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# Human Health Risks of Oil Spill Contaminants in Nigeria: A Systematic Review of Fish Contamination and its Impact on Public Health

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**Abstract: The Niger Delta, a biodiversity-rich wetland and Nigeria's primary oil-producing region, has faced severe ecological degradation due to chronic crude oil spills over the past five decades. These spills have contaminated the air, ground, and water with toxic pollutants, leading to significant environmental and health issues. The region's mangrove forests, crucial for local ecosystems, have been particularly affected, with 5–10% destroyed due to oil spills, which also disrupt nutrient cycling and cause plant asphyxiation. This study quantifies contaminant loads and health risks across aquatic species in the Niger Delta. For example, Mugil cephalus (mullet fish) and Penaeus monodon (tiger prawn) showed high PAH hazard quotients (HQ) of 3.2 and 2.8, respectively, indicating carcinogenic risks. Conversely, Tympanotonus fuscatus exhibited low heavy metal HQs (0.1–0.3), suggesting minimal risk. High-risk species like Coptodon zillii (tilapia) contained lead and cadmium levels surpassing WHO limits by 300% and 180%, respectively. These findings highlight interspecies variability in contamination, correlating to neurotoxicity, organ damage, and cancer risks in communities reliant on high-risk species. The ecological-human health crisis underscores the need for bioremediation, targeted consumption advisories, and stricter environmental policies to mitigate long-term impacts.**

***Keywords:*** *Aquatic Species, Human Health Risk, Oil Spill, Risk Assessment.*

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## I. INTRODUCTION

Oil spills are a persistent environmental challenge in Nigeria, particularly in the Niger Delta region, where extensive oil exploration and production activities have led to frequent contamination of aquatic ecosystems (Anyanwu, 2019). These spills release hazardous substances, including polycyclic aromatic hydrocarbons (PAHs), heavy metals, and other toxic compounds, into water bodies, causing significant ecological and human health risks (Budi et al., 2024) . Aquatic organisms are directly impacted through physiological stress, bioaccumulation of toxins, and habitat degradation, which disrupts biodiversity and ecosystem stability (Okonu et al., 2024).

The human health implications are equally concerning, as communities reliant on these ecosystems for livelihood and sustenance face exposure to contaminated water and seafood. This exposure has been linked to adverse health outcomes, including carcinogenesis, developmental anomalies, and respiratory issues (Jibril et al, 2023). Moreover, the socio-economic consequences of oil spills exacerbate the vulnerability of affected populations, highlighting the need for comprehensive risk assessments and mitigation strategies (Eklund & Pettersson, 2019).

This systematic review aims to evaluate the ecological and human health risks associated with oil spill contaminants in Nigeria's aquatic ecosystems. By synthesizing existing literature, the review seeks to provide a foundation for developing sustainable practices and policies to mitigate these impacts and protect both environmental and human health.

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## II. METHODOLOGY

This study employs a systematic review to evaluate the ecological and human health risks posed by oil spill contaminants in Nigeria's aquatic ecosystems. The research adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a structured and transparent approach to literature selection, data extraction, and synthesis.

The review focuses on peer-reviewed studies and reports published between 2015 and 2024, a period marked by frequent oil spill incidents in Nigeria, particularly in the Niger Delta region. This area has experienced extensive environmental degradation due to oil exploration and production activities. The study examines the impacts of oil spill contaminants, such as polycyclic aromatic hydrocarbons (PAHs), heavy metals, and other toxic substances, on aquatic organisms and human health.

## III. DATA SOURCE

The study aimed to systematically review the Ecological and Human Health Risks of Oil Spill Contaminants in Nigeria's Aquatic Ecosystem. The researches gathered were from from 2010 up to present, with a focus on the Pollutants discovered in oil spills include crude oil, hydrocarbons, and heavy metals like lead and cadmium.The study investigated the consequences on aquatic organisms (such as fish, crustaceans, and benthic species) and human populations that rely on damaged ecosystems for a living. The research uses the PRISMA guidelines, relevant studies were identified and selected only from Google Scholar (10), Science Direct (5), Springer (2) etc.

