastics

In order to minimise the impact of organisms and sediments on the acquired samples, a methodology was implemented to separate the microplastics from the gathered specimens. The pre-processing of samples was carried out with a methodology recommended by the National Oceanic and Atmospheric Administration (NOAA, 2018), but with some modifications. During the treatment of the surface water samples, a solution of hydrogen peroxide with a concentration of 30% (v/v) was utilised to eradicate visible organisms that were present in the samples. The catalyst used in this experiment was a solution of ferrous sulphate. The density separation procedure involved the use of a zinc chloride solution with a density of 1.5 g/cm3 to selectively remove sand and minerals from the samples. In this study, a basic density separator was utilised. A metallic frame made of iron, together with a corresponding iron ring, was placed on the laboratory bench. A glass funnel was attached to a latex tube at the lower end of its stem. Furthermore, the implementation of a pinch clamp will be employed to control the liquid flow originating from the glass funnel. The supernatants were acquired by the use of a density separator and afterwards filtered using a GF/C filter with a particle size of 0.22 μm (Membrane Solutions LLC., Kent, WA, USA). In light of the possibility of filter curling during the process of natural air drying, it is regarded essential to utilise an alternate approach. As a result, all filters will undergo a drying process in an oven, which will be maintained at a temperature of 60°C.

Observation and Identification of Microplastics

The filters that underwent treatment were meticulously placed into a well sterilised Petri plate to enhance subsequent examination. The Petri dishes were placed underneath a stereomicroscope that was coupled with a digital camera in order to facilitate examination. The identification of particles that were thought to be present was predicated upon their morphological characteristics. The procedure of identification was dependent on the categorisation criteria that were created in previous study studies (Blumenröder et al., 2017; Yu et al., 2018; Di et al., 2017). The researchers recorded the many attributes of the microplastics, encompassing their quantity, dimensions, morphology, and chromaticity. The microplastics were categorised into four discrete categories according to their size: A1 (<0.5 mm), A2 (0.5–1 mm), A3 (1–3 mm), and A4 (3–5 mm). Previous studies (Baldwin et al., 2016; Zhang et al., 2017) conducted the classification of microplastics into four separate categories based on their physical characteristics. The aforementioned classifications encompass fibre, fragment, pellet, and film. In adherence to established academic norms, it is common to designate an elongated and thin structure with a narrow form as a "fibre." Fragments, however, are inflexible residues that originate from a split plastic item. Debris characterised by a thin coating is frequently denoted as "film." According to Changbo et al. (2018), microplastics that exhibit spherical and cylindrical shapes are frequently referred to as "pellets". After the conclusion of the microscopic examination, the microplastics that were detected were subjected to identification using a spectroscope. The laser's wavelength utilised in the experiment was set to 532 nm, as documented by Wang et al. (2018) and Zhang et al. (2016). The Raman spectra seen in this study spanned a range of 50 to 3500 cm^{-1}. The quantification of microplastic content in water and sediment is conducted using measures of items per cubic metre (items/m^3) and items per kilogramme (items/kg), respectively (Changbo et al., 2018).

Sample Collection

During the time spanning from January to April 2022, fishermen were recruited to gather fish samples by employing fishing netts from their boats. The identification and documentation of several fish species were conducted using the approach described in Udodo-Umeh's (2003) study. The study involved the collection of a comprehensive sample of fish, consisting of more than 500 individuals from various species. Each pooled fish sample comprised 2-5 individual fish samples that had the same species classification. The samples that were gathered were classified into three unique groups based on the specific habitat of the fish: benthic, pelagic, and migratory. The fish samples were wrapped in aluminium foil and stored in a portable cooler box, maintaining a temperature range of 0–4 °C. Following this, the collected samples were expeditiously conveyed to the laboratory and subjected to freezing at a temperature of -20 °C, as described by Lu et al. (2021). The measurements and documentation of fish data, including length, weight, and sex, were conducted prior to the dissection and grinding procedures. The musculature and organs of the fish were removed from the skeletal structure using a stainless-steel device, and afterwards homogenised in a blender. A amount above 30 grammes of homogenate was retained for the purpose of measuring microplastics. Subsequently, the collected samples were treated to freeze-drying and subsequently stored at a temperature of -20 °C until they were subjected to chemical analysis, as described (Lu et al. 2021).

