ASSESSING THE CHEMICAL EFFECTS OF OCEAN POLLUTION ON MARINE LIFE

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ABSTRACT

Pollution - undesired waste discharged to air, water, and land by human activities – is the leading environmental cause of disease in the world today. It is responsible for an estimated nine million premature deaths each year, massive economic losses, depreciation of human capital, and damage of ecosystems. Ocean pollution is a major, but little acknowledged and badly regulated component of global pollution. It presents major hazards to human health and well-being. The nature and severity of these repercussions are only beginning to be appreciated. Water quality concerns have been the major challenges that humanity has faced for so many decades. Natural water pollution in practically all places of the world has become a serious societal problem. This study report seeks to give a complete overview of the consequences of ocean pollution on marine life. It covers the numerous sorts of pollutants, including plastic trash, chemical contaminants, oil spills, and fertilizer runoff, and their adverse consequences on marine life.

Keywords- *Ocean; Marine life; Water; Chemical; Pollution*

INTRODUCTION

The degradation of marine ecosystems due to pollution is a global environmental emergency. Plastic trash, chemical contamination, oil leaks, and fertilizer runoff are all part of this. The waters are contaminated by contaminants from a wide range of human activities, including manufacturing, inappropriate waste management, and farming. Once released into the ocean, they pose a serious threat to aquatic ecosystems. Microplastics are consumed by a broad variety of species, resulting in long-term health concerns, while plastic waste entangles and suffocates marine creatures. Heavy metals and pesticides are only two examples of the chemical pollutants that may accumulate in marine species' tissues and wreak havoc on their reproductive systems, immunological responses, and general health. Not only do oil spills leave a visible film on the water, but they also poison the marine environment, leading to huge die-offs and permanent harm to coastal ecosystems. The depletion of oxygen in the water and the formation of dead zones can be caused by toxic algal blooms brought on by nutrient runoff from fertilizers and sewage. There has to be strict rules, better waste management procedures, and more public awareness to combat ocean pollution. The stability of marine ecosystems and the well-being of future generations depend on our collective efforts to preserve the seas.

Ocean pollution is a serious issue. Although the dynamics of biomagnification may cause high tropic-level species to contaminate large portions of the world's waters, this is not certain. Coastal

contamination is a major problem. The major culprits are toxic wastes, oil spills, and sewage. Coastal waters were discovered to have high nutrient levels, a variety of disease-causing bacteria, pollutants, and low oxygen levels. Estuaries, some of the most vital ecological systems on Earth, are threatened by pollution in the coastal zone. Species that play crucial roles in a wide variety of marine food chains and ecosystems rely on estuaries as breeding grounds. In terms of biodiversity and environmental productivity, estuaries rank quite high.

The oceans act as a sink for a wide range of chemical pollutants, which find their way into the marine environment through various pathways. Industrial activities, such as manufacturing, mining, and energy production, release heavy metals, solvents, and other industrial chemicals that can enter waterways and eventually reach the oceans. Agricultural practices, including the use of fertilizers, pesticides, and herbicides, contribute to nutrient runoff and pesticide contamination in coastal areas. The disposal of waste, both from households and industries, can introduce a multitude of chemicals into the marine environment. Additionally, oil spills from shipping accidents and offshore drilling operations have catastrophic effects on marine ecosystems, releasing petroleum hydrocarbons that coat the water surface and penetrate deep into the ocean.

The consequences of ocean pollution, specifically the chemical contaminants it harbors, extend far beyond the visible and immediate impacts. Marine organisms, from the smallest phytoplankton to the largest whales, face a multitude of risks and challenges in their increasingly contaminated habitats. The toxic effects of chemical pollutants can disrupt vital physiological processes, impair reproductive success, compromise immune responses, and induce developmental abnormalities. These effects can be observed in a range of marine species, including fish, shellfish, marine mammals, seabirds, and corals.

The phenomenon of bioaccumulation further exacerbates the threats posed by chemical pollutants. Many of these substances have the ability to accumulate in the tissues of organisms, leading to higher concentrations as they move up the food chain. Predatory species at the top of the food chain, such as sharks, dolphins, and large predatory fish, can experience significant biomagnification, accumulating high levels of pollutants in their bodies. This not only threatens the health and survival of these top predators but also has cascading effects on the entire ecosystem.

