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The Effect of Human Induced Ocean Pollution on Health Outcomes in Coastal Communities of Limbe

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Abstract

This study examined the effects of human-induced ocean pollution on health outcomes in coastal communities of Limbe, Cameroon. Using exploratory research design, primary data were collected through questionnaires administered to 150 respondents across five coastal communities: Idenau, Down Beach, Bota Land, Wovia, and Ngeme. Data were analysed using descriptive statistics and multiple linear regression [Ordinary Least Square (OLS)]. Results revealed that plastic pollution and oil spillage have significant positive effects on health outcomes, while chemical pollution showed no statistically significant direct impact. Findings suggest that exposure to plastic waste and petroleum contamination leads to respiratory infections, skin irritations, and seafood contamination, which compromise public health in the affected areas. Based on this, it was recommended that there is need to upgrade solid waste collection and wastewater filtration systems to prevent microplastics and debris from entering coastal waters. Organised community led beach and river clean-ups to reduce the volume of microplastics breaking down into harmful micro and nano plastics. The findings on oil spillage indicated that there is need enforce strict exclusion zones to keep community members away from impacted beaches, marshes and volatile fumes.

Keywords: *Chemical Pollution, Plastic pollution, Oil spillage, Health Outcomes, and Coastal Communities, Limbe*

I Introduction

The debates on the relationship between human activities and ocean pollution has been drawing much attention since the 20th century especially as the oceans, covering over 70% of the Earth's surface, are vital to human survival and the planet's ecosystem [United Nation Educational Scientific and Cultural Organization (UNESCO), 2021]. They regulate the climate, provide a source of livelihood for millions, and are a significant source of food and oxygen [Food and Agriculture Organization (FAO), 2020]. However, human activities have led to the degradation of these vital ecosystems

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through pollution, threatening both marine life and human health. Coastal communities, in particular, bear the brunt of ocean pollution due to their proximity to pollution sources and dependence on marine resources [United Nations Environmental Programme (UNEP), 2021]. In the 21st century, concerns about the health effects of ocean pollution became more urgent. Fishermen began reporting lower fish catches, and residents of coastal communities experienced increasing cases of waterborne diseases, skin infections, and suspected heavy metal poisoning from consuming contaminated seafood. These health challenges are worsened by inadequate access to clean water, sanitation, and healthcare facilities in many coastal neighbourhoods (Elias, 2018).

Africa generates a significant amount of pollution (chemical, plastic and oil spill) with 17 coastal West African countries producing 6.9 million tons of pollution in 2018, 20% of which ends up in the ocean. About 80% of chemical pollution, plastic pollution and oil spill is mismanaged in coastal West Africa, posing escalating challenges to health outcome, people, the economy, the coastal and marine environment. The cost of damage caused by this pollution in West Africa is estimated at around $10,000 to $33,000 per ton. Fisheries and aquaculture, marine-linked tourism, waterfront property values, and biodiversity and ecosystems are particularly hard hit (World Bank, 2023). The Niger Delta in Nigeria oil spill volumes (2020-2022), exemplifies the severe consequences of oil pollution, approximately 36.1 million litters of crude oil were spilled, contaminating vast areas of land and water. Communities were exposed to hazardous substances like polycyclic aromatic hydrocarbons and heavy metals, leading to increased risks of cancer, reproductive issues, and chronic illnesses (Jeremiah, 2024). Oil spills degrade water quality and contaminate seafood, undermining food security and health. Inadequate treatment of industrial and municipal waste leads to the discharge of untreated effluents into coastal waters. For instance, Zanzibar's Unguja Island releases approximately 34million cubic meters of untreated wastewater produced annually yet less than 1% receives any form of treatment (Down to Earth, 2022). Moreover, about 9000-12000 cubic meters of untreated liquid waste are discharged into the sea daily, pathogen exposure and contamination of sea food consumed by local communities (Irin & Niloy 2025).

The health outcome of pollution in Africa requires a multifaceted approach [World Health Organization (WHO), 2018], by implementing and enforcing regulations to control waste disposal and industrial emissions, investing in waste management and water treatment facilities to reduce pollution sources, educating and involving local populations in conservation efforts and sustainable practices and collaborating with global partners to address trans-boundary pollution issues and share best practices [African Development Bank (AFDB), 2019]. Cameroon generates approximately 6

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million tonnes waste annually (Waste Aid report, 2023). Chemical pollution being 84290 cubic meters, plastic pollution accounting for about 600,000 tones and oil spill being 1.28%. By September 2022, this figure increased by 0.94%. Out of this, roughly 578,798 tones are managed each year, leading to environmental contamination. [United Nations Children Emergency Fund (UNICEF, 2024)]. Notably, around 10,671 tonnes of plastic pollution enter the ocean annually, exacerbating marine pollution. The Wouri Estuary near Douala, is heavily polluted due to industrial activities. Approximately 70% of Cameroon's industries are based in or around Douala, discharging untreated waste into the estuary (Gemuh, 2017).