Extraction, Cleanup, and Analysis of Phthalates

The phthalate standards, which had a purity level above 99.0%, were obtained from Supelco/Sigma-Aldrich Co., situated in St. Louis, MO, USA. In this investigation, the surrogate standard employed was Dibenzyl phthalate, whereas the isotope internal standards, such as DEHP-d4, were obtained from Cambridge Isotope Laboratories. The chemicals ethyl acetate, methanol, dichloromethane, acetonitrile, n-hexane, and acetone were obtained from Merck, a company based in Darmstadt, Germany. During the course of this experiment, a combination was formed by mixing 1 gramme of desiccated fish powder with 10 microliters of an internal standard solution that was marked and possessed a concentration of 1 part per million (ppm). Subsequently, the concoction was amalgamated with a solution of 20 millilitres of a solvent mixture composed of methanol and dichloromethane, within a centrifuge tube having a capacity of 50 millilitres. The tube was immersed in an ultrasonicator bath and exposed to sonication for a period of 30 minutes. The aqueous phase was collected, and the extraction process was repeated. The volume of the sample was decreased to 2 mL and afterwards mixed with a 10 mL solution of hexane and acetone in a 4:1 (v/v) ratio. The combination was subsequently treated to solid phase extraction (SPE) utilising a HyperSepTM Florisil cartridge (6 mL, 1000 mg, ThermoFisher SCIENTIFIC, Waltham, MA, USA) following the methodology outlined by Lu et al. in 2021. Subsequently, the eluate underwent concentration by the use of a nitrogen stream till it attained a condition of approximate dryness. then, the residue obtained was reconstituted in 1 mL of methanol, resulting in the production of eluted solutions that were then used for analysis. The eluate underwent analysed with triple-quadrupole liquid chromatography-tandem mass spectrometry (LC/MS-MS) employing an Acquity UPLC/Waters Xevo TQ-S Micro equipment (Waters, Milford, MA, USA). The study was conducted using a reversed-phase C18 high-performance liquid chromatography (HPLC) column, namely the Waters XBridge C18 column with a particle size of 3.5 μm and dimensions of 2.1 mm (inner diameter) by 10 cm (length). Before introducing a 20 μL extract into a sample loop, the eluate was subjected to filtration using a 0.45 µm polytetrafluoroethylene membrane. The quality assurance and control (QA/QC) procedures will conform to the methodology suggested by the TFDA. These processes will include the use of solvent and sample blanks, determination of limits of detection, measurement of recovery rates, and evaluation of the signal-to-noise ratio. The levels of several phthalates, such as benzyl phthalate (BBP), diisobutyl phthalate (DIBP), di-iso-nonyl phthalate (DINP), di-n-octyl phthalate (DNOP), dimethyl phthalate (DMP), and DEP, were quantified in nanograms per gramme of dry weight (ng/g d.w.). The concentrations of BBP, DIBP, DINP, DNOP, DMP, and DEP were determined to be 20 ng/g dry weight (d.w.), 60 ng/g d.w., 5 ng/g d.w., 30 ng/g d.w., and 5 ng/g d.w., respectively. A total of ten samples were exposed to blank tests as well as spike testing. Lu et al. (2021) reported the recovery rates of several phthalates.