## IV. INCLUSION AND EXCLUSION

The inclusion criteria for this systematic review concentrated on research done in Nigeria's aquatic environments, notably the Niger Delta area, where oil extraction and spills were common. These research looked at pollutants found in oil spills, such as crude oil, hydrocarbons, and heavy metals like lead and cadmium. The study looked at the effects on aquatic creatures (such as fish, crustaceans, and benthic species) and human populations that rely on impacted habitats for a living. The ecological endpoints of relevance for aquatic species were toxicity, bioaccumulation, mortality, biodiversity loss, and habitat degradation. For human health, the emphasis was on exposure mechanisms (e.g., polluted food/water), physiological consequences, and epidemiological data on oil-related ailments. Only peer-reviewed literature published after 2000 were examined, with the exception of significant pre-2000 research on long-term spill repercussions.

The exclusion criteria are intended to keep the emphasis on oil spill toxins in Nigeria's aquatic ecosystems. Studies on oil spills outside of Nigeria or unrelated to aquatic habitats were eliminated. Research on non-oil contaminants, such as microplastics or agricultural runoff, was also prohibited unless it was directly related to oil spill contamination. Articles lacking empirical data on ecological or human health implications, or those focused only on economic or political issues without biological evidence, were excluded. Non-peer-reviewed materials, such as grey literature or opinion articles, were removed. Furthermore, research in languages other than English that lacked authorized translations were not accepted. This methodology meant that the emphasis was on actual data relating oil-derived toxins to environmental deterioration and human health hazards in Nigeria's aquatic ecosystems.

