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Oil Spills Impact and Toxicological Stress on Fisheries-Dependent Livelihoods in the Coastal and Marine Environment: Implications for the Blue Economy

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Abstract: *Several oil spills have occurred offshore, within shallow waters and around the riverine areas of the Niger Delta, Nigeria. Spill response procedures and emergencies are often triggered when oil spill incidents happen with the defunct Department of Petroleum Resources, now NUPRC and NOSDRA called to action. Often, this is in compliance with statutory environmental regulations, that requires 'an operator responsible for a spill to conduct an Environmental Evaluation (Post Impact) Study of any adversely impacted environment in accordance with Article 2.0 of the EIA guidelines' in Part VIII-A. The guidelines so appertaining are, however, short of consideration for the human (socioeconomic) environment. Professional practice and compliance with due diligence have often compelled the consideration of the socioeconomic aspect. This has become unavoidable as the coastal communities and population which may have experienced some impacts continue to put pressure on the regulating body, particularly NOSDRA to live up to its responsibilities. Post impact assessments of oil spill incidents have revealed that fisheries livelihood has always almost been affected around fish catch, income reduction and toxicological impact as fish products become contaminated and those caught not fit for consumption. Without laboratory investigation, many are tempted to discountenance the claims made by fishers on the toxicological effect of oil spills on coastal and marine fisheries products. Nonetheless, this paper put forward occasions where these perceptions have prevailed, aided by visuals of toxic fisheries contamination. Three incidents of such investigations are reported are presented here.*

Keywords: oil spills, post-impact assessments, fisheries livelihoods, toxicological impact, Niger Delta

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INTRODUCTION

Coastal and riverine environments have long sustained human societies through food provision, trade, and employment. Their importance extends beyond local livelihoods to global systems of exchange. Maritime activities account for more than 90% of international trade by volume, accentuating how deeply coastal systems are embedded in economic life at multiple scales (UNCTAD, 2023). Yet, while global trade highlights their strategic value, dependence on these environments is most immediate and personal at the local level. In many developing regions, coastal and riverine communities rely directly on artisanal fisheries for survival. Fishing supports household nutrition, generates income, and anchors social organisation. These livelihood systems operate at the boundary between ecological processes and economic activity. When environmental conditions shift, the effects are felt quickly in daily life. This close coupling between nature and livelihood makes fisheries-based communities particularly vulnerable to environmental disturbance. As argued by Ojile (2018), communities whose livelihoods depend on water-based resources face significant socioeconomic risks when access to fishing grounds or ecological conditions is disrupted.

The Niger Delta exemplifies this vulnerability. The region possesses an extensive coastline, estimated at about 112,110 km², supporting marine and coastal ecosystems that underpin the livelihoods of a large riverine population (Adewumi et al., 2018; Akpan et al., 2024). Fishing dominates local economies, supplying protein and income where alternative employment options remain limited. Beyond subsistence fishing, a range of fisheries-related occupations, such as boat building, fish processing, net mending, and firewood supply, form an interconnected local economy centred on aquatic resources (Ojile, 2018). These activities reinforce the centrality of marine environments to household income, food security, and cultural identity (Ojile, 2018). In this context, the Niger Delta's fisheries represent a lived expression of the blue economy, where economic activity, social wellbeing, and ecosystem health are closely intertwined rather than treated as separate policy objectives (OECD, 2016; FAO, 2020).

This dependence, however, exists within a region heavily shaped by oil exploration and production. The Niger Delta is among the most oil-impacted coastal environments globally. Recurrent oil spills linked to offshore operations, pipeline failures, and operational discharges have affected open marine waters, estuaries, creeks, and mangrove ecosystems (UNEP, 2011; Igho & Abolaji, 2024; Sheriff et al., 2025). These habitats function as spawning and nursery grounds for many fish and shellfish species that sustain artisanal fisheries. When crude oil contaminates aquatic systems, it releases mixtures of toxic substances including petroleum hydrocarbons and heavy metals that persist in sediments and accumulate in aquatic organisms, as documented in recent studies from polluted Nigerian waters (Chidugu-Ogborigbo et al., 2025; Ogunbanwo et al., 2025).