Quantitative Analysis of Microplastics (MPs)
The present investigation employed the qualitative screening approach for microplastics (MPs) based on the standard method (NIEA M907.00B) developed by the Environmental Protection Administration in Taiwan (TEPA), with certain adjustments incorporated. The study utilised filter sizes to measure the range of diameters seen in the microplastics under enquiry, which ranged from 5 mm to 50 µm. The filters utilised in this study underwent weighing after being conditioned, and the experiment was carried out inside the boundaries of a type II laminar flow bench. The fish samples, with a wet weight of 30 g, will be introduced into a 250 mL flask in order to achieve complete homogenization with 20 mL of n-hexane. Following this, the combination will be left undisturbed for a period of one hour, in order to facilitate the extraction of the lipid component. The aforementioned procedure shall be iterated thrice in order to guarantee precision and dependability. A flask was inserted to a solution of 150 mL of potassium hydroxide (KOH) with a concentration of 10%, and the contents were well stirred. Following this, the combination underwent incubation at a temperature of 60 °C for a period of 24 hours. Based on the research done by Lu et al. (2021),... After undergoing a 24-hour period of vortexing, the solution was allowed to rest for 1 hour before precipitation occurred. The liquid component underwent filtering using filters with pore diameters measuring 5 mm and 50 µm, respectively. Subsequently, the remaining substance was placed to a beaker with a capacity of 1 litre. After introducing a 500 mL saturated salt solution into the beaker, the solution was subjected to agitation for a period of 10 minutes. Following this, a period of waiting for one hour occurred, after which the liquid portion was filtered using filters with particle diameters of 5 millimetres and 50 micrometres. A 500 mL solution containing sodium tungstate (Na2WO4) at its saturation point was carefully poured into the beaker and well stirred. Following the aforementioned procedure, a designated interval of 60 minutes was implemented as a waiting time. Subsequently, the supernatants underwent filtering utilising filters possessing pore diameters of 5 millimetres and 50 micrometres, respectively. The filters were gathered for the purpose of undergoing a process of drying and conditioning. Fourier Transform Infrared Spectrometry (FT-IR) was employed to confirm the presence of dried plastic particles that were attached to the filter. Following that, the non-microplastic impurities were removed using a needle while seeing them under optical microscope before quantifying them based

on their weight. The mass of the dehydrated microplastics (MPs) was assessed both prior to and afterwards to the filtration procedure. Chang and colleagues (2010).

Assessment of Human Health Impacts of Microplastics and Phthalates via the Fish in the Study Area

The assessment of health risks posed by phthalates in the human population within the research region was conducted by the examination of fish consumption from said area. The fish harvested from these regions are predominantly consumed within the immediate vicinity, primarily because these five rivers are situated in the heavily populated Niger Delta. The research region conducted an assessment of the health hazards linked to the consumption of phthalates. This evaluation utilised many indices, including daily intake, chronic daily intake, hazard quotient, and cancer risk. These indices were employed to determine the potential health effects resulting from long-term exposure to these pollutants.

Statistical Analysis

The statistical analysis was performed utilising the Statistical Package for Social Science (SPSS), Version 25.0. Descriptive statistical measures, namely the mean and standard deviation, were utilised to ascertain the average levels of plastic pollutants. The study employed inferential statistics, especially analysis of variance (ANOVA), with a significance threshold set at 0.05. The statistical analysis employed the Tukey test to determine the significance of the observed differences between the groups, with the aim of calculating the mean separation.

Quality Assurance and Quality Control

This study employed several measures to minimise the potential for background contamination during both the sample collection and laboratory processing phases. During the whole duration of the experimental procedures, the researchers wore cotton laboratory coats and nitrile gloves. Before use, all containers and experimental apparatus underwent a comprehensive cleansing procedure, which entailed three cycles of washing with ultrapure water. Furthermore, during periods of non-utilization, these objects were suitably shielded with aluminium foil. Changbo et al. (2018) conducted a series of four tests with the aim of examining possible contamination. The experiments encompassed the use of parallel processing techniques for both the samples and the background contamination levels originating from the laboratory. Nevertheless, a precise quantity of thirty litres of distilled water was meticulously filtered using a GF/C filter. Following this, the aforementioned filters were introduced into the laboratory setting, where they were left exposed for a period of 72 hours. After a duration of 72 hours, the filters were subjected to examination under a stereomicroscope to ascertain the existence or non-existence of microplastics and phthalates. The absence of microplastic present in the study shows that the researchers may have failed to consider the potential background contamination.

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RESULTS

Impact of Plastics on the Physicochemical Parameters of Surface Water from Selected Rivers (Iwofe, Aleto, Bonny and Woji) in Port Harcourt

The results of this study suggest that the physicochemical properties of surface water were influenced by the presence of plastic waste at many sampling locations. The levels of dissolved oxygen (DO) exhibited variability, ranging from 4.50±0.40mg/L to 5.47±0.29mg/L, in the Iwofe and Bonny/Nembe River, respectively. The experiment yielded no statistically significant fluctuation in the level of dissolved oxygen (DO).