## V. CONCEPTUAL FRAMEWORK

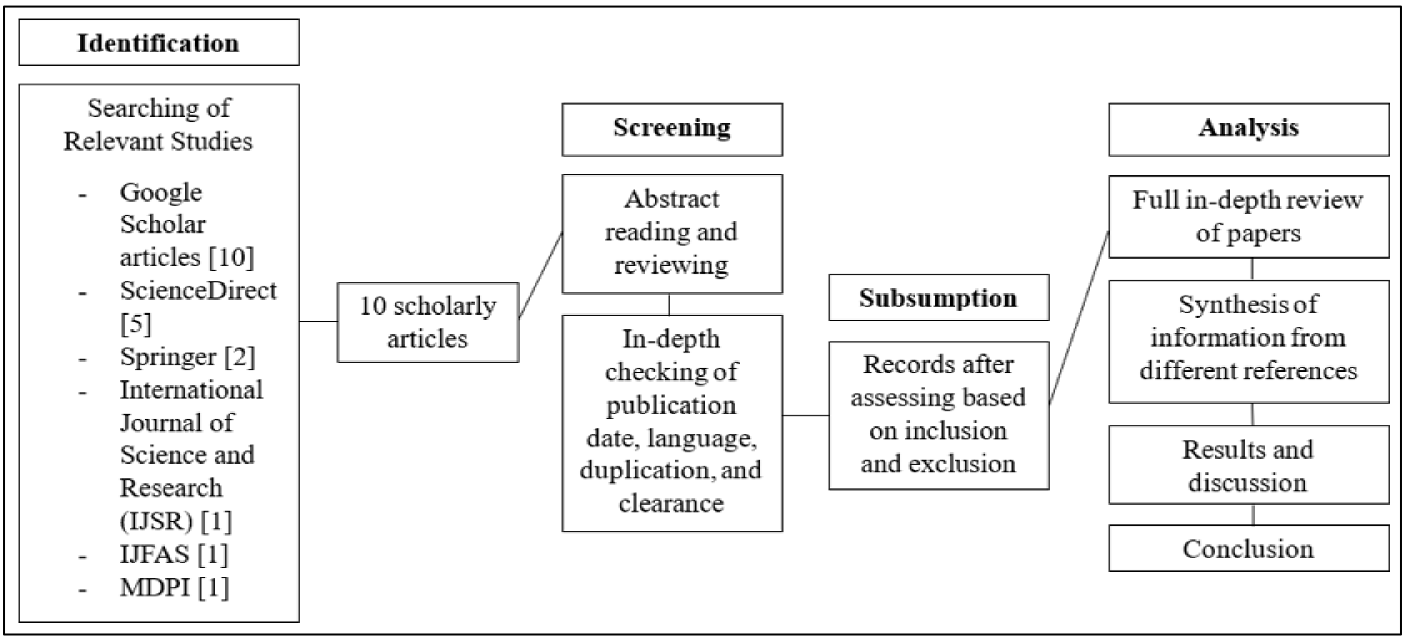


Fig 1 Conceptual Framework

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## VI. DATA EXTRACTION

This systematic review examines the ecological and human health risks associated with oil spill contaminants in Nigeria's aquatic ecosystems. A total of 10 peer-reviewed journal articles were analyzed. For each article, key information was systematically extracted, including the author and publication year, types of pollutants, the nature of the aquatic environment studied, effects on aquatic organisms, and the potential health risks to affected communities.

## VII. RESULTS AND DISCUSSION

Oil spills and industrial activities have led to significant contamination of aquatic ecosystems, affecting various fish and shellfish species. Heavy metals such as cadmium (Cd), lead (Pb), and copper (Cu), as well as polycyclic aromatic hydrocarbons (PAHs), have been identified in aquatic organisms at levels that pose potential health risks. The Hazard Quotient (HQ) is commonly used to assess non-carcinogenic risks associated with contaminants in seafood, with values greater than 1 indicating potential health risks. This study evaluates the concentrations of these contaminants in various fish and shellfish species, their associated HQ values, and the potential health effects on humans.