The consequences of such contamination are commonly examined within the domain of marine toxicology. Conventional toxicological assessments rely on laboratory-based analyses to quantify contaminant concentrations and biological responses. While these methods provide important evidence of toxicity, they often fail to represent chronic, low-dose exposure conditions typical of contaminated aquatic environments, where pollutants persist, bioaccumulate, and affect organisms long after initial release events (Wang et al., 2024; Olowojuni et al., 2025; Vieira et al., 2025). In mangrove and shallow coastal systems, oil-derived toxicants bind strongly to fine sediments, creating prolonged exposure pathways for benthic organisms and early life stages of fish. These exposures may not always result in immediate mortality but can produce ecologically significant sub-lethal effects that influence population dynamics and fisheries productivity (Mohanty et al., 2025).

In Nigeria, spill response procedures and emergencies are often triggered when oil spill incidents happen with the defunct Department of Petroleum Resources, now NUPRC and NOSDRA called to action. Often, this is in compliance with statutory environmental regulations, that requires 'a*n operator responsible for a spill to conduct an Environmental Evaluation (Post Impact) Study of any adversely impacted environment in accordance with Article 2.0 of the EIA guidelines'* in Part VIII-A. The guidelines so appertaining are, however, short of consideration for the human (socioeconomic) environment, most at times they tend to prioritise biophysical indicators such as vegetation loss, water quality, and sediment contamination, and with limited attention to livelihood systems that depend directly on affected ecosystems

For fisheries-dependent communities, toxicological stress is rarely experienced as an abstract chemical concentration. It is expressed through reduced catch, damaged fishing grounds, altered species availability, and growing concern over the safety and marketability of harvested fish. As environmental stress accumulates, fishing livelihoods become increasingly strained. Toxic exposure can impair fish growth and reproduction, degrade nursery habitats, and disrupt food webs, leading to declining catch per effort and intensified fishing activity (FAO, 2020; Ogunbanwo et al., 2025). Fishers respond by travelling farther, staying longer at sea, and increasing labour input, often with diminishing returns. These patterns signal not only ecological degradation but also a gradual weakening of the economic foundation upon which fisheries-dependent livelihoods and the broader blue economy depend. This study therefore, examines the toxicological stress on fisheries-dependent livelihoods within oil-impacted marine and coastal environments of the Niger Delta. Adopting an inferential socio-ecological approach, the study links observable environmental degradation and fisheries decline to established toxicological processes.

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MATERIALS AND METHODS

Study Area

The study was conducted in Nembe Local Government Area (LGA) of Bayelsa State, located within Nigeria's South–South geopolitical zone. Nembe LGA lies within the coastal Niger Delta and is characterised by an extensive network of creeks, rivers, and mangrove-fringed waterways that support artisanal fisheries. The administrative headquarters is located in Nembe town at approximately 4.5369°N and 6.4062°E. The LGA covers about 760 km² and forms part of the low-lying coastal plain typical of the central Niger Delta.

Field Study Design and Data Collection

The study adopted an inferential socio-ecological field-based approach focused on documenting fisheries dependence, livelihood patterns, and perceived environmental impacts following an oil spill incident within the Nembe axis. Data collection combined primary field methods with secondary information from relevant literature.

Primary socioeconomic data were collected using Participatory Rural Appraisal (PRA) techniques. These included structured questionnaire administration, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), town hall meetings, and direct field observations supported by photographic documentation. The use of multiple PRA tools allowed for triangulation of information and improved the reliability of community-level data, consistent with established best practice in coastal livelihood studies (Akpofure & Ojile, 1999; Ojile et al., 2016). A total of 240 questionnaires were administered and successfully retrieved. Although the oil spill incident occurred at Worikumakiri, its effects extended beyond the immediate spill location to surrounding fishing settlements. Based on proximity to the spill site and observed impact intensity, eight communities were selected for detailed assessment.

Classification of Impact Zones

The selected communities were categorised into three impact zones to reflect varying levels of exposure and disturbance (Fig. 1).

- Heavily impacted communities included Worikumakiri, the spill location, and Shellkiri.
- Slightly impacted communities comprised Ikegimakiri, San San village, and Sunnykiri.
- Impacted communities included Obioku, Owukubu, and Tweni.

In addition, two control locations were designated to provide baseline comparison and were treated as Control Area 1 and Control Area 2. Beyond the core study sites, over twenty settlements were visited and mapped across the wider Nembe riverine environment to contextualise fishing activities and spatial patterns of impact.