The levels of sulphate in the Iwofe and Bonny/Nembe Rivers exhibited a range of concentrations, specifically ranging from 19.45±9.58mg/L to 23.30±2.31mg/L, respectively. The study found a significant discrepancy in the concentration of sulphate. The Bonny/Nembe and Aleto Rivers demonstrated a biochemical oxygen demand (BOD) ranging from 2.33±2.31mg/L to 5.67±4.56mg/L, respectively. The experiment yielded no statistically significant fluctuation in the level of dissolved oxygen (DO). The levels of phosphate in the Iwofe and Aleto Rivers exhibited a range of 3.09±5.31mg/L to 8.09±13.89mg/L, respectively. The analysis yielded no statistically significant differences in the levels of phosphate content. The study revealed that the levels of nitrate concentrations in the Aleto and Bonny/Nembe rivers exhibited a range of 9.87±16.22mg/L to 18.87±16.17mg/L, respectively. The research yielded no statistically significant differences in the nitrate content.

Table 1: Impact of Plastics on the Physicochemical Parameters of Surface Water from Selected Rivers (Iwofe, Aleto, Bonny and Woji) in Port Harcourt

Parameter	Standard	Iwofe River	Aleto River	Bonny/Nembe River	Woji River	P-value
DO (mg/L)	5-10	4.50±0.40	4.50±0.87	5.47±0.29	4.67±1.33	.536
Sulphate (mg/L)	200	19.45±9.58	22.38±13.20	23.30±2.31	21.20±0.001	.003
BOD (mg/L)	3-6	2.83±2.02	5.67±4.56	2.33±2.31	2.60±0.50	.607
Phosphate (mg/L)	5	3.09±5.31	8.09±13.89	3.87±3.33	8.02±6.92	.822
Nitrate (mg/L)	50	10.09±17.33	9.87±16.22	18.87±16.17	17.77±15.13	.848

Impact of Plastic Wastes on Heavy Metals in Fish from Aquatic Ecosystems in Port Harcourt
The study included the collection of several fish species from a variety of aquatic habitats. These fish included crayfish (Paeneus monodon), crabs (Callinectes sp.), electric eels (Electrophorus electricus), tilapia (Tilapia guinensis), and bonga shad (Ethmalosa fimbriata). According to the findings of the test that was carried out on the fish specimens, the levels of lead (Pb) in T. guinensis and C. amniocola ranged from 0.6330.025mg/kg to 1.3430.169mg/kg. This information was gleaned from the results of the examination. During the course of the study, the amounts of lead that were discovered in the various fish samples that were analysed revealed a substantial disparity. In E. fimbriata, the concentration of cadmium (Cd) showed a variety of values, ranging from 0.0010.000 mg/kg to 0.1230.007 mg/kg. These results represent a range of values. Cd was found in concentrations ranging from 0.123 0.007 mg/kg to 0.251 0.026 mg/kg in E. electricus. The amount of chromium (Cr) that was found in the species E. fimbriata and P. monodon showed a wide range of values, which went from 0.0010.000mg/kg to 1.2660.040mg/kg. These values ranged from very low to very high. The results that were reported for P. monodon and T. guinensis fell anywhere between 1.266 and 1.995 mg/kg, with a standard deviation of 0.040 mg/kg. The levels of arsenic that were discovered in the various kinds of fish that were put to the test showed a wide range of values. It was discovered that the total amount of mercury (Hg) that was detected in all of the fish specimens that were analysed was less than 0.001 mg/kg. The levels of mercury that were found in the various fish samples that were analysed showed a high degree of variation from one another.

Heavy Metals Pollution Index
The results of the heavy metals pollution index showed that the values of HPI were 0.19, 0, 0.06, 0.05, 0.04 in *P. monodon, C. sp., E. electricus, T. guinensis,* and *E. fimbriata* respectively.