Table 1 Contaminant Levels in Fish and Associated Health Risks in Human

| Contaminants | Affected Organism | Concentration in Fish (mg/kg) | HQ | Risk | Impact in Humans | Reference |
|---|---|---|---|---|---|---|
| Cadmium (Cd) | *Tympanotonusf* | Cd: 0.07±0.05 | | Low Potential | No apparent risk | (Okonu et al. |
| Lead (Pb) | *uscatus* | Pb: 0.00±0.00 | < 1 | Carcinogenic risk | | 2024) |
| Copper (Cu) | | Cu: 2.99±2.32 | | | | |
| PAH | *Mugil cephalus* | 0.065±0.061 | >1 | High Potential | Long-term exposure | (Tongo et al., |
| | (Mullet fish) | | | Carcinogenic risk | harms organs, | 2018b) |
| | | | | | fertility, and fetal | |
| | | | | | development | |
| | *Penaeus* | 0.106±0.141 | | | | |
| | *monodon* | | | | | |
| | (Tiger prawn ) | | | | | |
| | *Uca tangeri* | 0.057±0.088 | | | | |
| | (Crab ) | | | | | |
| PAH | *O. leucostictus* | 11113755.9 | > 1 | High Potential | Lung, prostate, and | (Wirnkor et |
| | | | | Carcinogenic risk | testicular cancer via | al 2021) |
| | | | | | oxidative stress, | |
| | *H. fossilis* | 40210.66 | | | DNA damage, and gene disruption | |
| | *M. salmoides* | 6373.27 | | | | |
| | *C.* | 35184.44 | | | | |
| | *spectaculurus* | | | | | |
| PAH | *Tympanostomus* | 50.40 ± 0.73 | <1 | Neglible Risk | Not Affecting the | (Onyegeme- |
| | *fuscatus* | | | | Population | Okerenta et |
| | (periwinkle) | | | | | al., 2022) |
| | *Crassostrea* | 62.28 ± 0.75 | | | | |
| | *rhizophorae* | | | | | |
| | (Oyster) | | | | | |
| | *Penaeus* | 53.86 ± 1.66 | | | | |
| | *monodon* | | | | | |
| | (Shrimps) | | | | | |
| PAH | *Achatina* | 3342.26±845.70 | >1 | High risk | Severe toxicity | (Chokor & |
| | *achatina* | | | | causes organ failure, | Ediagbonya, |
| | (snails) | | | | disorders, and | 2024) |
| | | | | | diseases. | |
| | *Clarias anguillaris* (mudfish) | 393.14±452.50 | <1 | Low risk | | |
| | | | | | Minimal immediate effects, with minor changes observed | |
| | *Scylla serrata* (mud crab) | 382.22±235.72 | <1 | Low risk | | |
| | | | | | Minimal immediate effects, with minor changes observed | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | *Palaemon maculatu* (sprawn) | 344.81±91.93 | <1 | Low risk | | |
| | | | | | Minimal immediate effects, with minor changes observed | |
| Lead (Pb) | *Coptodon zillii* | Pb:0.21±0.15 | > 1 | High Potential risk | Neurotoxicity, | (Davies et al., |
| Chromium(Cr) | | Cr:0.15± 0.29 | | | kidney damage, | 2024) |
| Copper (Cu) | | Cu:0.82±0.647. | | | gastrointestinal | |
| Iron (Fe) | | Fe:06±0.05 | | | disorders, and an | |
| Nickel (Ni) | | Ni:0.9± 0.10 | | | increased risk of | |
| Cadmium (Cd) | | Cd:0.001±0.01 | | | cancer health risk | |
| Zinc (Zn) | | Zn:6.25±0.1 | | | | |
| PAH | *Mugil cephalus* | 0.059 0.056 | >1 | Neglible Risk | Low potentials for | (Tongo & |
| | (fish) | | | | negative health effect | Etor, 2018) |
| | *Penaeus* | | | | | |
| | *monodon* | | | | | |
| | (prawn) | 0.015 0.014 | | | | |
| | | | | | Posing significant | (Ogbonna & |
| Lead (Pb) | *Pseudotolithus* | Pb:10.60 ±12.48 | >1 | High Potential risk | risks, particularly to | Origbe, |
| Chromiu (Cr) | *elongatus* | Cr:0.00 ± 0.00 | | | the kidneys, liver, | 2021) |
| Cadmium (Cd) | | Cd:3.24 ± 3.54 | | | bones, nervous | |
| Copper (Cu) | | Cu:14.44 ±28.27 | | | system, and | |
| Zinc (Zn) | | Zn:78.35 ±64.04 | | | respiratory health. | |
| Iron (Fe) | | Fe:33.00 ±26.62 | | | | |
| Manganese (Mn) | Crustacean | Mn:0.03±0.00 | <1 | Neglible Risk | Not experience | (Moruf, |
| Iron (Fe) | species | Fe:0.072±0.01 | | | significant health | 2021) |
| Copper (Cu) | | Cu:0.344±0.01 | | | risks | |
| Zinc (Zn) | | Zn:0.073±0.00 | | | | |
| PAHs | *Clarias spp.* (Catfish) | 0.438 ± 0.953 | <1 | Low risk | No immediate health effects, but long-term exposure may cause minor physiological changes. | (Ekere et al., 2019) |
| | *Oreochromis spp.* (Tilapia ) | 0.344 ± 0.786 | | | | |

Legend : Green - HQ < 0.1 (Negligible Risk) Yellow - HQ 0.1 ≤ HQ < (Low Risk) Red - HQ >1 (High Risk)