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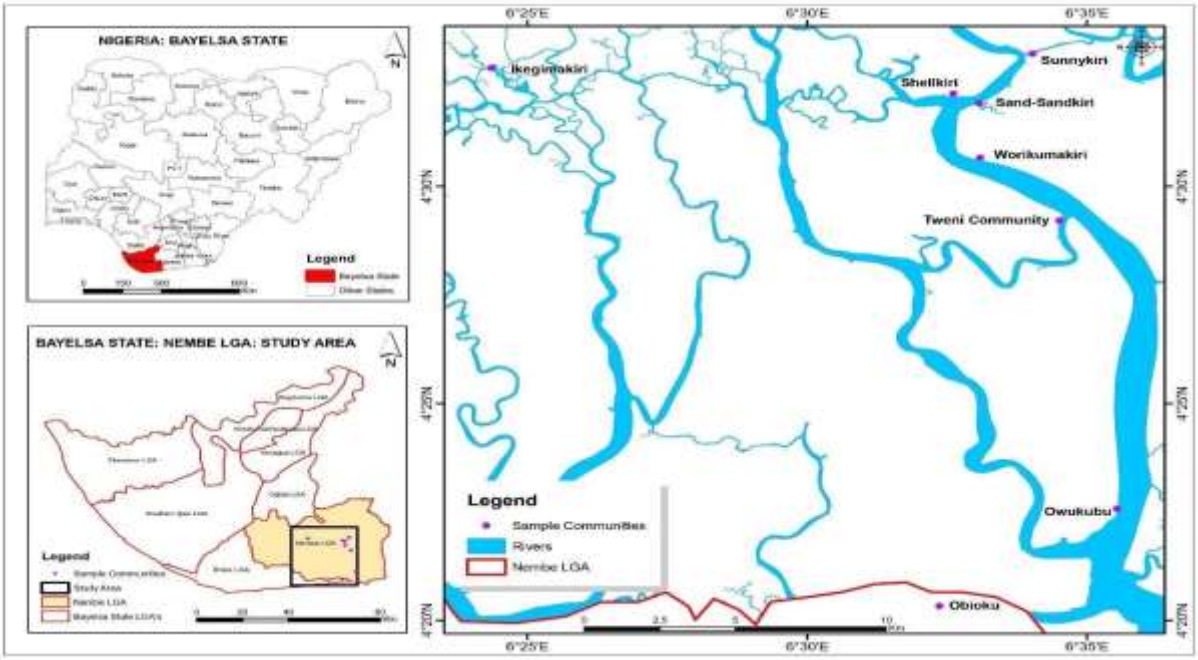

Fig. 1: Map of the Study Area Showing the Location of Sampled Communities in Nembe Local Government Area, Bayelsa State, Nigeria.
Source: Author's field survey, 2022.

RESULTS

Fisheries-Based Livelihoods in the Nembe Riverine Environment

The livelihood of the Nembe riverine and coastal communities depends much on their natural resource-based traditional occupations. Fishing and trading are the major occupations practiced. The communities are located along the coasts and around water courses and thus surrounded by large and small waterbodies as the case may be. It is only natural therefore, that fishing and fisheries predominate as main economic activity of the population. By providence the study environment is endowed more with water than cultivable land, so little farming is undertaken. Statistically, over 90 percent (92.5%) of the resident population across the surveyed fishing camps/ports and communities are into fishing and fisheries-related activities. The percentage of persons involved in fisheries, however, increases as one travel towards the coast with those by the coastline entirely dependent on fishing and fisheries.

At the wholly fishing settlements like Sunnykiri, Tweni, Shellikiri, Ikegimakiri and constituent settlements, the intensity and extensiveness of fishing activities are on display with a much higher number of persons engaged in fishing can be observed. In these essentially fishing communities and settlements, canoes fitted with various grades of out-board engines (mostly

25/30 HP engines), are used for fishing with some going as far as the Sea, up to 10-20 fathoms (5-10km) into the sea. The catch is greater in the dry season (September/October-May) while rough ocean waves and currents in the rainy season was claimed to be a serious hazard to good fishing, as those who venture into sea sometimes get drowned and killed. In the rainy season (June- August), hand-dug canoes are commonly used for inshore fishing while the women-folks also get involved in inshore fishing. This usually involve the collection of pelagic fisheries species, oysters' and shellfishes and periwinkles, setting of fish/animal traps in the mangroves, hand (scooping) nets' fishing (mostly by the women folks and adolescents), and use of hooks and drag nets by the men folks (Plates 1-13). Thus, both the men and women are actively engaged in productive economic activities.