TYPES OF CHEMICAL POLLUTANTS

Chemical pollutants in the ocean encompass a wide range of substances originating from various sources. These pollutants can have diverse chemical properties and pose different risks to marine life. The following are key types of chemical pollutants found in the ocean:

A. Heavy Metals

Heavy metals such as mercury, lead, cadmium, and arsenic are released into the ocean through industrial activities, mining, and atmospheric deposition. They can accumulate in the tissues of marine organisms and cause toxic effects, including impaired neurological function, reproductive disorders, and organ damage.

B. Pesticides

Pesticides, including insecticides, herbicides, and fungicides, enter the ocean through agricultural runoff and urban runoff. These chemicals can contaminate marine ecosystems, affecting aquatic organisms. Pesticides can disrupt hormone systems, impair reproduction, and harm the immune systems of marine life.

C. Industrial Chemicals

Various industrial chemicals find their way into the ocean through wastewater discharge, accidental spills, and atmospheric deposition. Examples include polychlorinated biphenyls (PCBs), dioxins, flame retardants, and solvents. Industrial chemicals can bioaccumulate in marine organisms, leading to adverse effects on their health and reproduction.

D. Petroleum Hydrocarbons

Oil and petroleum products are released into the ocean from oil spills, leaks during offshore drilling, and improper disposal of waste oil. These hydrocarbons can coat the feathers, fur, and gills of marine organisms, impairing their ability to thermoregulate, breathe, and move. Exposure to petroleum hydrocarbons can also lead to organ damage and compromised immune systems.

E. Pharmaceuticals and Personal Care Products (PPCPs)

PPCPs, including prescription drugs, over-the-counter medications, and personal care products, enter the ocean through wastewater discharge and improper disposal. These chemicals can accumulate in marine organisms and impact their physiological functions. Endocrine-disrupting effects, genetic abnormalities, and changes in behavior have been observed in marine life exposed to PPCPs.

F. Chlorinated Compounds

Chlorinated compounds, such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT), were widely used in the past but are now regulated or banned. However, they persist in the environment and continue to affect marine organisms. Chlorinated compounds can bioaccumulate and biomagnify, causing reproductive issues, immune system suppression, and developmental abnormalities in marine life.

G. Acidifying Agents

Carbon dioxide (CO2) emissions from human activities are leading to ocean acidification, whereby the pH of seawater decreases. This acidification can affect the physiology and behavior of marine organisms, including shell-forming organisms like corals, mollusks, and some plankton, leading to reduced calcification rates and weakened structures.

Understanding the types of chemical pollutants present in the ocean is crucial for assessing their impacts on marine life. It helps in developing strategies to minimize pollution sources, regulate their use, and mitigate the harmful effects on marine ecosystems and the organisms they support.

MECHANISMS OF CHEMICAL TOXICITY

The mechanisms of chemical toxicity in marine organisms involve a series of processes that occur when organisms are exposed to chemical pollutants in the ocean. Understanding these mechanisms is crucial for comprehending the impacts of ocean pollution on marine life. The following are key mechanisms of chemical toxicity:

A. Absorption

Chemical pollutants can enter the bodies of marine organisms through various routes, including direct contact with contaminated water, ingestion of contaminated food, and absorption through the skin or gills. The absorption of chemicals depends on their physicochemical properties, such as solubility and lipid solubility.

B. Distribution

Once absorbed, chemicals can be transported through the circulatory system and distributed to various tissues and organs. Distribution is influenced by factors such as blood flow, lipid content, and specific affinity of chemicals for certain tissues.

C. Metabolism

Marine organisms possess metabolic pathways that aim to detoxify and eliminate chemical pollutants. Metabolism involves the enzymatic transformation of chemicals into more water-soluble compounds, facilitating their excretion. However, some chemicals may undergo bioactivation, converting into more toxic forms in the process.

D. Excretion

Chemical pollutants and their metabolites are eliminated from the body through different excretory pathways, including the liver, kidneys, gills, and digestive system. The efficiency of excretion mechanisms can vary among species, and some chemicals may persist in the organisms for extended periods.

