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Impact of Marine Pollution on Human Health and Well-being

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Abstract: Healthy ocean supports the human health with the provision of food, marine drugs, recreation, and also acts as a natural sink to absorb different types of wastes produced by the anthropogenic activities. Health of the ocean ecosystem is directly related with the human activities such as fishing, aquaculture, agriculture, coastal industries, urbanization, coastal infrastructure, development, etc. Due to the indiscriminate release of wastes into the sea, the marine ecosystem is threatened by limiting the carrying capacity of the ocean; finally resulting in ocean pollution. Ocean pollution causes negative impacts on human health due to the presence of harmful marine microorganisms (harmful algal blooms, viruses, bacteria, protozoa, etc.), marine litter, solid wastes, plastic, persistent organic pollutants (POPs), nutrients, sewage, etc. Present study focuses on marine pollution with reference to its definition, types, sources, impacts on human health, protections for human health, and preventive measures. It is observed that, ocean pollution have a devastating effect on the human health. The study recommends that policy of '5 R' such as recycle, reduce, refuse, rethink, and reuse can reduces the ocean pollution of the global scale.

Keywords: Chemicals, Diseases, Health impacts, Marine pollution, Oil, plastics, Sewage

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Introduction

The marine ecosystem supports the human health by the provision of food and also by acting as a natural sink to accommodate the wastes (Watkins, 2004). Different marine-derived bioproducts have been used as pharmaceuticals, molecular probes, nutrients, industrial uses, and interdisciplinary marine biomedical research; along with medical devices, diagnostics, enzymes, pigments, and cosmetic additives (NRC, 2002).

WHO (2019) stated that, ocean supports the human health and well-being by the provision of healthy seafood, animal proteins, vitamins and marine metabolites. Coastal system promotes the physical and mental health of humans by decreasing the vulnerability to depression (Wheeler *et al.*, 2014). Ocean pollution poses serious threats to human health and well-being (Landrigan *et al.*, 2020).

NAS (2007) noted that, pollution is the release of undesirable substances into the environment as a result of human activities such as industrial production, burning of fossil fuels, agriculture, and product use. Pollutants generated by these activities can find their way into the ocean and significantly alter marine ecosystems and cause deadly harm to species from the top to the bottom of the food web (The Aquarium of the Pacific, 2009).

Yusuf *et al.* (2021) described the 'marine pollution' as "the introduction by man, directly, or indirectly, of substances or energy to the marine environment resulting in deleterious effects such as: hazards to human health, hindrance to marine activities, impairment of the quality of seawater for various uses and reduction of amenities." Ocean pollution is originated from land based sources and has been linked with discharge and wastes from the offshore industry, marine shipping, and unregulated wastes disposed at the sea (Verma *et al.*, 2020).

Pollution of the oceans is widespread, worsening, and poorly controlled. It is a complex mixture of toxic metals, plastics, manufactured chemicals, petroleum, urban and industrial wastes, pesticides, fertilizers, pharmaceutical chemicals, agricultural runoff, and sewage (Prakash, 2017). Visible component of ocean pollution includes plastic, mercury released from coal combustion and small-scale gold mining, industrialized agriculture with use of chemical fertilizers, and chemical pollutants contaminate seas (Landrigan *et al.*, 2020).

Ocean pollution is an ever-changing mixture of chemicals and biological materials that includes plastic waste, petroleum-based pollutants, toxic metals, manufactured chemicals, pharmaceuticals, pesticides, and a noxious stew of nitrogen, phosphorus, fertilizer, and sewage (Emenike *et al.*, 2023). Human activities are responsible for increase in global ocean temperatures, heat wave, and ocean acidification. Changes in climatic conditions could also drive pathogenic microorganisms into the water body causing

threat to human health due to the spread of infectious diseases (WHO, 2023).