For those residents in the smaller villages closer to or within the immediate influence of the wellhead oil spill, the fishing occupation is combined with little homestead farming, carried out to support the home on available arable lands, mostly on dredged spoils of isolated freshwater forest in the area. Staple crops include plantain, cassava, cocoyam, oil palm and coconut. Ancillary crops produced in the area were sweet potato, groundnut, sugar cane, banana, yam, and vegetables like okra, pepper and fruits like pineapple and mango. Farming is particularly important at the Obioku community, where freshwater rainforest is extensive. Some claim to have given up to 4 plots of land and major produce include cassava, plantain, banana, yam, cocoyam and pineapples. Trading too, particularly by the womenfolk is also very important economic activities in both fisheries and agricultural produce.

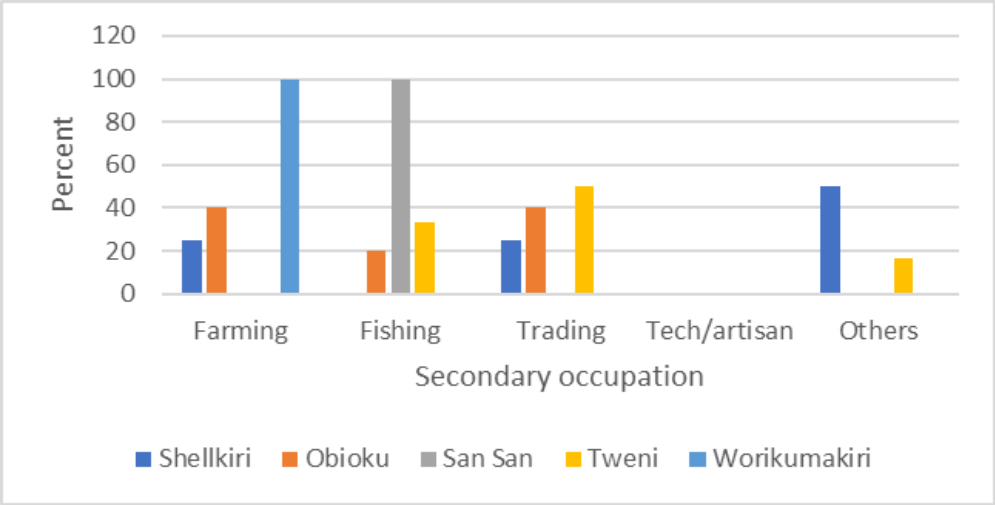

Fig. 2: Secondary occupations for residents in surveyed riverine camps/ports and communities
Source: Author's field survey, 2022.

The type of fishing done in the area falls within the artisanal category. The artisanal fishing is a low technology, labour intensive fishery, using canoes 6-13m long (7 fathoms long), paddled or

motorized with different grades of HP engines and manned by a 3-5-man crew. The gear is mainly gill nets, cast nets, hooks, beach seines and various forms of traps. Fishing is conducted year-round, and the amount of catch is usually more during the dry season. The number of fishing canoes and boats as well as nets found berth at the waterside during the field visit testified to the degree of fishing carried out within the Nembe riverine camps/ports and communities oil spill-impacted environment.

Going by the magnitude and proportion of the population involved in fisheries across the Nembe riverine study environment, its product (fisheries) is meant for the market. Trading is therefore, the second most important income-generating activities in the area, undertaken in all cases more by the females and at subsistent level (petty trading). There are no structured markets for the sale of the fisheries; instead, these (most times already processed, i.e., smoked/dried) are taken outside the communities to far-flung markets in the urban areas such as Nembe Waterside and Creek Road Markets in Port Harcourt, and Swali Market in Yenagoa, where better prices are obtained for the fisheries while sometimes buyers also come to the fishing camps/ ports and communities for direct buying of the fisheries. The womenfolk (and sometimes assisted by the children) engage in the drying and eventual sale of the fish. Obioku community is the only settlement where trading activities were confirmed to be conducted every Tuesday, but mostly for agricultural produce (crops).

Plate 1-13: Fishing intensity in Tweni community by number of persons involved and gears used
Source: Author's field survey, 2022.