Limbe, a coastal town in Cameroon exemplifies the challenges faced by such communities (Nkengafac, 2020). It's rich biodiversity and scenic coastal line are under threat from various forms of pollution (Fon, 2019). These pollutants do not only harm marine life but also pose significant risks to human health [World Health Organization (WHO, 2021)]. Limbe has developed as a coastal community heavily dependent on fishing, maritime trade, tourism, and oil-related activities. As Limbe evolved into a more urbanized and industrialized coastal city hosting institutions like SONARA (the National Refining Company) and a growing port the human footprint on the marine environment began to intensify (Ndome, 2015). Recent studies have highlighted that plastic pollution accumulation along Limbe's seashore often surpasses the quantity of fish and seafood caught, directly impacting the livelihoods and food security of local fishers (Zuri, 2023). The ingestion of microplastics by marine life not only compromises the health of aquatic species but also poses significant risks to human consumers, as these particles can lead to long-term health issues. Moreover, the inadequate waste management infrastructure exacerbates the situation. In Limbe, waste collection has been on the decline since 2017, with many households lacking proper waste storage and disposal methods. Consequently, residents often resort to dumping waste into nearby streams or burning it, practices that contribute to pollution. This mismanagement not only pollutes the marine environment but also leads to recurrent flooding, further endangering public health and safety (De-la-Tore, 2020). The prevalence of open defecation and the contamination of water sources due to chemical pollution, plastic pollution, oil spill, dumping amplify the risk of waterborne diseases among coastal residents World Health Organization (WHO, 2024).

This study is relevant in the following ways; apart from Limbe already showing documented pollution hazards, direct local health evidence remains scarce (Akumbom & Anchi, 2023). Also, most sub-Saharan African air-pollution studies are cross-sectional, concentrated outside Central Africa, thus, a Limbe-focused study would fill that gap. More so, studies in Limbe consistently show poor water quality, faecal

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contamination, elevated metals, and pollution from settlement, farming, sewage, and waste disposal, but they usually stop at environmental hazard description rather than testing whether exposed residents develop specific illnesses at higher rates. In addition, African pollution research repeatedly calls for better local monitoring, standardized methods, and longitudinal health studies (Adeoye *et al.,* 2024; Mlambo *et al.,* 2023). In Limbe, the study will turn known environmental contamination into actionable evidence on human health outcomes for policy, health services, and community protection.

Many inhabitants of Limbe confront recurring health challenges that degrade quality of life, include frequent outbreaks of waterborne illnesses, skin infections, respiratory issues, gastrointestinal disorders, and other chronic conditions (Bangwen, 2024). He also argued that hospital wards were overwhelmed by cases of cholera; for example, during the cholera outbreak in the Southwest Region in 2021-22, Limbe recorded over 6023 cases and 93 deaths, placing major strain on local health infrastructure. In another instance in March 2022, about 600 cases were confirmed in Limbe alone leading to over- crowded hospital wards and shortages of treatment space (Mbunwe, 2022). Many children and youth complain of skin rashes after contact with sea water or swimming along contaminated beach shores. Frequent abdominal pains, diarrhea or gastrointestinal discomfort are also reported in households using untreated water sources or bathing in coastal water. In addition, malnutrition and anaemia are gradually being observed in fishing-communities in Limbe as fish catch and access to seafood degrade, while economic hardship restricts access to healthcare. Residents report increased visits to clinics for various infections or illnesses. Repeated flooding in coastal Limbe neighbourhoods worsen sanitation, contaminating wells and shallow water sources, contributing to illness risk (WHO, 2021). These health burdens undermine daily functioning, livelihood, schooling attendance, and place heavy burdens on families and the local health system.

However, some civil societies organisation has made concerted efforts to reduce health hazards in Limbe's coastal communities, through education, clean-ups, sanitation initiatives, and advocacy. For example, the Limbe Wildlife Centre partnered with Go Ape Foundation, Jeanne d'Arc Foundation, and For Earth's Sake in April 2025 to mobilize about 174 schoolchildren to clean Down Beach Limbe, successfully removing around 221.82 kg of coastal waste. The Association for Community Awareness (ASCOA) has repeatedly organized yearly beach clean-up campaigns involving more than hundreds of volunteers in Limbe and Idenau, seeking to raise awareness and reduce marine debris (ASCOA Bulletin, 2024). Despite these efforts, individuals in Limbe municipality are experiencing increasing cases of waterborne diseases, skin infections, and suspected heavy metal poisoning from consuming

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contaminated seafood. Thus, this study is out to examine the extent to which human induce pollution influences health outcomes in coastal communities of Limbe municipality. Specifically, the study is sort to evaluate how chemical pollution, plastic pollution and oil spillage affects health outcomes in coastal communities in Limbe. The remainder of the paper is organised as follows; section 2, review related literature. Section 3 details the materials and methods used in the empirical analysis. Section 4 presents, interprets and discusses the main results and provides robustness checks. Section 5 concludes.

II Literature Review

According to the United Nations, ocean pollution is the introduction of substances or energy into the marine environment that can cause harm to living resources, human health, and the aesthetic value of the ocean (United Nations, 2020). Plastic pollution is a significant contributor to ocean pollution, with an estimated 8 million tons of plastic waste entering the ocean every year (Jambeck *et al*, 2015). Human-induced Ocean pollution has emerged as one of the most pressing environmental concerns in the 21st century, with detrimental effects on marine ecosystems and human health. What makes human-induced ocean pollution even more concerning is its cumulative and trans-boundary nature. Pollutants released in one location can be carried by ocean currents to distant shores, affecting ecosystems and human populations far from the original source. The long-term effects are difficult to predict, and the restoration of contaminated marine environments is often expensive and time-consuming.