Table 2: Heavy Metals Pollution Index (MPI) in Fish from Aquatic Ecosystems in Port Harcourt

Cray Fish (*Paeneus monodon*)	Crab (*Callinectes sp.)*	Electric eel (*Electrophorus electricus*)	Tilapia (*Tilapia guinensis*)	Bonga Shad (*Ethmalosa fimbriata*)
0.1906	0	0.0604	0.0482	0.0403

Estimated Daily Intake (EDI) in (mg/day/person) of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State
According to the findings of the research project that looked into the estimated daily intake (EDI) of heavy metals in various fish species, the EDI values for lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg) in C. sp were measured as 0.44 mg/day/person, 0.06 mg/day/person, 0.00 mg/day/person, and 0.40 mg/day/person, respectively. The EDI values for the elements lead, cadmium, chromium, and mercury for the species E. electricus were as follows:

0.38 mg/day/person for lead; 0.08 mg/day/person for cadmium; 0.00 mg/day/person for mercury; 0.45 mg/day/person for mercury; and 0.00 mg/day/person for mercury. T. guinensis was used in the study to calculate the estimated daily intake (EDI) values of lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg). A computation was carried out to obtain these values. According to the findings, the EDI values for each of these components are as follows: 0.26 mg/day/person; 0.05 mg/day/person; 0.00 mg/day/person; 0.00 mg/day/person; and 0.00 mg/day/person. In E. fimbriata, the EDI values for lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg) were found to be 0.21 mg/day/person, 0.04 mg/day/person, 0.44 mg/day/person, and 0.00 mg/day/person, respectively. However, the EDI values for mercury (Hg) were found to be 0.00 mg/day/person. According to the findings of the study, the estimated daily intake (EDI) of lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg) in P. monodon was determined to be 0.30 mg/day/person, 0.06 mg/day/person, 0.01 mg/day/person, 0.00 mg/day/person, and 0.00 mg/day/person, respectively. The estimated daily intake (EDI) for lead (Pb) revealed a considerable rise in all of the fish specimens that were examined, which suggests that lead contamination is present across the whole fish population. In compared to other species of fish, which had relatively lower values of the Environmental Diversity Index (EDI), the E. electricus species was shown to have a considerably higher degree of environmental diversity, as measured by the EDI. Estimated Daily Intake (EDI) levels for chromium (Cr) and mercury (Hg) were found to be higher in every species of fish that was examined. According to the data that was presented, the EDI values of the fish were much higher in comparison to the EDIs that came before them.

Table 3: Estimated Daily Intake (EDI) in (mg/day/person) of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State

Metals	Crab (*Paeneus monodon*),	Electric eel (*Electrophorus electricus*),	Tilapia (*Tilapia guinensis*)	Bonga Shad (*Ethmalosa fimbriata*)	Crayfish Cray Fish (*Paeneus monodon*),	References
Pb	0.44	0.38	0.26	0.21	0.30	0.21 (JECFA, 2009)
Cd	0.06	0.08	0.05	0.04	0.06	0.06 (JECFA, 2009)
Cr	0.00	0.00	0.00	0.00	0.01	0.20 (RDA, 1989)
As	0.40	0.45	0.65	0.44	0.41	0.13 (JECFA, 2009)
Hg	0.00	0.00	0.00	0.00	0.00	0.03 (JECFA, 2009)

Total Hazard Quotient of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State

The results of the hazard quotient (HQ) of heavy metals in the various fish species examined reveal that in C. amniocola, the HQ values for heavy metals Pb, Cd, Cr, As, and Hg were found to be 0.0109, 0.0063, 1.3E-07, 0.0134, and 0.0001, respectively. The levels of lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg) in E. electricus were quantified as 0.0095, 0.0082, 4.33E-07, 0.0149, and 0.0001, correspondingly. The measured HQ values in T. guinensis were 0.0065, 0.0053, 2.17E-08, 0.0149, and 0.0001. The HQ (Hazard Quotient) values for E. fimbriata were found to be 0.0051, 0.0040, 2.17E-08, 0.0147, and 0.0001. The reported values of HQ in P. monodon were 0.0074, 0.0056, 867E-07, 0.0137, and 0.0001. The levels of risk associated with many metals were shown to be negligible, except for arsenic. In the investigation, it was shown that Mercury (Hg) had the least concentration of hazardous quotient (HQ) compared to the other compounds that were investigated.