DISCUSSION

Marine Pollution, Toxicological Stress, and Fisheries Decline

The study found a complete dependence (92%) of Nembe riverine communities on fisheries, reflecting a livelihood system tightly bound to the condition of the aquatic environment. In such settings, environmental disturbance has immediate consequences for income, food security, and social stability, as households have limited alternatives outside fishing-related activities (Ojile, 2018). This high level of dependence heightens vulnerability to pollution, especially where contamination disrupts the ecological processes that sustain fish populations. The oil spill incident affected not only active fishing grounds but also spawning areas, shellfish beds, and mangrove-associated habitats that underpin artisanal fisheries. Similar patterns have been documented across the Niger Delta, where oil pollution has degraded critical nursery habitats and reduced the ecological integrity of coastal waters (UNEP, 2011; Alongi, 2018).

Crude oil contains toxic constituents such as polycyclic aromatic hydrocarbons, volatile organic compounds, and trace metals. These compounds once released into marine and estuarine environments, tend to persist in sediments, particularly within mangrove mudflats. Sediment-bound contaminants can remain biologically available for years, creating chronic exposure conditions for benthic and demersal organisms (Chidugu-Ogborigbo et al., 2025; Ogunbanwo et al., 2025). Mangrove ecosystems, which dominate the Nembe coastal landscape, are especially vulnerable because their low-energy environments promote contaminant retention rather than dispersal (Alongi, 2018).

Community accounts indicating reduced catch per effort and increased fishing intensity following the spill event reflect ecosystem-level disruption rather than isolated fishing pressure. Reports of fishers travelling farther offshore, remaining longer at sea, and engaging younger labour align with documented responses of artisanal fishers operating in polluted environments (Peterson et al., 2012). Sub-lethal toxicity, habitat degradation, and disrupted recruitment processes reduce fish abundance over time, forcing behavioural adaptation among fishing households (Mohanty et al., 2025). These dynamics explain the persistent fisheries decline observed in the study area.

Toxicological Implications for the Marine Food Web

Oil-contaminated sediments act as long-term toxic reservoirs. Benthic organisms that feed or burrow within these sediments experience prolonged exposure, leading to impaired growth, reduced reproductive capacity, and increased mortality (Chidugu-Ogborigbo et al., 2025; Ogunbanwo et al., 2025). These impacts propagate through the marine food web, resulting in lower fish availability and shifts in species composition, particularly in shallow coastal systems where artisanal fisheries operate.

Shellfish and crustaceans, which are heavily harvested in the study area, are among the most vulnerable taxa. Their sedentary nature and close contact with contaminated sediments increase the likelihood of bioaccumulation of oil-derived toxicants (Beyer et al., 2016). Declines in shellfish populations have been widely reported following oil spill events and are often slower to recover than finfish stocks (Peterson et al., 2012). In Nembe, the reduced abundance of these resources directly affects women-led fisheries activities and household protein intake, intensifying gendered livelihood impacts.

The observed environmental degradation, including stressed mangrove systems and stranded organisms, reflects ecological imbalance consistent with chronic toxic exposure (Plate 14-16). Mangrove damage reduces habitat complexity and nursery function, weakening the resilience of coastal food webs and prolonging fisheries recovery (Alongi, 2018).

Plate 14–16: Degraded Environments at Study Area
Source: Author's field survey, 2022.

Human Exposure and Livelihood Risk

Although laboratory-based toxicological analyses were not conducted, human exposure pathways remain evident within the study environment. Consumption of fish and shellfish harvested from oil-impacted waters represents a recognised route for the transfer of bioaccumulated toxicants to humans (Santos Fogaça et al., 2025; Chidugu-Ogborigbo et al., 2025; Ogunbanwo et al., 2025). In wholly fishing settlements such as Sunnykiri, Tweni, Shellikiri, Ikegimakiri, and their constituent communities, near-total dependence on fisheries heightens nutritional and public health vulnerability.

Beyond food-chain exposure, oil spill impacts extend into livelihood systems through damage to fishing assets. Reports of oil-contaminated nets, boats, canoes, hooks, and outboard engines reflect indirect economic losses commonly associated with oil pollution in small-scale fisheries (UNEP, 2011). Contaminated fishing environments undermine artisanal livelihoods by degrading aquatic resources, increasing operational strain, and reducing household income, as oil pollution in the Niger Delta has been shown to damage fisheries and threaten the means of sustenance for fishing communities (Ejiba et al., 2016; Akafa et al., 2025).