E. Bioaccumulation

Bioaccumulation occurs when the rate of uptake or absorption of a chemical pollutant exceeds its excretion rate in an organism. This leads to an accumulation of the pollutant in various tissues, with higher concentrations observed in organisms higher up the food chain. Lipophilic (fat-soluble) chemicals tend to bioaccumulate more readily.

F. Biomagnification

Biomagnification is the process by which chemical pollutants become increasingly concentrated as they move up the food chain. Predatory organisms at higher trophic levels consume prey containing lower concentrations of pollutants but accumulate them in their tissues at higher levels. This phenomenon can result in biomagnification of pollutants and greater impacts on top predators.

G. Interactions and Synergistic Effects

Chemical pollutants can interact with each other or with other environmental stressors, resulting in synergistic or additive effects on marine organisms. Synergistic effects occur when the combined

toxicity of multiple pollutants is greater than the sum of their individual toxicities, posing heightened risks to marine life.

Understanding these mechanisms of chemical toxicity helps in assessing the potential risks and impacts of ocean pollution on marine organisms. It guides the development of effective management and mitigation strategies to minimize the harmful effects of chemical pollutants and preserve the health and integrity of marine ecosystems.

LITERATURE REVIEW

Kumar, P. & Gurunathan, Prasannamedha (2021) Several types of pollution, including organic chemicals, oil spills, solid waste, increased nutrients, and radioactive waste, threaten marine ecosystems. Threatening marine life, ecosystems, and biodiversity, these toxins alter the physical, chemical, and biological features of the ocean and coastal zones. At long last, they are impairing the ecosystem's health and efficiency. Pollutants' effects on the marine environment can be either sudden and severe or gradual and persistent. Pollutants enter the environment through a wide variety of causes. This chapter provides a high-level overview of the most common types of marine pollution. Effects of various contaminants on marine life are discussed, with emphasis on the most significant of them. Algal blooms, ocean acidification, and shipbreaking are just a few of the major threats to the marine environment that are covered. Direct contact, ingestion, and toxicity of pollutants relative to organisms are just few of the primary processes discussed in this chapter that operate between pollutants and ecosystem. Additionally the ways in which biota respond to pollution are evaluated and explored.

Verma, Jyoti et al., (2020) The introduction of dangerous chemicals or particles into the water has a detrimental effect known as marine pollution. In estuaries, oxygen levels drop to dangerously low levels because of the chemical reactions of many particles. Causes, effects, and solutions to marine pollution are discussed. Marine pollution has been broken down into three distinct categories: that which originates on land, that which originates in the air, and that which originates from human traffic. Pollutants from the land, such as industrial wastes and other wastes, are dumped into sewage, and the runoff from agricultural fields, contaminated with fertilizer and pesticides, is then dumped into rivers. The usage of plastics in everyday life also adds to the problem of pollution in the ocean. Marine life is threatened by oil spills and the carelessness of those who carry it. Animals and microorganisms mistake plastic for food and perish as a result. Many laws have been passed to ensure the protection of the natural world. In this article, we will map out a plan to curb the environmental damage that human activity has created. This brief study provides an overview of what is now known about the effects of pollutants on marine viruses, virus-host systems, and the possible ecological consequences of these findings. Marine eutrophication and mucilage production are frequently linked to the emergence of complex viral assemblages, both of which are exacerbated by the introduction of excess nutrients from sewage and river effluents. Hydrocarbons, polychlorinated biphenyls, and pesticides can disrupt ecosystem functioning, which in turn can cause alterations to virus-host interactions and raise the risk of viral infection. The combined effects of these contaminants on the virus-host system and their ability to produce prophage might have a significant negative impact on marine ecosystems.