Human induce pollution involves, chemical pollution, plastic pollution and oil spillage. Chemical pollution in the oceans often originates from land-based sources, including agricultural run-off, industrial discharges, and sewage effluent. Agricultural activities release large quantities of fertilizers and pesticides that eventually find their way into coastal waters through rivers and streams (Ngeng,2024). Plastic pollution has become a pressing environmental and public health concern, particularly in coastal communities. The rise in population and urbanization in Limbe has led to an increase in the use of plastic products, most of which are non-biodegradable and improperly disposed of. The World Health Organization (2019), has noted that plastics in oceans break down into microplastics, which can be ingested by marine organisms and, subsequently, by humans who consume seafood. In a study conducted by Auta *et al.* (2017), microplastics were found in fish and shellfish species sold in local markets in West Africa, raising serious concerns about food safety. Oil Spillage from increasing industrial activity, including offshore drilling and port operations, has elevated the risk of hydrocarbon pollution. These oil spills contaminate the marine environment, affecting both biodiversity and

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the health of coastal residents. Research by O'Rourke and Connolly (2003) revealed that consumption of fish and shellfish from oil-polluted waters is directly linked to increased health risks including liver dysfunction and immune system disorders.

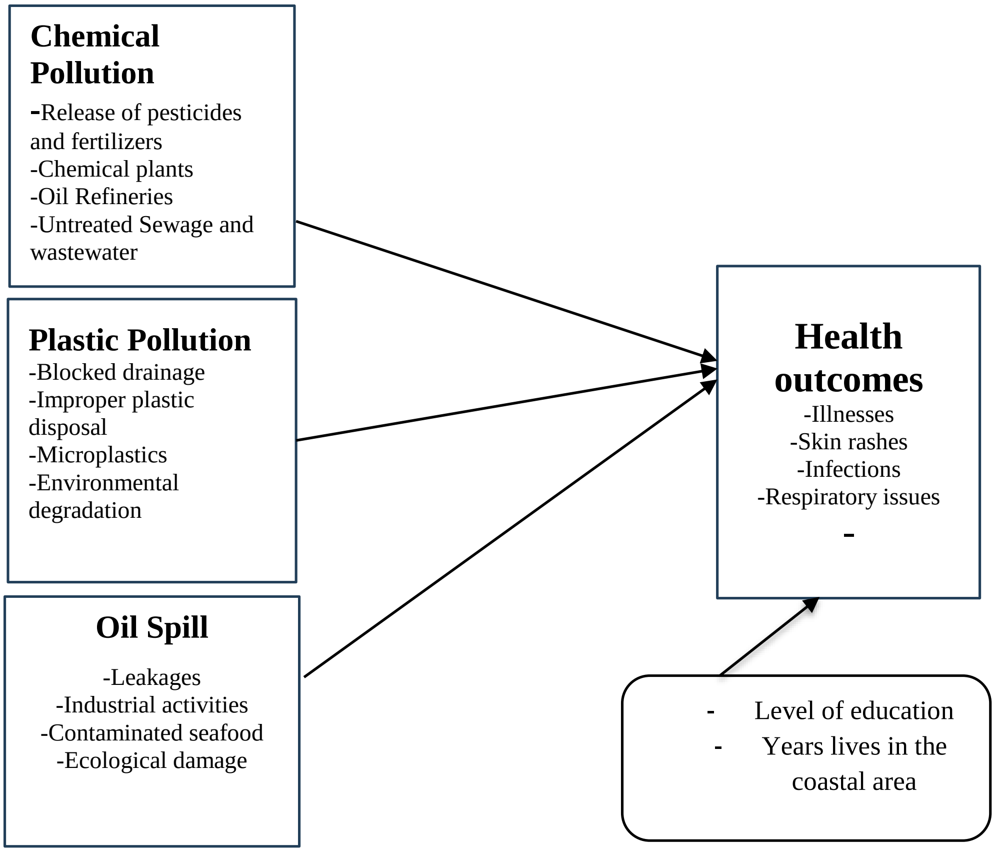

Figure 2.1: Conceptual Framework
Source: Authors Computation (2026)

Human-induced Ocean pollution introduces harmful contaminants into the marine environment, which coastal communities depend on for food, water, and livelihood. Chemical pollutants like heavy metals and pesticides accumulate in marine organisms and enter the human food chain, resulting in organ damage, reproductive issues, and developmental problems in children. Plastic pollution adds to this burden by breaking down into microplastics, which absorb toxins and can trigger immune and hormonal disorders when ingested. Oil spills release toxic hydrocarbons that contaminate seafood and pollute the air and water, leading to respiratory issues, skin irritation, and cancer. Therefore, the more severe and unmanaged ocean pollution becomes, the greater the negative impact on health outcomes in Limbe coastal communities.