Law (2017) noted that increased ocean pollution by unregulated disposal of plastics, pharmaceutical wastes, petroleum wastes and oil spills, and microbial load have devastating effect on the human health, marine species, and the health of the planet. Accumulation of undigested plastic wastes in the gastrointestinal tract of marine fishes and seabirds has resulted in increased mortality in these animals. Microplastics can cause damages to the tissues and cells of marine species while nanoplastics can penetrate the gut lining, bloodstream, and organs of marine species when ingested, leading to organs damage and death (Moore, 2021; Mehta *et al.*, 2023).

Water pollution is a major contributor of health problems in humans and ocean ecosystems. It has an impact on human lives, hence, we should not throw trash or chemicals into water bodies. One can contribute to the improvement of aquatic life and health in general. Not only the government but also the non-governmental organizations as well as every individual should contribute their part in conserving the marine resources to lead a healthy life (Jeyakumar, 2013).

Health of the marine ecosystem is affected by anthropogenic activities of human and it finally causes hazards to human health by impairing the quality of sea-water (Liu, 2022). Also, changes in the marine and coastal systems exert negative effects on the human health (Raes *et al.*, 2021). Coastal tourists which are engaged in sea activities and eat seafood were also exposed to marine pollution that harms human health (EMB and CEFAS, 2020).

Petrie *et al.* (2015) described that, main causes of the marine pollution includes agricultural waste, industrial effluents, marine debris, marine garbage, oil spills, and disposal of sewage in the ocean. Rapid industrialization; expansion of chemically intensive agriculture; massive releases of liquid and solid waste into rivers, harbors, and estuaries; and insufficient re-use and recycling of

feedstock materials are also the major drivers of ocean pollution (Landrigan *et al.*, 2020).

Major marine pollutants include ballast water with invasives, sewage, waste oil, heavy metals, biological waste, and millions of tonnes of solid waste (Leo, 2021). Parr (2020) stated that, waste products produced by human finally end up in the sea and endangers the marine life through entanglement, ingestion and intoxication. People engaged in sea activities such as recreation, swimming, tourism and eat the seafood are exposed to marine pollution that harms the human health. Marine litter has direct consequences on human health and safety.

According to Mehta *et al.* (2023), ocean pollution seriously threatens the ecosystem, marine life, and human health. It causes loss of biodiversity and ecosystem services, choking, asphyxia, and hunger in marine creatures, harm and even death of marine species due to entanglement, infertility, abnormal development, and population decline of marine organisms, displacement of native species and disturbs the entire ecosystems due to establishment and spread of invasive species.

Moore (2021) stated that health of the ocean has significant consequences on human health because about 70% of the oxygen is generated by marine plants and around 97% of the Earth's water supply is stored in oceans. Also, most of the carbon emissions produced by human activity are absorbed by the ocean. Therefore, the ocean is vital to the health of humans, and human are vital to the health of the ocean. Further, exposure of human to the pollutants poses the greatest threat to humanity and is a significant cause of environmental illness and mortality (Shetty *et al.*, 2023).

Landrigan (2021) noted that pollution and climate change are two linked threats to planetary health. Both threaten the health and well-being of all people and the sustainability of human societies. Pollution requires a global response and urgent attention is needed to control hazardous

chemical pollution. Also, control of pollution needs a globally supported policy and funding. Pollution has to be considered as a local issue and to be addressed through regional policy and national regulation (Fuller *et al.*, 2022).

Ocean pollution was ignored for years, but recently the consequences have become more visible. Even small amounts of pollution can become a problem when they accumulate overtime (The Aquarium of the Pacific, 2009). The pollutants can cause detrimental effects to the activities, health, and survival of humans. It threatens biodiversity, climate, and the preservation of some of the most treasured locations on the planet. Ocean pollutants are grouped into different classes based on similar characteristics, sources, and effects (Bergmann and Klages., 2012).