Ramanayaka, Sammani et al., (2020) The widespread identification of MPs in aquatic and terrestrial ecosystems has elevated MPs to the status of a worldwide environmental threat. There has been much research on the movement, release, and impact of chemical pollutants bound to MPs on aquatic and soil species. Both organic and inorganic pollutants have been shown to interact with MPs in laboratory investigations. The establishment of weak bonds between pollutants such hazardous metals and antibiotics and MPs leads to quick desorption, whereas contaminants that are tightly attached to the MPs are taken along with the MPs as a carrier in both aquatic and terrestrial settings. Adsorption and desorption capabilities of pollutants are, however, affected by polymer type, color, particle size, and weathering degree. Antibiotic resistance in microorganisms may result from MP's role as a vector in the movement of compounds like medicines, i.e., antibiotics. It is unclear whether the toxicological effects observed in aquatic vertebrates and invertebrates are the consequence of MPs or the adsorbed pollutants, although they have been linked to digestive system blockages and inflammation. Plant growth may be stunted if biosolids were applied to farms because pollutants bound to MPs would be released into the soil. Similarly, these pollutants may be absorbed by plants and build up over time. Plants and animals that are constantly exposed to chemical toxins from MPs bioaccumulate harmful chemicals.

Citarasu, Thavasimuthu & Babu, Mariavincent (2017) Human activities produce a wide range of contaminants that have a devastating effect on marine ecosystems. Pollutants in the maritime environment mostly enter the system via atmospheric deposition, waterways, shipping, and other human activities. Marine life, fauna, and the stability of food webs are all severely impacted by pollution. Carbon tetrachloride, polychlorinated biphenyls, trichloroethylene, and vinyl chloride are only some of the synthetic chemical wastes discovered in marine sediments and wildlife. There is evidence that this form of marine pollution is harmful to human health, either immediately or over time. To prevent contaminants from entering marine water bodies, biotechnological methods including bioremediation, probiotics, waste treatments by micro algae, and seaweeds are helpful. This article discusses the many ways in which marine pollution endangers marine life.This chapter also covers the subject of pollution prevention strategies and education initiatives.

Mearns, Alan et al., (2013) Articles from 2012 are included here that focus on the biological consequences of pollution and human physical disturbances on marine and estuarine ecosystems, animals, and vegetation. The review, based primarily on journal articles, discusses pollution issues such as endocrine disruptors, emerging contaminants, wastewater discharges, dredging and disposal, etc., as well as field and laboratory measurement activities (bioaccumulation of contaminants, field assessment surveys, toxicity testing, and biomarkers). The Deepwater Horizon oil rupture in the Gulf of Mexico in 2010 and the Japanese tsunami in 2011 have brought the impacts of oil spills and marine debris into sharp focus. Several previously discussed hot topics, like ballast water and ocean acidification, were not included in this year's report. The impacts are the main emphasis of this review, rather than the destiny and movement of pollutants. It's not uncommon to find references to studies on one topic in those on another (for example, certain bioaccumulation publications may be mentioned in other thematic categories). In order to find the dispersed but connected documents, please utilize textual keyword searching. Please use the original publications as your primary source material and refer back to this review for clarification.

Thompson, Richard et al., (2013) Oil spills and what is increasingly being called "biological pollution" (pathogens, parasites, and invasive species) are just two examples of the many ways in which the marine environment is polluted. Other sources of pollution include the introduction of chemicals, radioactivity, solid waste, human-induced sedimentation, energy (i.e., heat and noise), and so on. This chapter attempts to summarize the current and predicted risks associated with marine pollution on a global scale by describing the sources, pathways, and threats to marine ecosystems posed by some of the most frequently discussed pollutants within research and policy (excluding nutrients and organic material). Marine ecosystems across the world may be very tolerant to single forms of pollution of typical magnitudes, even if pollution may have substantial consequences on species and habitats in many sites and regions. Synergies between different forms of pollution are poorly understood, as are the cumulative impacts of chemicals and other pollutants over time. The effects of pollution on ecosystems may also reduce their resistance to other stresses, such as rising sea temperatures and ocean acidification. Since the future of global development might take several forms in terms of, for example, production, transportation, and consumption patterns of products, services, and energy, it is impossible to make accurate and succinct predictions about the quantity and effect of marine pollution on a worldwide scale in the future.

Borja, Angel et al., (2011) Comprehensive but accessible, Ecological Impacts of Toxic compounds details the known disruptions produced by a wide variety of toxic compounds to both aquatic and terrestrial ecosystems. The origins of poisonous substances, their movement around the globe, their effects on various ecosystems, and the role of natural processes in cleaning them up are all discussed. Authors who are themselves experts in their fields write each chapter with the layperson, the student, and the scientist in mind. The goal of this book is to alert readers to the seriousness of chemical contamination in today's industrialized, globally traded world. Because the problems are so pervasive and far-reaching, it is believed that addressing them head-on would result in improved management practices across all sectors of industry and agriculture and at all administrative levels, from the community to the national government.