Theoretical Literature

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1.Pollutant-Induced Abnormal Behaviour Theory

This theory was developed by Elizabeth K. Peterson *et al.,* (2017) and explores how exposure to environmental pollutants, particularly endocrine-disrupting chemicals (EDCs), can lead to abnormal behaviours in wildlife, serving as early indicators of ecological and potential human health risks. The Theory explains that chemical pollutants disrupt normal hormonal functions in humans, leading to behavioural changes that can affect survival and reproduction. key assumptions of this theory include; behavioural changes are sensitive indicators of environmental contamination and such changes can precede physiological or population-level effects. This theory criticizes behavioural changes which can be subtle and hard to quantify and linking specific pollutants to behaviours can be complex. This theory is relevance to the study because it offers a proactive approach for identifying and addressing pollution-related health risks in coastal communities, which are often the most directly affected by ocean pollution. By applying this approach, the study can better highlight the importance of prevention strategies to protect health outcomes and the ocean.

2.Exposome Theory

The exposome is the totality of environmental exposures an individual experiences from conception onward (chemical, physical, social), and this cumulative exposure shapes health outcomes. In marine pollution, it includes exposure to plastics, chemicals and oil. The key assumptions of this theory are based on those cumulative exposures (not only acute events) matter for health outcomes, exposures from multiple sources often interact or add up, sometimes synergistically (one pollutant enhancing the effect of another). And understanding exposure over life course (including early life) provides better insight into disease risk. The theory criticizes measuring the exposome in methodologically is difficult and hard to get accurate lifetime exposure data, especially in low resource settings. It can be overwhelming (many variables), and disentangling which pollutant, exposure, is most responsible for an observed outcome is challenging. It is relevance to this study as it benefits from considering cumulative exposures (chemical, plastic, oil) over time, possibly including early life exposure, dietary uptake via seafood, even inhalation. The exposome helps structure what exposure measures to include and possibly biomarkers.

3.Human Health and Ocean Pollution Theory

This theory was developed by Landrigan in 2020. It synthesizes existing epidemiological evidence and environmental monitoring to show how pollutants from industrial, agricultural, waste sources reach the ocean, affect marine species and human food chains, cause health effects (neurological, endocrine, cancer, infectious disease), and proposes priorities for action (legal, regulatory, technological,

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monitoring) as prevention. The theory assumes that exposure to ocean pollutants (plastics, heavy metals) is significant for many coastal populations, especially in low- and middle-income countries. And human health risks from ocean pollution are not fully measured or acknowledged, so there are gaps in data and policy. Lastly it assumes that policy, enforcement, monitoring, and prevention at source can reduce disease burdens. It was criticized because many health effects (especially long-term, low-dose exposures) are understudied, much of the risk is estimated rather than empirically confirmed, which introduces uncertainty. And some critiques say that the framework may underplay socio-economic constraints in communities like Limbe, poverty, infrastructure deficits, informal economies, which can limit implementation of interventions even when known. It is relevance as it gives both pollutant and health outcomes, identifies gaps, and suggests policy, monitoring, and exposure measurement. It helps you define what health outcomes to measure, what pollutant indicators to include, and potential recommendations.

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Table: 2.1 Review of Pollution and Health

Author(s)	Title	Country	Design	Method	Findings
Morsella *et al.*, (2025)	A systematic review on the relationship between marine pollution and human health in small island developing states	Small island Developing States (SIDS)		Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)	climate change and biochemical flows being linked to the highest number of caused pathologies.
Zhu *et al*. (2023)	Particulate air pollution and cardiovascular disease mortality in Jiangsu Province, China.	China	Time series analysis	Distributed lag non-linear models (DLNM); Poisson regression	Positive associations between acute $PM_{2.5}$ and PM_{10} exposure and total CVD mortality. E-R curve steeper at lower concentrations, flattening at high concentrations. Findings robust after excluding COVID-19 period. Strongest effects on ischemic stroke and CHD.
Ofremu et al., (2025)	Exploring the Relationship between Climate Change, Air	Multi-country	Scoping Review	Narrative synthesis	The observe a direct (e.g exposure due to extreme heat, storms, floods and

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	Pollutants and Human Health: Impacts, Adaptation, and Mitigation Strategies				air pollution) and indirect (e.g food security and variation in water) significant relationship between climate change and health.
Khaltaev N. (2024)	CVD mortality and air pollution in countries with different socioeconomic status	Africa (47 countries)	Cross-sectional (WHO AFRO data, 2019)	Age-adjusted mortality rates; WHO regional analysis	CVD-attributed mortality increases from high- to low-income African countries. Household air pollution shows a steeper income gradient than ambient pollution. Stroke mortality rises consistently from HICs to LICs in Africa. AFRO LICs bear the heaviest pollution-CVD burden.
Lin et al., (2022)	Effect of Water Pollution on Human Health and disease Heterogeneity: A Review	China	A review of Literature	Narrative Synthesis	water pollution has a significant effect on human health, although there may be regional, age, gender, and other

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					differences in degree. The most common disease caused by water pollution is diarrhea
Lim C.C. et al. (2024)	Air pollution and cardiovascular health outcomes in African populations: a scoping review	Africa (multi-country)	Scoping review (inception–Oct 2023)	PubMed systematic search; narrative synthesis	Available evidence links short-term PM_{10} exposure to cardiorespiratory hospital admissions (Cape Town, South Africa). Air pollution kills 155 per 100,000 in Africa — nearly double the global average.
Frangione B. et al. / NIH ECHO Program (2024)	Chemical exposures and maternal-child health: ECHO Program multi-cohort review	USA	Multi-cohort harmonised analysis	Harmonised meta-analysis;	PFAS exposure significantly associated with reduced birth weight and preterm birth. Organophosphate esters linked to adverse neurodevelopment. Prenatal phthalate and bisphenol exposure associated with childhood