Table 4: Total Hazard Quotient of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State

Metals	Crab (*Callinectes amniocola*),	Electric eel (*Electrophorus electricus*),	Tilapia (*Tilapia guinensis*)	Bonga Shad (*Ethmalosa fimbriata*)	Crayfish Cray Fish (*Paeneus monodon*),	References
Pb	0.0109	0.0095	0.0065	0.0051	0.0074	
Cd	0.0063	0.0082	0.0053	0.0040	0.0056	
Cr	1.3E-07	4.33E-07	2.17E-08	2.17E-08	867E-07	
As	0.0134	0.0149	0.0216	0.0147	0.0137	
Hg	0.0001	0.0001	0.0001	0.0001	0.0001	

Cancer Risk (CR) of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State

According to the findings of this research, the species of fish that were investigated, notably P. monodon, exhibited varying degrees of cancer susceptibility that were connected to their exposure to heavy metals. It was determined that the cancer risk estimations for lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg) were, respectively, 6.699E-07, 8.9096E-06, 1.7267E-06, and 2.59E-10. According to the findings of the research, the likelihood of developing cancer as a result of exposure to the elements Pb, Cd, Cr, As, and Hg in C. amniocola was estimated to be 9.86E-07, 1E-05, 2.59E-07, 0.00016, and 2.59E-10, respectively. According to the findings of the research, the cancer risk posed by the elements Pb, Cd, Cr, and As in E. electricus is, in descending order, 8.53E-07, 1.3E-05, 8.63E-08, and 0.000178, and 2.59-10 respectively. In T. guinensis, the cancer risk associated with the elements lead (Pb), cadmium (Cd), chromium (Cr), and arsenic (As), as well as mercury (Hg), was found to be, respectively, 5.87E-07, 8.44E-06, 4.32-08, and 0.00025, while the risk associated with mercury (Hg) was 2.59E-10. According to the findings of the research, the likelihood of developing cancer from exposure to the elements Pb, Cd, Cr, and As in E. fimbriata was calculated to be 4.65E-07, 6.37E-06, 4.32E-08, and 0.000176, and 2.59E-10, respectively. In addition, it was found that the metals identified as having a greater tendency to promote cancer in human populations that consume the seafood species that were investigated for this study were lead (Pb) in E. electricus, C. amniocola, and P. monodon. These species were consumed for the purpose of this research. In addition, it was shown that the element Cd followed the same pattern, particularly in the species P. monodon, T. guineensis, and E. fimbriata. In contrast, the element chromium shown a greater tendency for carcinogenicity throughout the course of a lifetime exposure that spanned 70 years (356 days), with E. electricus displaying significant levels of CR.

Table 5: Cancer Risk (CR) of Heavy Metals in Fishes from Selected Rivers in Port Harcourt, Rivers State

Metals	Crayfish (*Paeneus monodon*)	Crab (*Callinectes amniocola*)	Electric eel (*Electrophorus electricus*)	Tilapia (*Tilapia guinensis*)	Bonga Shad (*Ethmalosa fimbriata*)
Pb	6.699E-07	9.86E-07	8.53E-07	5.87E-07	4.65E-07
Cd	8.9096E-06	1E-05	1.3E-05	8.44E-06	6.37E-06
Cr	1.7267E-06	2.59E-07	8.63E-08	4.32E-08	4.32E-08
As	0.00016395	0.00016	0.000178	0.00025	0.000176
Hg	2.59E-10	2.59E-10	2.59E-10	2.59E-10	2.59E-10

DISCUSSION OF RESULTS

Impact of Plastic Wastes on Surface Water in the Niger Delta

Water is sometimes considered to be an invaluable natural resource that is easily accessible to humankind. This is because water plays a critical part in ensuring the continued survival of all forms of life on Earth. In light of the information presented above, it is of the utmost importance to provide a sufficient and dependable supply of water, since this is one of the most important prerequisites for considerable socioeconomic growth within any given civilization (Algaon-odot et al., 2012). Plastic debris dumped into rivers like the ones under investigation has the potential to contaminate the water in those rivers. The unrestricted discharge of plastic garbage into these rivers, whether it be via direct or indirect ways, without sufficient treatment, has the potential to have negative repercussions for the plant and animal life that resides in these aquatic ecosystems, as well as for the organisms that rely on them.