Mearns, Alan et al., (2010) To better understand the biological, chemical, and physical consequences of natural and anthropogenic contaminants on marine and estuary plant and animal life, this review focuses on publications published in 2009 and selected by the journals' editorial boards. This overview looks at a wide range of measuring techniques used in the field and in the lab (contaminant concentrations, field surveys, toxicity tests, and biomarkers). Endocrine disruptors, wastewater discharges, dredging and disposal, etc. are some of the other hot topics in pollution research papers. The massive continuing Deepwater Horizon breach in the Gulf of Mexico prompted an increased focus on oil spills. Several previously examined areas (including related work on the Deepwater Horizon catastrophe) had to be scrapped this year owing to events beyond our control. It's not uncommon to find references to studies on one topic in those on another (for example, certain bioaccumulation publications may be mentioned in other thematic categories). Readers should only use this as a reference and check the source papers for accuracy before referencing them.

METHODOLOGY

To achieve the objectives of this research paper on the chemical effects of ocean pollution on marine life, a comprehensive methodology was employed. Data pertaining to the chemical pollutants in the oceans and their effects on marine organisms were collected from various sources, including scientific studies, government reports, and environmental organizations. Data on pollutant concentrations, toxicity levels, bioaccumulation, and biomagnification were compiled to provide a comprehensive understanding of the chemical effects.

EFFECTS OF OCEAN POLLUTION ON MARINE LIFE

The vast number of species in the ocean makes it challenging to get accurate statistics on the impact of pollution on fish and other marine life. There are a lot of gaps in our understanding of science. There have, however, been several promising pilot projects using tiny samples of marine species and specific regions of the ocean.

According to a 2015 scientific study, 693 marine species have been seen to encounter marine trash. Ninety-two percent of the trash they found was plastic. Marine debris poses a threat to the survival of 17% of IUCN Red List species, according to the same study. 55-67% of marine species tested positive for human-made garbage, according to a research published in Nature.

According to a 2017 study of scientific literature, plastic was found in the bodies of 233 marine species. This includes 100 percent of marine turtles, 36% of seals, 59% of whales, and 59% of seabirds. This resulted in the animal's malnutrition, sickness, and eventual death. Shieh et al. (1999) found that fish dispersal is regulated by water chemistry. Pritchard (1985) examined the far-reaching consequences of pollution on the ecosystem.

Of the 344 species studied, 100% of marine turtles, 67% of seals, 31% of whales, and 25% of seabirds were entangled at some point; 89 fish species and 92 invertebrate species were also affected. This leaves them open to dangers like predators, water, and malnutrition by causing injuries and limiting their range of motion.

According to a research by the Center for Biological Diversity, the British Petroleum oil spill in the Gulf of Mexico certainly damaged or killed 82,000 birds representing 102 species within a year. Somewhere between 6,165 and 25,900 marine turtles perished, along with an unknown number of marine animals and fish. There were 658 seabirds, 279 sea turtles, 36 marine animals, and countless fish reported dead as a result of the leak as of mid-June 2010. Five of the Gulf of Mexico's turtle species are in perilous straits right now. Two fish embryos were found to have heart problems, significant levels of poisons were identified in whales and loons, and 900 dolphins were discovered dead, all as reported by National Geographic. A 2017 research published in The Guardian found that marine garbage drifting and accumulating on distant islands far from places of dense human populations was polluting or damaging coastal ecosystems of marine birds and animals. Therefore, all marine ecosystems are affected by ocean pollution since water is transported throughout the planet by ocean currents. Marine life is threatened by ocean pollution because –