Field observations showing the spread of oil from the Worikumakiri spill site into neighbouring rivers, creeks, ponds, and drinking water sources highlight the spatial reach of contamination. Tidal exchange and interconnected waterways facilitate the redistribution of oil across wide areas in the Niger Delta, exposing multiple communities simultaneously (Eferebo, 2022). Visible contamination of shorelines, residential areas, and household surroundings increases the likelihood of repeated exposure through domestic water use and daily activities. Oil spill impacts also extend to land-based livelihood activities. In Obioku, where homestead farming supplements fishing income, oil-contaminated soils have reduced agricultural productivity and rendered some plots unusable. Similar interactions between aquatic pollution and terrestrial livelihood loss have been reported in freshwater rainforest zones of the Niger Delta (Ordinioha & Brisibe, 2013). The loss of supplementary food production increases dependence on fisheries at a time when aquatic resources are already under stress, reinforcing livelihood fragility.

Against this backdrop, prevailing conditions reflect compounded livelihood risk, where toxicological stress affects marine resources, water quality, fishing infrastructure, and supplementary livelihood systems. This convergence of impacts heightens vulnerability among fisheries-dependent households, with direct implications for food availability, household health, and income stability.

Plate 17: Oil Spill–Impacted Farmland in Obioku Community Showing Degradation of Homestead Agricultural Land
Source: Author's field survey, 2022.

Implications for the Blue Economy

The blue economy relies on healthy marine ecosystems to sustain fisheries, employment, and coastal well-being (OECD, 2016). In Nembe, oil-induced toxicological stress undermines this

foundation by degrading habitats, reducing fisheries productivity, and eroding livelihood resilience. Reduced fish availability weakens income stability and increases occupational risk, particularly as fishers are forced to operate farther offshore under hazardous conditions. The intensification of fishing effort in degraded ecosystems, which can in turn accelerate economic disruption often leads to a decline in the standard of living for affected communities and can trigger broader economic instability (Sumaila et al., 2012; Almeida, 2023). These conditions create a feedback loop where environmental decline and economic vulnerability reinforce one another.

A functional blue economy cannot be realized in chronically polluted marine systems. Without effective spill prevention, remediation, and long-term ecosystem restoration, fisheries-based livelihoods in oil-producing coastal regions remain incompatible with sustainable blue economy objectives.

CONCLUSION

Oil spill contamination in the marine and coastal environments of Nembe has imposed sustained toxicological stress on ecosystems that directly support fisheries-dependent livelihoods. Where reliance on fisheries is near total, environmental degradation translates rapidly into reduced catch, damaged fishing assets, and heightened livelihood insecurity. Even in the absence of laboratory toxicology data, field observations, community accounts, and visual evidence indicate chronic exposure pathways consistent with the behaviour of crude oil constituents in mangrove and estuarine systems. Persistent contamination of sediments, nursery grounds, and shellfish beds disrupts recruitment processes, alters food-web structure, and entrenches long-term fisheries decline.

The consequences extend beyond ecological damage. Human exposure risks emerge through the consumption of contaminated fish and shellfish, while declining water quality and degraded farmlands reduce household resilience. This interaction creates a reinforcing cycle in which environmental stress weakens income security, increased fishing effort accelerates resource depletion, and recovery becomes progressively more difficult. Such conditions undermine the foundations of the blue economy, which depends on healthy marine ecosystems to sustain fisheries productivity, employment, and coastal well-being.

Addressing these challenges requires responses that recognise toxicological stress as both an ecological and livelihood issue. Remediation efforts should prioritise mangroves, mudflats, and shellfish beds that act as long-term toxic reservoirs and control fisheries recovery. Post-impact assessments should integrate livelihood indicators, such as catch trends, gear damage, and access to safe fishing grounds, alongside conventional biophysical measures. Community-based environmental monitoring can strengthen documentation of chronic pollution where laboratory data are limited, while targeted public health screening and fish safety measures can reduce

human exposure risks. Supporting livelihood diversification and enforcing stricter spill prevention and response standards are essential steps toward restoring ecosystem integrity. Without these integrated actions, the prospects for a functional blue economy in oil-impacted coastal regions such as Nembe remain severely constrained.

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