The Effect of Water Pollutants on Aquatic Life

Sarin Singhal ‘27

Each year, millions of aquatic life die due to human activity. Plastic pollution kills 100,000 mammals each year (WWF Australia, 2023). Human activities such as “urbanization, industrialization, and agricultural activities" have accelerated plastic and other contaminants in our natural water sources (Bashir et al., 2020). Human activities such as agriculture, sewage pollution, metal contamination, oil spillage, and plastic waste have significantly degraded aquatic life by introducing new toxic substances, altering habitats, increasing marine mortality rates, and limiting biodiversity.

First, agriculture, specifically agrochemicals (chemicals used throughout the agricultural industry), is one source of anthropogenic water contamination that has severely influenced aquatic life. Due to the increasing demand for food, which has greatly increased agricultural production, agrochemicals such as “fertilizers, pesticides, herbicides and plant hormones” have significantly impacted water sources such as lakes, rivers, aquifers, and coastal waters (Bashir et al., 2020). One type of these agrochemicals is fertilizers, which if applied too heavily on soil or removed through surface runoff, can find their way to water sources through runoff or contaminating sources of groundwater. Pesticides, another type of agrochemical, “make up 17%... of the pollutant-effect relationships studied in marine mammals” (Schaap et al., 2023). Furthermore, these toxic chemicals contain carcinogens and other deadly or harmful substances. Excess nutrients are another part of agriculture that immensely contributes to water contamination. One example is manure, which if applied too heavily in agriculture fields or is not stored properly, can be washed away during heavy rainfall into waterways. Manure is rich in nutrients, so when it interacts with certain water sources, it enriches the water, leading to a

process called eutrophication. This process prompts excess growth of algae blooms that can cause significant harm to ecosystems. First, these algae blooms harm animals as well as "limit light penetration, reduce growth and cause death of plants in littoral zones and also lower the success of predators that need light to catch prey" (Bashir et al., 2020). Further, when these large algae blooms photosynthesize, they can raise the pH of the water to abnormally high levels, impairing the chemosensory abilities of certain aquatic animals, which prevents them from finding food or avoiding predators. Also, when these algae blooms die, microbial decomposition severely depletes the dissolved oxygen in the habitat, creating a hypoxic dead zone that lacks oxygen to support organisms. As much as "415 coastal areas have been identified worldwide which experience eutrophication," highlighting how this harmful process leads to the destruction of ecosystems, aquatic life, and water quality (Bashir et al., 2020). Salt is another example of a harmful nutrient, which through accumulation in solids and irrigation, can cause salinization of fresh waterways. As a result of highly salinated waters, "the geochemical cycles of major elements such as carbon, iron, nitrogen, phosphorus, silicon, and sulfur" are altered along with the "decline of the biodiversity of microorganisms, algae, plants and animals" in freshwater ecosystems (Bashir et al., 2020).

Second, sewage pollution is another significant source of water contamination that affects aquatic life. Sewage can range from industrial, city, and home waste. Sewage waste plays a significant role in contaminating waterways, as "58% of the wastewater from urban areas and 81% of industrial wastes are discharged directly into water bodies with no or inadequate treatment resulting in contamination of ~73% of the water bodies" (Bashir et al., 2020). As a result of sewage pollution, there have been many environmental effects such as: depleted clean water resources, inadequate water quality, mass flooding, and endangered aquatic species.

Additionally, sewage impacts the oxygen levels in water (Bashir et al., 2020). The organic load of sewage increases the biochemical oxygen demand (BOD) levels, as increased microorganism activity is required to break down these compounds, hence depleting oxygen in the water. As BOD rises, oxygen levels drop, suffocating and killing aquatic life populations (*What Causes High BOD in Wastewater?*, 2023). In addition, the increase in organic matter from sewage can lead to eutrophication, a process where excess nutrients enrich water sources, promoting the overgrowth of plants and algae blooms. This can significantly alter an ecosystem and likely result in high mortality rates. Because of eutrophication, "plant and animals' biomass increases, sedimentation rate increases, species diversity decreases, and anoxic conditions may develop," all of which affect the development and lifespan of an ecosystem (Bashir et al., 2020).

Third, heavy metals can also pollute waterways and negatively affect aquatic organisms. Heavy metals enter aquatic systems from both natural and human activity such as direct discharge, run-off, atmospheric deposition, volcanism, or rock erosion. However, this natural production of heavy metals poses no problems to the environment, rather it is "the development of industry and agriculture [which] promotes the rapid increase of heavy metal pollution" (Bashir et al., 2020). Specifically, metals such as zinc and copper are present in fertilizers while arsenic, cadmium, and mercury are found in different fungicides and algaecides. These substances are particularly significant because of their high toxicity and persistence, which can severely impact the environment (Bashir et al., 2020). Heavy metals can devastate an aquatic environment. When these metals remain in water, they accumulate to a toxic concentration and enter the food chain of various species. These metals also cause ecological damage when they become incorporated in sediments of the aquatic floor, which acts as "one of the ultimate sinks" or sustainable storage areas for these toxic metals (Bashir et al., 2020). Later, they may dissolve again into the water,

further contaminating the water and continuing the cycle of pollution. The effect of heavy metals on aquatic systems is becoming a growing issue as they can persist in an environment, bioaccumulate in organisms, and cause harmful effects on human health (Bashir et al., 2020).