Cadmium (mg/L)

The concentration of cadmium (Cd) was found to vary anywhere from 2.23 to 1.87 milligrammes per kilogramme in the Bonny/Nembe River and from 20.75 to 17.97 milligrammes per kilogramme in the Woji River, respectively. The findings of the investigation did not reveal any changes in the concentration of cadmium that were statistically significant. The amounts of cadmium (Cd) that were found in this research exceeded the suggested limits of 0.01mg/L and 0.05mg/L, which were provided by the World Health Organisation (2011) and the Environmental Protection Agency (2022), respectively. These standards were established to protect human health. The influence of various human activities in the region, with a particular focus on the oil and gas sector, may be traced to the observed event, and this can be done by using the chain of causation method. The amounts of lead that were found in this research were higher than the limits that were suggested by the Environmental Protection Agency (EPA) in 2022 and the World Health Organisation (WHO) in 2011, respectively. Those limits were 0.010 and 0.015 mg/L. It was established that the cadmium (Cd) contents that were detected in this investigation were higher above the threshold of 0.01mg/L. This level was published by the Federal Ministry of Transportation in the Draught Report of the Proposed Deep Sea Port Project at Bonny LGA., Rivers State (2020). In addition, the Cd content of 0.003mg/L for surface water that was recorded in the SHELL SPDC Environmental Impact Assessment of Bonny Deep Exploration Appraisal Wells Project (2019) was surpassed. This finding was made public by the Bonny Deep Exploration Appraisal Wells Project. The fact that the level of Cd that was found in this research was higher than the cutoff of 0.005 mg/L that was advised by the Environmental Protection Agency (EPA, 2006) indicates that there may be an association between Cd and renal impairment. Researchers Ejelonu et al. (2011) and Dami et al. (2012) performed independent studies that provided data revealing a noticeable link between the presence of heavy metals in drinking water and the prevalence of chronic illnesses such as renal failure, liver cirrhosis, anaemia, and hair loss. The findings indicated that the presence of heavy metals in drinking water was significantly associated with the frequency of these diseases. It has been shown that the presence of heavy metal contaminants, in particular lead (Pb) and cadmium (Cd), is linked to an increased risk of renal failure. Copper (Cu) and molybdenum (Mo) levels in the human body have been proven to have a positive correlation with liver cirrhosis. This link has been proved to be causal. In addition, the presence of nickel and chromium in drinking water (Ni/Cr) has been linked to the development of alopecia, and the pollution of water with copper and cadmium (Cu/Cd) has been linked to the development of chronic anaemia. Both of these conditions are characterised by the body's inability to produce sufficient red blood cells. In addition, it is of the utmost importance to note that chronic health ramifications include a variety of harmful effects, some of which include cancer, birth abnormalities, organ damage, neurological system problems, and weakened immune system functioning (United States Geological Survey [USGS], 2002). The United States Geological Survey (USGS, 2002) has identified the chemicals Cd, Cu, Co, Cr, Mn, Ni, Pb, and Zn as having the potential to cause cancer as well as toxic effects. These chemicals are often found to damage drinking water supplies in many locations across the globe.

Arsenic (mg/L).

Both the Bonny/Nembe River and the Aleto River revealed a range of values for the amounts that were examined; more precisely, the measured values varied from 0.790.04mg/kg to 1.210.33mg/kg, respectively. There was no discernible statistically significant difference in the amount of as found in any of the several locations that were examined. According to the findings of the current research, the detected concentration of arsenic (As) is slightly higher than the threshold value of 0.010 mg/L, which was suggested by the Environmental Protection Agency (EPA) in 2006. However, the purpose of this research was to explore the lead (Pb) content levels that were discovered in the rivers located in the state of Rivers. On the other hand, it is a fact that prolonged exposure to the inorganic arsenic that may be present in drinking water can result in a wide variety of adverse effects on an individual's health. This is a fact that is well accepted. The onset of cancer, changes in skin colour and texture, problems in the vascular system, elevated blood pressure, illnesses related to the cardiovascular system, and neurological symptoms characterised by sensations of numbness, discomfort, and disturbances in essential physiological processes are all included among the aforementioned consequences (2022). However, the levels of arsenic that were found in this study have the potential to pose health risks. These health risks may include, but are not limited to, the development of cancer, dermal manifestations such as changes in skin thickness and coloration, complications related to blood vessels, high blood pressure, cardiovascular disorders, neurological impairments such as sensations of numbness and pain, and disturbances in the functioning of essential organs, among a variety of other effects. In addition, short-term exposure to higher amounts of arsenic may be responsible for the existence of acute manifestations such as stomach discomfort, vomiting, diarrhoea, headache, and weakness, as well as potentially life-threatening effects. These symptoms may be caused by the accumulation of arsenic in the body. It has been observed, on the basis of the findings of the Michigan Department of Environment, Great Lakes and Energy (2022), that prolonged exposure to low levels (0.005 mg/L) of arsenic through the consumption of drinking water has the potential to result in a decline in cognitive function, as evidenced by reduced IQ scores in children. This observation is based on the fact that it has been observed that arsenic can be found in drinking water. In addition, a wide range of negative effects on health have been conclusively linked to the presence of arsenic in the world's water supplies, which contributes to contamination of the water supply on a worldwide scale. Arsenic has been designated as a heavy metal by the World Health Organisation (WHO, 2023) because to the severe risks it poses to human health.