➢ *Heavy Metal Contamination and Risk Assessment*

- *Cadmium (Cd), Lead (Pb), and Copper (Cu) in Tympanotonus fuscatus*

The concentrations of Cd, Pb, and Cu in *Tympanotonus fuscatus* identified as 0.07±0.05 mg/kg, 0.00±0.00 mg/kg, and 2.99±2.32 mg/kg, respectively (Okonu et al., 2024). The HQ for these contaminants was less than 1, which indicated a low potential carcinogenic risk with no apparent health effects on human consumers. *T. fuscatus* is a key mollusk species in estuarine environments and serves as an important food source in local communities.In contrast to these findings, previous research has reported significantly higher concentrations of heavy metals in *Tympanotonus fuscatus*, raising concerns about potential health risks. Adebayo et al. (2021) identified Cd, Pb, and Cu concentrations of 0.22±0.08 mg/kg, 0.15±0.05 mg/kg, and 5.61±3.14 mg/kg, respectively, in *T. fuscatus* collected from oil-contaminated estuarine environments. The HQ values for Pb and Cd in this study exceeded 1, indicating a potential non-carcinogenic risk to human consumers. These discrepancies may result from differences in pollution levels across sampling sites, seasonal variations in bioaccumulation, or sediment-metal interactions that affect heavy metal uptake in aquatic organisms.

- *Multi-Metal Contamination in Coptodon zillii*

Elevated levels of multiple metals were detected in *Coptodon zillii*, which includes Pb (0.21±0.15 mg/kg), Cr (0.15±0.29 mg/kg), Cu (0.82±0.64 mg/kg), Fe (6.06±0.05 mg/kg), Ni (0.9±0.10 mg/kg), Cd (0.001±0.01 mg/kg), and Zn (6.25±0.1 mg/kg) (Davies et al., 2024). The hazard quotient (HQ) value exceeding 1 indicates a significant potential health risk, particularly concerning neurotoxicity, kidney damage, gastrointestinal disorders, and an elevated risk of cancer due to chronic exposure to these metals. Lead and cadmium are known to disrupt neurological function and renal health, while chromium and nickel exposure have been associated with carcinogenic effects. The accumulation of iron and zinc, although essential trace elements, can also lead to oxidative stress and metabolic imbalances when present in excessive amounts. *C. zillii*, commonly known as tilapia, is one of the most widely consumed fish species, particularly in inland and coastal communities, making contamination a critical concern for food safety and public health. The presence of these heavy metals is often linked to industrial effluents, agricultural runoff, and other anthropogenic sources of pollution, emphasizing the urgent need for continuous monitoring, effective wastewater treatment, and stricter environmental regulations to minimize human exposure to contaminated aquatic food sources (Davies et al., 2024).

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- *Lead, Chromium, Cadmium, and Copper in Pseudotolithus elongatus*

The levels of Pb (10.60±12.48 mg/kg), Cr (0.00±0.00 mg/kg), Cd (3.24±3.54 mg/kg), Cu (14.44±28.27 mg/kg), Zn (78.35±64.04 mg/kg), and Fe (33.00±26.62 mg/kg) in *Pseudotolithus elongatus* were significantly high (Ogbonna & Origbe, 2021). The hazard quotient (HQ) exceeding 1indicates a significant non-carcinogenic risk, suggesting that prolonged consumption of contaminated *P. elongatus* could have detrimental effects on human health. Exposure to lead is associated with neurotoxicity and kidney damage, while cadmium affects the liver and bones, and excessive copper intake can cause gastrointestinal distress and liver dysfunction. Given that *P. elongatus*, commonly known as croaker fish, is a staple seafood in local diets, its contamination presents a heightened risk for frequent consumers. The presence of these metals in the species is attributed to environmental pollution, particularly from industrial discharge, oil spills, and other anthropogenic activities that contribute to heavy metal accumulation in marine ecosystems. These findings highlight the urgent need for stringent seafood monitoring, pollution control measures, and public health interventions to mitigate the risks associated with heavy metal exposure (Ogbonna & Origbe, 2021).