Fourth, oil spillage is another important factor of water contamination that significantly impacts marine life. When liquid petroleum hydrocarbons are discharged into a marine ecosystem, there can be various impacts on the marine ecosystem because the substance is toxic to all forms of marine life. Oil spills can result from damage, transportation accidents, and activities involving oil tankers, pipelines, and various other sources which contribute to oil spills being the most "frequent organic pollutants of aquatic ecosystems" (Bashir et al., 2020). Oil spills can affect marine life at various biological levels. At the biochemical level, oil disrupts the metabolic functions of marine life; at the organism level, it causes behavioral, developmental, and psychological problems; at the population level, it can alter the reproductive and survival rates of species; and at the communal level, it shifts entire ecosystem structures, e.g., through shifting the diversity indices of species. Moreover, the effects of petroleum hydrocarbons can be either acute or chronic. Acute toxicity involves short-term exposure to oil, causing immediate death or harm. Chronic toxicity involves constant exposure to petroleum hydrocarbons at small concentrations, leading to slowly lethal effects that damage growth and reproduction. Many marine animals respond differently when exposed to oil. Fish eggs and embryos experience issues such as "developmental malformations, genetic damage, mortality, decreased size at hatching, and impaired swimming" ("Biological Effects of Oil Releases," 2003). Likewise, seafloor ecosystems suffer from contamination as oil sinks into sediments and impacts these organisms through increased mortality rates. Marine mammals are also significantly affected by oil spills, as they are prone to hypothermia, due to the destruction of their feathers or fur,

poisoning from consumption, respiratory damage from the toxic vapors, and reproduction issues ("Biological Effects of Oil Releases," 2003).

Lastly, plastics and microplastics are another significant factor of water contamination impacting aquatic biology. Among the numerous harmful human activities on marine life, the accumulation of plastic and microplastic is least studied despite its significance. Despite the increasing benefits of plastic in everyday human life, improper disposal and waste management of these plastics lead to significant accumulation in marine habitats. Plastic debris has spread globally across the marine ecosystem because "70 to 80% of marine litter, most of it is plastics, originate from inland sources and are emitted by rivers to the oceans," leading to its immense spreading (Bashir et al., 2020). Due to the large use of plastics in low-income countries along with the frequent dumping of plastics on beaches, lakes, and other water masses, plastic contamination is seen as a global issue. Additionally, microplastics "may pose more threat than macroplastics" as they can easily be digested by all marine creatures, accumulating through the food web as predators will consume creatures with microplastics (Bashir et al., 2020). These microplastics are effective in absorbing outside chemicals such as harmful metals which can increase their toxicity and can significantly impact organisms who consume them. These microplastics absorb "persistent, bioaccumulative, and toxic compounds" that would last in an environment for a long time and be toxic, spreading contamination (Bashir et al., 2020). Also, microplastics can carry human pathogens such as Vibrio bacteria, chemical additives, and organic contaminants, exposing aquatic life to disease and toxic chemicals (Bashir et al., 2020).

The contamination that we have brought upon our aquatic life is significant due to human activity including agriculture, sewage pollution, metal contamination, oil spillage, and plastic waste. These actions have guided new toxic substances into marine ecosystems, disrupted

ecosystem balance, increased death rates, led to the accumulation of harmful substances and plastics, and significantly reduced the biodiversity of marine life. Despite the damage we have already caused to marine life, there is still hope for the future to improve. With the implementation of stricter environmental policies, increased public awareness, and sustainable practices of agriculture and waste management, we can increase the protection efforts of our waters for generations to come.

References

Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A., & Dar, S. A. (2020). Concerns and Threats of Contamination on Aquatic Ecosystems. *Bioremediation and Biotechnology: Sustainable Approaches to Pollution Degradation*, 1–26. https://doi.org/10.1007/978-3-030-35691-0_1

Biological Effects of Oil Releases. (2003). In *Oil in the Sea III: Inputs, Fates, and Effects*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK220710/

Schaap, I., Buedenbender, L., Johann, S., Hollert, H., & Dogruer, G. (2023). Impact of chemical pollution on threatened marine mammals: A systematic review. *Journal of Hazardous Materials*, *459*, 132203–132203. https://doi.org/10.1016/j.jhazmat.2023.132203

What Causes High BOD in Wastewater? (2023, August 28). MAC Water Technologies. https://www.macwatertechnologies.com/blog/what-causes-high-bod-in-wastewater

WWF Australia. (2023, June 26). *Plastic in Our Oceans Is Killing Marine Mammals*. Wwf.org.au. https://wwf.org.au/blogs/plastic-in-our-oceans-is-killing-marine-mammals/