This review focuses on the recent information available on, 'marine pollution' with respect to definition, types, sources, impacts on human health, protections for human health, and preventive measures. This review summarises and analyses primary information created and provided by other academic and professional researchers who studied ocean pollution and its effects on human health. Literature review was conducted using the search terms such as, pollution, ocean, diseases, health, and hazards in relevant studies on EMBASE, Google Scholar, Medline, NCBI, PubMed, Science Direct, Scopus, and Web of Science databases.

Types of marine pollution:

- *Agricultural runoff:* Chemical nutrients (nitrates and phosphates), herbicides and pesticides (DDT, PCBs, furans, TBT, radioactive waste, phenols, and dioxins) (Verma *et al.*, 2020).
- *Biological contamination:* By marine algae; Harmful Algal Blooms (HABs); ocean bacteria, viruses, and protozoa (Moore, 2021).
- *Chemicals, Metals and Radioactive substances:* Persistent Organic Pollutants (POPs), Mercury,

Methylmercury, and Manufactured chemicals: Halogenated aromatic hydrocarbons (HAHs), Organometals, Organophosphorus flame retardants (OPFRs), Perfluoroalkyl substances (PFAS), Pesticides, and Polynuclear aromatic hydrocarbons (PAHs). Pharmaceuticals: Therapeutic drugs (medical and veterinary applications) (Landrigan *et al.*, 2020).

- **Energy:** Thermal and light.
- **Oil Spills:** Crude oil and petroleum products (Polycyclic aromatic hydrocarbons [PAHs], toxic metals, and other chemicals) (Mehta *et al.*, 2023).
- **Sedimentation:** Sediments contaminated with pollutants, Siltation due to surface runoff (Fuller *et al.*, 2022).
- **Sewage:** Faecal Coliform and nutrients (Shetty *et al.*, 2023).
- **Solid Waste:** Marine debris (The Aquarium of The Pacific, 2009). Plastics (Microplastics, Microfibers, and Tire-wear particles); Personal Care Products (PPCPs): Cosmetics, and cleaning products (Mehta *et al.*, 2023).

Sources of marine pollution:

Jeyakumar (2013) reported that the primary sources of marine pollution are runoff from fertilizers, animal manure, sewage discharges, car and power plant emissions, failing septic tanks and residues from industries. According to EMB and CEFAS (2020), sources of marine pollution are either land-based or from maritime activities.

- **Land-based sources:** About 80% of ocean pollution comes from land based activities and includes discharge of sewage and chemical wastes from industries and food processing units directly into marine waters. It also includes riverine flows and air discharges with pollutants to the sea (Verma *et al.*, 2020).
- **Maritime sources:** Major sources include discharge of oils, ballast water and bilge water of ship operations and illegal dumping of solid waste; along with wastes from dumping

grounds at sea (dredged spoil, old munitions, sewage sludge, fly ash, oil based drilling muds). Accidental spills from ships carrying hazardous substances, oil, gas etc., and discharges from marine shipping, offshore industrial operations, and waste disposal at sea are the other maritime sources (EMB and CEFAS (2020).

- **Specific sources:** Coal combustion and gold-mining as a major source of mercury pollution; manufactured chemicals; plastic wastes; industrial releases, agricultural runoff and sewage; pathogenic bacteria, viruses, parasites, and harmful algal blooms (HABs); and oil from natural seeps, oil discharge during the extraction, transportation and consumption of oil from sea-based and land-based sources (Landrigan *et al.*, 2020).

Impact of Marine Pollution on Human Health and Well-being:

WHO (2023) recorded that in 2016, 13.7 million deaths were attributable to modifiable environmental factors, such as chemicals, waste and pollution. The most hazardous ocean pollutants with public health concern include lead, mercury, cadmium and highly hazardous pesticides. Even marine pathogens can also threaten the health of humans, marine organisms, and the marine ecosystems (Watkins, 2004).

The rising ocean pollution causes detrimental effect on the health of humans. Human health risks from plastics are mainly from their building blocks, their additives, or from a combination of the two (Prakash, 2017). Significant threats of ocean pollution on the human health are presented in Table 1.