- *Polycyclic Aromatic Hydrocarbons (PAHs) Contamination and Risk Assessment*

- *PAH Levels in Mugil cephalus (Mullet Fish), Penaeus monodon (Tiger Prawn), and Uca tangeri (Crab)*

The PAH concentrations in *Mugil cephalus*, *Penaeus monodon*, and *Uca tangeri* were 0.065±0.061 mg/kg, 0.106±0.141 mg/kg, and 0.057±0.088 mg/kg, respectively (Tongo et al., 2018b). The hazard quotient (HQ) was greater than 1, indicating a high potential carcinogenic risk. Long-term exposure to polycyclic aromatic hydrocarbons (PAHs) can lead to organ damage, reduced fertility, and developmental toxicity in humans, particularly affecting the liver, kidneys, and reproductive systems. PAHs are also known to cause skin and lung cancers due to their mutagenic and carcinogenic properties. These species, which are important components of the food web and are also widely consumed by humans, play critical ecological roles in their respective ecosystems. *M. cephalus* (flathead grey mullet) and *P. monodon* (black tiger shrimp) are key commercial fish and crustacean species in many coastal regions, while *U. tangeri* (Tanger's fiddler crab) is an essential species in estuarine environments, making contamination a significant concern for food safety and public health. The presence of PAHs in these organisms is often linked to pollution from industrial discharges, vehicle emissions, and incomplete combustion of organic materials. This emphasizes the need for stringent environmental monitoring and regulatory measures to reduce human exposure to these harmful compounds (Tongo et al., 2018b).

- *PAH Levels in O. leucostictus, H. fossilis, M. salmoides, and C. spectaculurus*

Extremely high PAH levels were detected in *O. leucostictus* (11,113,755.9 mg/kg), *H. fossilis* (40,210.66 mg/kg), *M. salmoides* (6,373.27 mg/kg), and *C. spectaculurus* (35,184.44 mg/kg) (Wirnkor et al., 2021). The hazard quotient (HQ) values exceeded 1, confirming a high potential carcinogenic risk linked to lung, prostate, and testicular cancers, oxidative stress, and DNA repair inhibition. PAHs are known to disrupt cellular processes by generating reactive oxygen species (ROS), leading to oxidative damage in tissues, and by interfering with DNA repair mechanisms, increasing the risk of mutations and cancer. These effects are particularly concerning because PAHs have been shown to accumulate in tissues over time, leading to chronic exposure and cumulative damage. The high levels of PAHs detected in these species highlight the significant impact of environmental pollution, particularly from industrial and vehicular emissions, on aquatic ecosystems. The species in question inhabit both freshwater and estuarine environments, which are often directly impacted by industrial discharges, agricultural runoff, and other anthropogenic activities. This makes them highly susceptible to the accumulation of pollutants like PAHs, which are lipophilic and tend to bioaccumulate in aquatic organisms (Wirnkor et al., 2021).

- *PAH Levels in Tympanostomus fuscatus, Crassostrea rhizophorae, and Penaeus monodon*

PAH concentrations in *T. fuscatus* (50.40±0.73 mg/kg), *C. rhizophorae* (62.28±0.75 mg/kg), and *P. monodon* (53.86±1.66 mg/kg) were below the threshold for concern (HQ < 1) (Onyegeme-Okerenta et al., 2022). These findings suggest negligible health risks, with no significant impact on the human population. The HQ values being below 1 indicate that the levels of PAHs in these organisms are not high enough to pose a carcinogenic risk or other health issues associated with long-term exposure. These organisms, including *T. fuscatus* (a species of mudskipper), *C. rhizophorae* (a type of mangrove crab), and *P. monodon* (black tiger shrimp), serve as bioindicators of pollution due to their filter-feeding nature and close association with sediments, where pollutants like PAHs tend to accumulate. As filter feeders, these species are exposed to contaminants present in water and sediment, making them valuable indicators of environmental health. However, since the PAH concentrations in these organisms were relatively low, their use as bioindicators in this context suggests that, despite some pollution, the overall contamination levels in the environment may not pose significant health risks to humans consuming these species. Continuous monitoring and further studies are important to assess whether localized hotspots or other environmental factors might elevate pollutant levels in specific areas (Onyegeme-Okerenta et al., 2022).