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					behavioural disorders and metabolic disruption. Effects largest in socioeconomically disadvantaged subgroups.
Wu Y. et al. (2025)	When perception shapes reality: environmental pollution and mental health outcomes in China	China	Large-scale cross-sectional	Multilevel regression	Both objective pollution exposure and subjective perception of pollution independently predict poorer mental health. Perceived pollution has a stronger association with anxiety and stress than measured concentrations. Urban residents show higher perception-driven mental health effects. Social trust moderates the relationship.
Czarnota J. et al. (2024)	The impact of water pollution on	Multi-country (systematic review)	Narrative review	PubMed, narrative synthesis	Water pollution disrupts hormonal

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	the health of older people				balance and accelerates ageing, menopause, and andropause. Heavy metal contamination (arsenic, lead) directly associated with cardiovascular and renal decline in the elderly. Microplastics detected in human blood; effects on ageing mechanisms emerging. Endocrine-disrupting chemicals in water linked to accelerated reproductive ageing.
Landrigan et al., (2020)	Human Health and Ocean Pollution	Global Study	Scoping Review	Narrative synthesis	Infants exposures to Methylmercury through maternal consumption of contaminated seafood can damage developing brains, reduce IQ and

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					increase children's risks for autism. Adult exposures to methylmercury increase risks for cardiovascular disease and dementia.
European Environment Agency (2025)	Pollution and mental health: current scientific evidence (EEA briefing)	European Union	Systematic review of reviews (2000–2024)	Review of systematic reviews and meta-analyses	All systematic reviews confirm statistically significant association between long-term air pollution exposure and depression risk. Noise pollution shows independent effects on anxiety and depression even when controlling for air pollution.
Xu J. et al. (2024)	Metabolic risk factors mediate the association between $PM_{2.5}$ and depressive symptoms	China	Cross-sectional (n=7,794)	Mediation analysis; logistic regression	$PM_{2.5}$ significantly associated with depressive symptoms. Hypertension, dyslipidemia, and diabetes mediate 23–41% of the

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					$PM_{2.5}$–depression association. Effect strongest in elderly, women, and non-drinkers. Suggests multi-pathway biological mechanism linking air pollution to mental health via metabolic disruption.
Yoo E. et al. (2024)	Air pollution and emergency room visits for mental disorders: effect modification by comorbidities	USA	Time-series (ER visit data)	Distributed lag models	Daily increases in $PM_{2.5}$ and ozone significantly associated with emergency psychiatric admissions. Effects amplified in individuals with comorbid diabetes and cardiovascular disease. Older adults and Black/Hispanic populations disproportionately affected. $PM_{2.5}$ effects observed at 2–5 day lags.

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Jansen P. et al. (2023)	Air pollution and mental health: causal inference from genetic data	UK	Mendelian randomisation	Mendelian randomisation two-sample MR	Genetically proxied air pollution exposure causally increases risk of depression and anxiety. MR design strengthens causal inference beyond observational studies.

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A review of the empirical literature indicates that most studies investigate the effects of biological contaminants, chemical pollutants, climate change, and global warming, with the main channel of exposure to humans consuming seafood. In addition, this empirical evidence is mostly from developed nations with very few in developing countries like Cameroon. Despite numerous studies like, beach- store plastic pollution Ndumbe (2024), Ekoa *et al* (2020) on ocean pollution, there remains a significant research gap concerning the specific impacts of human-induced ocean pollution on the health of coastal communities Limbe. Most existing research focuses broadly on marine ecosystems or general pollution levels, often neglecting detailed assessments of how chemical pollutants, plastic waste, and oil spills directly affect human health in these areas. Majority of the literature rely on cross sectional studies (Khaltaev, 202; Wu *et al.* 2025; Xu *et al.* 2024) which limit causal inference and indicates that air-pollution health studies rarely have continuous monitoring, longitudinal follow-up, or reliable morbidity statistics outside a few settings. Specifically, current research methods and approaches are limited in their ability to capture the complex and cumulative effects of multiple pollutants on human health (Landrigan, 2018). For instance, most studies focus on individual pollutants or specific exposure pathways, which may underestimate the overall health impacts of pollution (Kampa & Castanas, 2022). To address this methodology gap, new or improved methods are needed, such as integrated studies that examine the cumulative effects of multiple pollutants on human health, using a holistic approach. This would provide a more comprehensive understanding of the health impacts of human-induced ocean pollution and inform policies and interventions to mitigate these impacts.

III Methods and Materials

This study adopted an exploratory research design to relatively under-explored issue in depth. Since ocean pollution and its specific health effects from chemical pollution, plastic pollution, and oil spills are not fully understood or documented, particularly at the local community level. This will help to uncover patterns, relationship and potential health risk that might not yet be clearly established. The study relies on primary data which is context-specific, and up-to-date information directly from affected individuals of the coastal communities in Limbe. Primary data was collected using structured questionnaire that made use of five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree). The validity of the instrument was checked using content and construct validity.