- Effects of oil on the ocean
- Coral reef impact
- Toxic materials

Ocean life is being increasingly threatened as pollution levels rise throughout the world's waters. Millions of gallons of oil are poured into the world's oceans every year, yet only the large spills from offshore drilling receive the media's attention. More than half of all oil pollution is caused by human activity, as reported by the National Oceanic and Atmospheric Administration (NOAA). This is what Nearly half of the world's oil pollution comes from oil that seeps naturally from the ocean floor and then flows into the ocean. Water pollution is caused by the usage of oil in its many forms, including storage, as well as other forms of waste, such as municipal and industrial waste and urban runoff, which account for 37% of the problem. Ten percent of oil contamination is a result of oil being transported by water. Oil spills, both large and little, are a common cause of ocean contamination. Three percent of the oil extracted from offshore is also released into the ocean. There are several ways in which oil endangers marine life. Oil on the hair or feathers of birds or mammals with fur might hinder their ability to fly, move, keep warm, or eat, according to the NOAA. Polluting breeding and feeding habitats, oil washes up on beaches. Oil that marine creatures swallow while trying to clean themselves can be toxic. Fish and shellfish in the deep sea are unaffected, but those in shallow areas, where they may be eating or reproducing, may be at risk. Oil residues can also infect fish, rendering them unsafe for human eating, as reported by the University of Delaware and the Office of Environmental Health Hazard Assessment.

Coral reefs might be negatively affected by oil. Not only are these reefs visually stunning, but they also host a wide variety of marine life. According to NOAA, it is challenging to forecast how oil would affect coral reefs. Fish in the area can be killed because their gills become clogged with oil. Sunlight is essential for marine plant photosynthesis, but when oil floats on the surface, it blinds the sun and kills the plants. These plants play crucial roles in both the marine food web and reef ecosystems.

Toxic substances are an unintended consequence of contemporary culture. The ocean, sediment, and the micro-layer just below the surface of the water are common repositories for harmful pollutants because of water's solubility. The World Wildlife Fund (WWF) says that 8% of pollution originates from land-based non-point sources. Industrial trash, sewage discharge, radioactive waste from power plants, nuclear wastes, and nuclear submarines, fertilizers, manure waste, and home cleaning products and contaminants all find their way into the water and eventually settle to the bottom. The contamination of the food chain begins at the bottom when bottom-feeding creatures consume toxic poisons. The larger fish consumes the smaller one, and eventually a person consumes both. People who consume tainted fish are at risk of developing cancer, reproductive abnormalities, and congenital malformations, among other chronic conditions. You may find a list of fish to avoid owing to their high mercury and PCB concentrations on the National Resources Defense Council's website. The Environmental Protection Agency (EPA) reports that nutrient contamination from sources including fertilizers, sewage, and household garbage causes dead zones in oceans. Everything from plastic bags to balloons to medical waste to empty soda and milk cartons eventually ends up in the seas. These

things are carried by the tides to the shore. The World Wildlife Fund claims that marine garbage endangers the health of marine animals.Old nets prevent marine mammals from reaching the surface for air, leading to their deaths. Microbeads in particular are extremely small pieces of plastic that can easily become caught in the digestive tracts of birds, turtles, and fish. Plastic bags floating in the ocean seem like tasty jellyfish to sea turtles, so they eat them. Plastic bags choke them to death by blocking their digestive tract. Trash can result in suffocation, malnutrition, drowning, or strangling. Trash pollutes breeding grounds and ecosystems as it washes up on beaches and into marshes and wetlands. Debris in the ocean has the potential to kill marine life. Ecosystems might be impacted by efforts to clean up debris. There are already 5.25 trillion bits of plastic in oceans throughout the world, and 8 million tons of rubbish are added annually, according to the Daily Mail in 2017. Noise, acid rain, climate change, and ocean acidification are all kinds of ocean pollution that can harm marine life. Thermal and dynamic stratification of source water reservoirs is common. The major source of water quality issues is internal contamination produced from reservoir sediments.

CONCLUSION

Biodegradable pollutants are not only to blame for water contamination. Heavy metals, mineral oils, biocides, synthetic chemicals, etc. are examples of non-degradable or slowly degrading pollutants that are thrown into water and contribute significantly to the contamination load. Stabilization is the most cutting-edge approach of water pollution management. Waste minimization, biomass collection and disposal, nutrient capture, fish preservation, and oxygenation all play roles. Different methods can be employed to protect the water body's biodiversity and ecological balance against pollution.