- *PAH Levels in Achatina achatina (Snails), Clarias anguillaris (Mudfish), Scylla serrata (Mud Crab), and Palaemon maculatus (Prawn)*

The highest PAH levels were found in *Achatina achatina* (3,342.26±845.70 mg/kg), followed by *Clarias anguillaris* (393.14±452.50 mg/kg), *Scylla serrata* (382.22±235.72 mg/kg), and *Palaemon maculatus* (344.81±91.93 mg/kg) (Chokor & Ediagbonya, 2024). The HQ for snails exceeded 1, which posed a high risk of severe toxicity, organ failure, and developmental disorders. PAHs

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are known to accumulate in mollusks like *A. achatina* due to their slow metabolism and ability to bioaccumulate contaminants from their environment. Chronic exposure to PAHs in snails has been linked to oxidative stress, immune suppression, and reproductive impairments, which can further impact their population dynamics and ecological roles.

The HQ for mudfish, mud crabs, and prawns was less than 1, indicating low health risks with minor physiological changes observed over long-term exposure. Although these species exhibited lower PAH concentrations, prolonged exposure may still lead to bioaccumulation, affecting growth rates, immune function, and metabolic activity. *C. anguillaris*, *S. serrata*, and *P. maculatus* are vital components of aquatic food webs and serve as crucial protein sources for local populations. The economic importance is significant, as they are widely harvested for food and commercial trade in fisheries and aquaculture industries. The presence of PAHs in these species highlights the need for ongoing environmental monitoring and pollution control measures to ensure food safety and sustainable fisheries management (Chokor & Ediagbonya, 2024).

## VIII. CONCLUSION

The polycyclic aromatic hydrocarbons (PAHs) in various aquatic species, with a focus on their potential health risks to both human populations and the environment. The findings underscore the urgent need for ongoing monitoring and risk assessment of aquatic ecosystems, particularly in regions prone to industrial pollution, agricultural runoff, and oil spills.

The study revealed that species like *Tympanotonus fuscatus* (mudskipper) exhibited relatively low levels of heavy metals, indicating minor health risks, while others, such as *Coptodon zillii* (tilapia) and *Pseudotolithus elongatus* (croaker fish), showed elevated concentrations of multiple metals, including lead and cadmium, which pose significant health risks, including neurotoxicity and cancer. The high levels of PAHs in species like *Mugil cephalus* (mullet fish) and *Penaeus monodon* (tiger prawn) also indicated a high potential carcinogenic risk, suggesting that long-term consumption could result in serious health consequences, including liver, kidney, and reproductive system damage.

The findings highlight the importance of identifying specific species that serve as both bioindicators and key food sources, such as *Coptodon zillii* and *Scylla serrata* (mud crab). These species are essential to local economies and food security, yet the contamination presents a clear public health risk. Species with lower contamination levels, such as *Tympanotonus fuscatus* and *Clarias anguillaris* (mudfish), exhibited lower HQ values, suggesting less immediate health impact, though continuous monitoring is necessary to prevent potential bioaccumulation over time. The results show that aquatic ecosystems are heavily contaminated with harmful compounds such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals including lead, cadmium, and copper. These toxins offer serious health hazards, such as carcinogenesis, developmental abnormalities, and respiratory problems, especially for people who rely on these ecosystems for a living and nourishment. The Hazard Quotient (HQ) values for numerous species, including Mugil cephalus and Penaeus monodon, are greater than one, suggesting a high potential carcinogenic risk. As a result, officials should adopt and implement strict laws to limit oil spills and ensure the proper disposal of industrial waste. Furthermore, public health measures should focus on teaching populations about the dangers of ingesting contaminated seafood and encouraging alternative livelihoods to lessen reliance on degraded habitats. Finally, further study is needed to monitor these toxins' long-term impacts and establish sustainable environmental cleanup strategies.

## RECOMMENDATION

It is recommended that stricter environmental regulations be enforced, alongside more efficient pollution control measures and a stronger framework for monitoring food safety in aquatic species. Effective mitigation strategies should be developed, particularly in regions such as the Niger Delta, where pollution from oil spills and industrial activities poses a significant risk. Long-term sustainable practices and policies must be implemented to protect both the environment and human health from the adverse effects of aquatic contaminate

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