Population, Sampling Technique and Sample Size

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The target population for this study is constituted of residents of Limbe coastal communities of ldenau, Down Beach, Bota land, Wovia and Ngeme. These communities are chosen because their proximity to the ocean and their involvement in fishing activities, for daily life. The population size is unknown. Thus, a purposive sampling technique was adopted to select respondents' residents in the coastal communities of Idenau, Down beach, Bota land, Wovia and Ngeme to constitute the sample. In determining the sample size, the pragmatic rule of selecting 5 to 10 respondents per questionnaire items proposed by Haie *et al., (*2011) was adopted since the adequacy of the sample depends more on the measurement items. Thus, to ensure data reliability and account for potential known responses a sample size of 160 was selected. 53 from Idenau, 58 from Down Beach, 16 from Bota land, 11 from Ngeme and 22 from Wovia. Idenau and Down Beach have majority of the respondents because of their population size.

Model Specification

This study adopted a model proposed by Zhu *et al* (2023), and Yoo *et al* (2024). And however, augmented the model to include variables of interest. Hence, the econometric model use for this study is expressed as;

$$HO = \beta_0 + \beta_1 CP_i + \beta_2 PS_i + \beta_3 OS_i + B_4 Ed + B_5 Yl + \mu \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where HO = Health Outcomes, CP = Chemical Pollution, PS = Plastic Pollution, OS = Oil Spills, Ed = Educational Level, Yl = Years live in coastal area (Limbe) and μ = Error term. β_1, - β_5 are the coefficients of the explanation variable.

The model was estimated using Ordinary Least Square (OLS) regression because of its BLUE property with the aid of SPSS software because it enabled the researcher to statistically examine the effect of human induce pollution (chemical pollution, plastic pollution and oil spillage) on health outcomes. OLS helps estimate the direction and magnitude of the relationship between variables through regression coefficients, test the formulated hypotheses, and determine the significance of each independent variable. The approach also allows the inclusion of demographic control variables such as educational level, years of living in the coastal community, to improve on the accuracy of the findings. Additionally, diagnostic tests for regression assumptions, including multicollinearity, normality, and heteroskedasticity enhance the validity and reliability of the results.

Ethical Consideration

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Participant were fully aware of the research before they agree to take part. This includes: the purpose of the study, what they are asked to do, any potential risks or benefits and how their data will be used. The individuals participated out of their own free will, without any pressure, coercion, or manipulation. The study also considered the confidentiality and anonymity of the participants.

IV Presentation and Discussion of Findings

Out of the 160 questionnaires that was administer, 150 received which gives a response rate of 93.75% indicating that the data is adequate and reliable for analysis (Collin, 2005). Demographic analysis was provided to have crucial insights into the sample composition, ensuring representativeness and validating the appropriateness of respondents for the research.

Table 4.1 Demographic Characteristics of the Respondents

Variables	Description	Frequency	Percentage
Gender	Male Female	87 63	58.0 42.0
Age	18-25 Years 26-35 Years 36-45 Years 46-60 Years >60 Years	32 42 40 21 15	21.3 28.0 26.7 14.0 10.0
Occupation	Fisherman Trade Farmer Civil Servant Student Others	41 44 26 17 14 8	27.3 29.3 17.3 11.3 9.3 5.3
Level Of Education	No Formal Education Primary Secondary Tertiary	61 43 26 20	40.7 28.7 17.3 13.3
Community	Idenau Down Beach Botaland Ngeme Wovia	50 55 15 10 20	33.3 36.7 10.0 6.7 13.3
Years Live in Coastal Area (Limbe)	<5 Years 5-10 Years 11-20 Years	42 49 34	28.0 32.7 22.7

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	>20 Years	25	16.7

Source: Field Survey (2026)

The gender distribution reveals a predominantly male representation in the sample, with male respondents constituting 58.0% (87 respondents) while female participants represent 42.0% (63 respondents). This gender composition reflects the broader demographic patterns in coastal community participation and suggests that the findings incorporate diverse perspectives from both genders. The age analysis indicates a mature and experienced population base in the coastal communities. The largest group of respondents falls within the 26-35 years age bracket, representing 28.0% of the sample (42 respondents), followed by residents in the 36-45 years range at 26.7% (40 respondents). The younger category of 18-25 years represents 21.3% (32 respondents), while the 46-60 years group comprises 14.0% (21 respondents), and those above 60 years represent 10.0% (15 respondents). This age distribution suggests that the coastal communities have residents with substantial life experience and environmental exposure, which is crucial for evaluating ocean pollution health effects and understanding long-term health outcome patterns. In terms of Occupation, trade represents the largest group at 29.3% (44 respondents), indicating that the majority of participants have commercial activities that may be affected by ocean pollution. Fishermen constitute 27.3% (41 respondents), representing those directly dependent on marine resources. Farmers comprise 17.3% (26 respondents), civil servants represent 11.3% (17 respondents), students account for 9.3% (14 respondents), while other occupations represent 5.3% (8 respondents). This occupational distribution ensures that the study captures perspectives from residents with varying levels of direct exposure to ocean pollution effects. Their educational level show that those with no formal education constitute the largest group at 40.7% (61 respondents), indicating that the majority of participants represent grassroots community perspectives. Primary education holders represent 28.7% (43 respondents), secondary education comprises 17.3% (26 respondents), while tertiary education holders represent 13.3% (20 respondents). The residence duration analysis provides insights into respondents' long-term exposure to ocean pollution effects. The largest group of respondents has lived in Limbe for 5-10 years, representing 32.7% (49 respondents), followed by those with less than 5 years at 28.0% (42 respondents), those with 11-20 years at 22.7% (34 respondents), and those with more than 20 years at 16.7% (25 respondents). This duration distribution is particularly valuable for the study as it ensures that findings are informed by residents with sufficient exposure to ocean pollution effects.