REFERENCES

[1] Tekman, Mine B & Walther, Bruno & Peter, Corina & Gutow, Lars & Bergmann, Melanie. (2022). Impacts of plastic pollution in the oceans on marine species, biodiversity and ecosystems. 10.5281/zenodo.5898683.

[2] Kumar, P. & Gurunathan, Prasannamedha. (2021). Biological and chemical impacts on marine biology. 10.1016/B978-0-12-822279-9.00006-3.

[3] Gamage, Thushari & Senevirathna, Duminda. (2020). Plastic pollution in the marine environment. Heliyon. 6. e04709. 10.1016/j.heliyon.2020.e04709.

[4] Verma, Jyoti & Pant, Hemlata & Sing, Shilpi & Tiwari, Ankita. (2020). MARINE POLLUTION, SOURCES, EFFECT AND MANAGEMENT.

[5] Miranda, Alberto. (2020). Plastic Pollution in the Ocean.

[6] Zaman, Md & Zaman, Rakeen & Sizemore, Robert. (2020). Plastic Pollution of the Oceans: A Review of Marine Plastic Pollution and Its Environmental Impacts. 13. 1-8.

[7] Verma, Jyoti & Pant, Hemlata & Sing, Shilpi & Tiwari, Ankita. (2020). MARINE POLLUTION, SOURCES, EFFECT AND MANAGEMENT.

[8] Ramanayaka, Sammani & Hettithanthri, Oshadi & Sandanayake, Sandun & Vithanage, Meththika. (2020). Ecological Effects of Chemical Contaminants Adsorbed to Microplastics. 10.1007/978-3-030-10618-8_50-1.

[9] Senko, Jesse & Nelms, Sarah & Reavis, Janie & Witherington, B & Godley, Brendan & Wallace, Bryan. (2020). Understanding individual and population-level effects of plastic pollution on marine megafauna. Endangered Species Research. 43. 10.3354/esr01064.

[10] Anastasopoulou, Aikaterini (Katerina) & Fortibuoni, Tomaso. (2019). Impact of Plastic Pollution on Marine Life in the Mediterranean Sea. 10.1007/698_2019_421.

[11] Anastasopoulou, Aikaterini (Katerina) & Fortibuoni, Tomaso. (2019). Impact of Plastic Pollution on Marine Life in the Mediterranean Sea. 10.1007/698_2019_421.

[12] Krishnakumar, Periyadan. (2017). Environmental impacts of marine pollution- effects, challenges and approaches..

[13] Citarasu, Thavasimuthu & Babu, Mariavincent. (2017). Biotechnology for Sustainability Marine Pollution and Its Impacts on Living Organisms.

[14] Macleod, Catriona & Eriksen, Ruth & Chase, Zanna & Apitz, Sabine. (2016). Chemical Pollutants in the Marine Environment: Causes, Effects and Challenges. 10.1093/acprof:oso/9780198718826.003.0013.

[15] Dahms, Hans-Uwe. (2014). The Grand Challenges in Marine Pollution Research. Frontiers in Marine Science. 1. 10.3389/fmars.2014.00009.

[16] Mearns, Alan & Reish, Donald & Oshida, Philip & Ginn, Thomas & Remple-Hester, M/A & Arthur, Courtney & Rutherford, Nicolle. (2013). Effects of Pollution on Marine Organisms. Water Environment Research. 85. 1828. 10.2175/106143013X13698672322949.

[17] Thompson, Richard & Holmström, Katrin & Linden, Olof & Eriksson Hägg, Hanna. (2013). Marine Pollution. 10.1016/B978-0-12-407668-6.00006-9.

[18] Borja, Angel & Belzunce, Maria & Garmendia, Joxe & Rodriguez, J. German & Solaun, Oihana & Zorita, Izaskun. (2011). Impact of Pollutants on Coastal and Benthic Marine Communities. 10.2174/978160805121211101010165.

[19] Mearns, Alan & Reish, Donald & Oshida, Philip & Ginn, Thomas. (2010). Effects of Pollution on Marine Organisms. Water Environment Research. 82. 2001. 10.2175/106143010X12756668802175.

[20] Valentukevičienė, Marina & Brännvall, Evelina. (2008). Marine pollution: an overview. Geologija. 50. 17-23. 10.2478/v10056-008-0002-9.