Protections for Human Health from ocean pollution:

Watkins (2004) reported that for protection of human health from the ocean pollution, better understanding of the links between the oceans and human health, and improvements in management are necessary. It should be achieved by protecting seafood safety and maintaining clean coastal waters and beaches.

Table 1: Potential human health impacts of ocean pollution

S. No.	Human health effects	Cause	Reference
1	Acute diseases and death	Consumption of seafood contaminated with toxin of algal bloom.	Leo (2021)
2	Acute gastrointestinal diseases, skin and other infections.	Antibiotic-resistant organisms (<i>Staphylococcus aureus</i> , <i>Vibrio</i> spp.) in coastal waters and seafood.	WHO (2019)
3	Alterations of metabolic profiles in the liver and disturbed lipid and energy metabolism	Ingestion and accumulation of microplastics in the liver and gut.	Blackburn and Dannielle (2022)
4	Antibiotic-resistant infections	Consumption of seafood with accumulation of the suspended particulate matter in the tissue.	Fuller <i>et al.</i> (2022)
5	Diseases, respiratory issues, and skin irritation	Swimming in dirty waters or eating contaminated seafood.	Mehta <i>et al.</i> (2023)
6	Disruption of food chain	Chemical additives (plasticizers and organic chemicals)	Raes <i>et al.</i> (2021)
7	Disturbed livelihoods	Littered beaches and polluted water does not attract tourists, causing financial loss, job displacement, and affect overall health.	Parr (2020)
8	Health hazards of Microplastics (Irritation in the eye, vision failure, breathing difficulties, respiratory problems, liver dysfunction, cancers, skin diseases, lungs problems, headache, dizziness, birth effect, reproductive, cardiovascular, genotoxic, and gastrointestinal causes for using toxic plastics).	Microplastics (fragments, granules, filaments, pellets, films, foams, fibers) and its components: Bisphenol-A (BPA), Phthalates, Persistent Organic Pollutants (POPs), Dioxins, Polycyclic aromatic hydrocarbon (PAHs), Polychlorinated biphenyls (PCBs), Styrene monomer, Polystyrene	Mathieu <i>et al.</i> (2014), Verma <i>et al.</i> (2020), Moore (2021), Yusuf <i>et al.</i> (2021), Liu (2022), Mehta <i>et al.</i> (2023)
9	Immunosuppression, developmental and neurological diseases, cancer	Persistent organic pollutants - Pesticides (DDT: dichlorodiphenyltrichloroethane), the industrial polychlorinated biphenyls (PCBs), heavy metals.	Shetty <i>et al.</i> (2023)
10	Immunotoxicity	Toxins produced by the interaction of microplastics and chemical pollutants (Persistent organic pollutants, POPs).	Watkins (2004), Prakash (2017)
11	Indirect health effects (Transmission of infectious diseases)	Chemicals, toxins, viruses, or bacteria in the water. Medical waste and sewage.	Parr (2020)
12	Inflammatory responses, respiratory lesions and irritation	Inhalation of plastic textile fibres; microfibers, fragments and granules of plastic.	Blackburn and Dannielle (2022)
13	Intestinal toxicity (Mucosal damage, increased permeability, inflammation, metabolism disruption and microbiota dysbiosis)	Accumulation of beads, fragments and fibres of microplastics in the intestine.	Jeyakumar (2013), Mathieu <i>et al.</i> (2014)
14	Long-term health effects (Cardiovascular threats and brain damage)	Consumption of marine food contaminated with mercury.	Landrigan <i>et al.</i> (2020)