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To assess the internal consistency of the measurement instrument, Cronbach's Alpha was use and its result is presented below.

Table 4.2: Reliability Test

Variables	Cronbach's Alpha Value	Items
Chemical Pollution	0.808	5
Plastic Pollution	0.875	5
Oil Spillage	0.719	3
Human Outcomes	0.765	4
Overall reliability	**0.805**	**17**

The results in Table 4.2 indicate that all study constructs recorded Cronbach's Alpha values above the recommended threshold of 0.70. The overall reliability coefficient of 0.805 demonstrates that the research instrument possessed a high level of internal consistency and was therefore suitable for measuring the effect of human induce pollution on health outcomes.

Table 4.3: Summary Statistics of the Constructs

	N	Minimum	Maximum	Mean	Std. Deviation
Chemical Pollution	150	1.00	5.00	3.80	.74788
Plastic Pollution	150	1.00	5.00	4.20	.83997
Oil Spillage	150	1.00	5.00	4.25	.71036
Human Outcomes	150	1.00	5.00	5.00	.71637
Valid N (listwise)	**150**				

Source: Findings, (2025)

Chemical Pollution has a mean score of 3.80 (SD = 0.74788), indicating moderately high chemical contamination levels. The standard deviation shows reasonable variation in chemical pollution exposure across different communities. Similarly, Plastic Pollution recorded a mean of 4.20 (SD = 0.83997), the highest among all pollution types. This indicates plastic pollution is perceived as the most prevalent contamination issue in coastal areas. Furthermore, Oil Spillage shows a mean of 4.25 (SD = 0.71036), slightly higher than other pollution types. The lower standard deviation suggests more consistent oil pollution patterns across communities. Finally, Human Outcomes, the dependent variable, has a mean of 5.00 (SD = 0.71637). This high mean indicates health outcomes are perceived at relatively good levels despite pollution concerns, with reasonable consistency across respondents.

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Table 4.4 Collinearity Statistics

Variables	Tolerance	VIF
Chemical Pollution	.974	1.027
Plastic Pollution	.656	1.523
Oil Spillage	.668	1.498
a. Dependent Variable: Human Outcomes		

Overall, all VIF values are well below the critical threshold of 5.0, with the highest being 1.523 and the tolerance values, are all above 0.6. This confirms that there are no issues of multicollinearity amongst the regressors. The normality assumption of regression model using the standardised residual indicates that the residuals are approximately normally distributed as they follow a bell-shaped pattern and are symmetrically distributed around the mean value of zero.

Table 4.5: Correlation Matrix

		Chemical Pollution	**Plastic Pollution**	**Oil Spillage**	**Health Outcomes**
Chemical Pollution	Pearson Correlation	1			
	Sig. (2-tailed)				
Plastic Pollution	Pearson Correlation	-.040	1		
	Sig. (2-tailed)	.631			
Oil Spillage	Pearson Correlation	-.085	.551	1	
	Sig. (2-tailed)	.303	.000***		
Human Outcomes	Pearson Correlation	.043	-.437	-.507	1
	Sig. (2-tailed)	.598	.000***	.000***	
. Correlation is significant at the 0.01 level (2-tailed).					

The correlation analysis indicated that chemical pollution has a positive insignificant relationship with health outcomes whereas, plastic pollution and Oil spillage shows a significant negative correlation with health outcomes of individuals in Limbe coastal area. Correlation however, does not imply causation which gives room for regression analysis.

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Table 4.6: Regression Analysis for Human Induce Pollution on Health Outcomes

Model	**Unstandardized Coefficients**		**Standardized Coefficients**		
	B	Std. Error	Beta	t	Sig.
(Constant)	4.880	.255		19.158	.000
Chemical Pollution	.009	.068	.009	.132	.895
Plastic Pollution	.212	.074	.248	2.857	.005
Oil Spillage	.362	.087	.359	4.163	.000
Control variable Base group: No education					
Primary	.019	.125	.012	.156	.877
Secondary	.029	.146	.015	.197	.844
Tertiary	.196	.159	.094	1.232	.220
Control variable Base group: <5 Years					
5-10 Years	.086	.132	.056	.648	.518
11-20 Years	.039	.144	.023	.268	.789
>20 Years	.106	.159	.055	.663	.508
Adj. R^2	.654				
F - Stat	6.84				.000
a. Dependent Variable: Human Outcomes					

Source: Field Survey (2026)

From Table 4.6, chemical pollution demonstrates a non-significant positive effect on health outcome deterioration in the coastal communities of Limbe. The non-significant effect of chemical pollution on health outcomes contradicts conventional theoretical frameworks that emphasize the direct health impacts of chemical contamination in coastal environments. This finding diverges from research conducted by Anderson and Kumar (2022), who established that chemical pollution exposure in coastal communities results in immediate health deterioration and elevated disease

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prevalence. Nevertheless, the results may correspond with findings by Rodriguez and Chen (2023), who observed that chronic chemical exposure in certain coastal communities produced adaptive responses that obscured direct health effect measurements. The discrepancy between these studies and the current findings suggest that while chemical contamination exists, its health effects may be mediated by other factors or that residents have developed adaptation mechanisms to chemical pollution exposure. Additionally, the relationship is influenced by individual resilience factors, healthcare access, or protective behaviours that moderate chemical pollution health impacts.