The assessment of risks associated with heavy metals

The findings of this study indicated a significant buildup of lead that was dangerously close to exceeding the permissible threshold. The chemical element lead (Pb) is often discovered in contaminated amounts in fish, sediment, and water. It is possible that the presence of lead in the aforementioned study regions may be traced back to the introduction of plastic and other forms of human waste into the river systems. According to Basey and Chukwu (2019), the measured concentration of lead may be prone to influence from the feeding behaviour of fish, namely demersal species that engage in scavenging at the bottom for food that is contaminated with lead. It is important to note that the quantities of lead that were found in fish species from both lagoons were found to be lower than the recommended threshold of 2 mg/kg that was set by the World Health Organisation (WHO) and the Federal Ministry of the Environment (FMEnv). This is something that should be mentioned. It is very necessary to realise that lead (Pb) poses significant health risks to the human population. According to the results of El-Ghasham et al. (2008), it has been shown that lead (Pb) holds the capacity to generate oxidative damage to many organs located inside the human body. This is the conclusion that can be drawn from the data. Even at low levels, the presence of lead-induced oxidative stress in aquatic environments has a variety of impacts on the components of cells, such as membranes, DNA, and antioxidant defence mechanisms (Weber et al., 1997). These effects may be seen in a wide range of organisms. People who eat fish species that have been exposed to lead for an extended length of time run the risk of developing a variety of diseases, according to the findings of this research. Even if the levels of lead may be relatively low, there is still a danger that people may get sick if they consume these fish. In addition to cognitive impairment, hypertension, renal sickness, and neurological disease are included in the previously stated conditions.

CONCLUSION

The findings of this study indicate that the surface waters under investigation are negatively impacted by the presence of plastic garbage and other human-generated waste materials. The elevated concentrations of Lead (Pb), Cadmium (Cd), and Arsenic observed in this study may be attributed to the pervasive occurrence of plastic waste and other components of crude oil in the biophysical environment of the Niger Delta, particularly in Rivers State. These findings indicate a potential detrimental effect of plastic waste on water quality, which could have implications for human health. The findings of this investigation suggest that the water is contaminated based on the detected concentrations of heavy metals. This study further demonstrates that the rivers have been contaminated by plastic and other hydrocarbon-based substances derived from oil and gas sources. This contamination was noticed during the physical collection of samples, indicating that the water has become harmful to the local human population.

Recommendations

The following suggestions are offered on the basis of the results of this study:

1. The government and Rivers State ministry of environment should regulate the spate of plastic waste disposal and monitor and enforce standards to curb this ugly trend.
2. Regular water quality monitoring should be carried out on both surface and underground water sources in the Niger Delta in order to evaluate the impact of the indiscriminate disposal of plastic wastes in the environment and possible consequences on the health of the people as provided by regulatory authorities.
3. Ecological studies on the surface waters of the Niger Delta should be extended to other aspects such as the fish composition, benthos, nekton, heavy metals, total hydrocarbon, sediment studies, radionuclear studies, epipelagic studies etc. And taken seriusly, especially how the improper disposal of plastic wastes affects these fauna, which are widely consumed by the general populace of the Niger Delta people.

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