15	Non-communicable diseases (Cancer)	Consumption of seafood contaminated with plastic residues.	Prakash (2017)
16	Physical damage by marine litter	Injury from debris: Broken glass, medical waste or entanglement in floating or submerged debris.	Parr (2020), TDS (2024)
17	Physical injury ((blockage of the gastrointestinal tract, reduced energy intake, impaired respiration, inflammation and stress), and chemical toxicity	Exposure to nano-microplastics induces physical injuries and chemical toxicity by bisphenol A, PCBs and polycyclic aromatic hydrocarbons.	WHO (2019)
18	Spread of infectious diseases	Cholera during contact with water contaminated by <i>Vibrio cholera</i> .	Leo (2021), Mehta <i>et al.</i> (2023)
19	Toxicity, Carcinogenicity and Mutagenicity	Consumption of seafood contaminated with additives, dyes, plasticizers and pigments leached from microplastics.	Verma <i>et al.</i> (2020), Moore (2021)

- **Seafood Safety:** Though the seafood is wholesome and nutritious, consumption of contaminated seafood is a serious risk to the public health. It may cause biological hazards from bacteria and viruses; chemical hazards from toxins (ciguatoxin, tetrodotoxin), POPs such as mercury.

For the safety, the seafood and aquaculture products must be monitored to analyse potential hazards in preparing, handling, and packaging seafood and implement plans to control these hazards. To protect against diseases, high concentrations of pharmaceuticals can be used as a preventive measure. The seafood must be checked for the contamination by harmful algal blooms, bacteria, and viruses; and also for chemical contaminants such as methyl-mercury (Dorfman, 2003).

- **Coastal Water Quality:** The coastal water is contaminated with pathogens that come from human and animal wastes. Health of the people participating in recreational activities in or near unhealthy waters may be threatened by swimming-associated diseases caused by viruses; and also by bacteria, harmful algal blooms, and microbial pathogens (amoebae and other protozoa). The coastal waters must be monitored for water quality parameters, especially for the presence of indicator organisms like *Escherichia coli* (Watkins, 2004).

- **Public Education and Outreach:** Human health can be protected by reducing the coastal pollution from various sources mainly by public education. General public should become aware regarding health impacts of ocean pollution by organization of educational campaigns. Common people should be informed about relation between coastal pollution and contamination of marine food resources, thereby affecting human health. Various seafood safety programs should be organized for the officials of seafood industry, recreational fishermen, and consumers to overcome and prevent the outbreaks of seafood-related illnesses (Watkins, 2004).

Prevention and Control of Ocean Pollution:

Parr (2020) noted that many small actions of the citizens can make a big difference in prevention and control of health hazards of marine pollution. The best way to prevent the ocean pollution is to minimize the entering of new litter in the marine environment.

The '5 R' policy can reduce the ocean pollution at the global scale (Parr, 2020).

- **Recycle:** Wastes like plastic, paper, cardboard are recycled separately.
- **Reduce:** Use of packed products should be reduced.

- **Refuse:** Single use disposable plastics should be avoided.
- **Rethink:** Before discard the waste, think for its effect on the human health.
- **Reuse:** Use reusable coffee mugs, water bottles and shopping bags.

Ocean pollution can be controlled by measures such as: global ban on production of single-use plastic; create marine protected areas; end plastic pollution of the oceans; International Marine Pollution Control Programs to all countries; prevent mercury pollution of the oceans; promote effective waste management; reduce releases of nitrogen, phosphorus, animal waste, industrial discharges and human sewage into coastal waters; and support robust monitoring of ocean pollution (Landrigan *et al.*, 2020). Reductions in chemical fertilizer use and opt for reusable bottles and utensils also control the ocean pollution to certain extent (TDS, 2024).

Conclusion

This review indicates that ocean pollution have a devastating effect on the human health. Review of published literature reveals that, still insufficient data is available on detailed impact of marine pollutants and their target organ in human body. It is suggested that special funds should be allocated to the various research organizations working on detailed impact of marine pollution on human health at regional, national and global level. Policy of '5 R' such as Recycle, Reduce, Refuse, Rethink, and Reuse can reduces the ocean pollution at the global scale.

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