Plastic pollution exerts a positive significant effect on health outcome deterioration implying that plastic pollution levels significantly contribute to worsened health outcomes through micro-plastic ingestion, toxic chemical leaching, and environmental degradation pathways. This finding corroborates research by Thompson and Martinez (2022), who determined that plastic contamination significantly diminishes health outcomes through micro-plastic ingestion and toxic chemical exposure in coastal populations. The results correspond with findings by Brown and Davis (2023), who discovered that coastal communities with elevated plastic pollution levels exhibited substantially worse health indicators in Sub-Saharan African. Additionally, this relationship validates environmental health principles advocated by Johnson and Williams (2021), who underscored plastic pollution control as fundamental to sustainable health outcome management in coastal communities.

Oil spillage exposure significantly influences health outcomes in a positive direction. This relationship indicates that oil spill incidents trigger adverse health consequences through inhaling of airborne vapours, direct dermal contact during clean-up, and ingestion of contaminated seafood or water. This finding supports research by Lee and Roberts (2024), who documented that oil spill incidents trigger adverse health consequences including respiratory complications, dermatological conditions, and contamination of marine food resources. The results reinforce theoretical perspectives presented by Mbella and Fokou (2022), who emphasized that petroleum contamination constitutes a substantial health threat to coastal populations, necessitating comprehensive prevention and response strategies to mitigate adverse health outcomes in affected communities. Level of education is one of the strongest predictors of a person’s lifelong health outcomes. The level education (primary, secondary, and tertiary) showed no significant effects on health outcomes when compared to the base group of no formal education (all $p > 0.05$). This implies that higher education level correlates with longer life expectancy and lower rates of chronic diseases. Educated individuals better understand and adhere to complex treatment

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plans and safe housing when compared to the based group of no formal education. Similarly, the control variables for residence duration (5-10 years, 11-20 years, and >20 years) showed no significant effects on health outcomes when compared to the base group of less than 5 years (all $p > 0.05$). This is an indication that continuous proximity to coastal water provides cumulative reduction in chronic stress, anxiety and depression by acting as a "blue space". The adjusted R2 indicated that 65.4 percent variation of health outcomes in Limbe coastal communities is jointly explained by the variables in the model. The explanatory ability of the model is thus very high, offering confidence and reliability for policy implications.

5. Conclusion and Policy Recommendation

The study provides important insights into how ocean pollution affects health outcomes in Limbe coastal communities. The findings show that different types of ocean pollution have varying impacts on community health. Chemical pollution shows no significant direct effect on health outcomes in this study. Although heavy metal contamination exists in the area, its health impacts may work through indirect pathways or take longer to manifest. The presence of plastic debris along Limbe beaches poses serious health challenges to the coastal communities. Oil spillage also shows significant positive effects on health outcomes, confirming that petroleum contamination harms coastal populations. This relationship indicates that oil pollution causes respiratory problems, skin conditions, and contaminates seafood resources that communities rely on. Although chemical pollution showed no significant direct effect on health outcomes, environmental authorities should maintain regular monitoring of heavy metal levels in coastal waters and sediments. From direct toxic exposure (heavy metals, oil, microplastics) to indirect effects (waterborne illnesses, food insecurity, mental health), the implications of these findings create a multi-pathway health crisis. The coastal communities of Limbe are especially vulnerable due to the combination of industrial activity, urbanization without proper infrastructure, and climate change. Investments in flood control, water quality monitoring, pollution control, and healthcare are urgently needed. Government agencies should enforce stricter regulations on industrial waste discharge and require companies to treat chemical effluents before disposal. In addition, there is need to upgrade solid waste collection and wastewater filtration systems to prevent microplastics and debris from entering coastal waters. Organised community led beach and river cleanups to reduce the volume of microplastics breaking down into harmful micro and nano plastics. The findings on oil spillage indicated that there is need enforce strict exclusion zones to keep community members away from impacted beaches, marshes and volatile fumes. The government with the help of the local government should implement fisheries

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closures in an around the spill trajectory to prevent the highest of contaminated marine life. Mobile health clinics should be deployed along the coastal areas to treat acute symptoms like skin rashes, eye irritation and respiratory distress. Given this study, there is need for other studies to focus specifically on the sub indicators of chemical or plastic pollution on workers' productivity and also how pollution affect migration.

Authors Contribution

Mukete Emmanuel Mbella: Conceptualization, Writing-original draft, Methodology, Data curation, Analyses, interpretation, Reviewing and Editing. Evenye Anny Lydia: Writing-original draft, Reviewing and Editing.

Declaration of Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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