Human Induced Toxicological Impacts on Aquatic Life

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SUMMARY

This chapter presents an in-depth exploration of the adverse impacts of human activities on aquatic ecosystems, focusing on the toxicological effects of anthropogenic pollutants like pesticides, heavy metals, and industrial wastes. Different pollutants from our daily routines enter the environment and disturb the balance and cause life threatening consequences. It discusses the mechanisms of bioaccumulation and the significance of toxicological studies in identifying and mitigating these impacts. The Chapter highlights the sources and causes of aquatic pollution, its transportation into water bodies, and its harmful effects on the health and diversity of aquatic life, stressing physiological and biodiversity disruptions. The chapter advocates for stricter water quality standards, incorporating macrophytes in toxicity assessments, and underscores the importance of comprehensive strategies for water conservation. It calls for urgent updates to environmental policies to better protect aquatic ecosystems from pollution, emphasizing the interconnectedness of aquatic health and human well-being. Through detailed analysis, the chapter aims to raise awareness and drive action towards sustainable management of water resources and the preservation of aquatic biodiversity.

INTRODUCTION

The biosphere's constituent parts soil, water, and air are interrelated environmental factors. Each of them supports a distinct flora and fauna that need a clean and healthy environment to flourish and thrive in order for the system to survive. To make this happen, we must comprehend the sources of pollution or the substances that might disrupt the course of life and have catastrophic effects on both the environment and life. Then we can only take action to reduce and prevent pollution of all environmental components (Brown & Takada, 2017). The persistent alteration of an aquatic environment caused by the ingestion of large amounts of naturally occurring or man-made harmful chemicals is counted to constitute pollution. These pollutants can result in a variety of pollution forms, some of which might alter physiological capacities, raise death rates for specific animal and plant species, or deteriorate the physicochemical qualities of water to the point that it is no longer fit for human use.

Certain pollutants, including pesticides or heavy metals, accumulate in animals through a process called bioaccumulation, accumulating in cells and organs at oftentimes far higher quantities than those found in water. Water contamination will unavoidably rise with population expansion, greater urbanization and industry, and more intensive agricultural activities. Because of this, the conditions surrounding contamination are highly complex, in these conditions, determining the sources of contamination or estimating their effects which vary depending on the kind and concentration of the contaminant as well as the environment in which it operates can be challenging. As a result, it is sometimes challenging to establish a maximum permissible quantity for each harmful substance in an environment. Since there is disagreement over the threshold that should not be crossed and, in the few instances where laws and regulations are in place they frequently differ between nations (Alimba & Faggio, 2019).

WHAT IS TOXICOLOGY?

In a broader sense, toxicology is the study of adverse effects on living organisms and the ecosystem caused by chemical, physical, or biological agents, including their prevention and refinement. However, this description continues to include some loose ends. A toxicologist would look at the macromolecular connections between poisonous substances with the receptors they attach to cause a toxic response. For instance, the toxicologist would not be able to assess a whole live organism or system. On the other hand, they can investigate how a pollutant affects a whole ecosystem that has interacting species from a wide range of taxa.

Toxicology is described as an adverse impact that might be a response to a chemical that is harmful or unfavorable The word "adverse" is the key to understanding this concept. The diverse array of compounds that give rise to hazardous reactions can be categorized as either toxins (substances generated by other living creatures that trigger toxic responses) or toxicants (naturally occurring or synthesized xenobiotics).

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However, all chemicals have the potential to cause negative consequences (Pope et al., 2020). As an organization and an applied science, toxicology has, in contrast, grown slowly. It requires that nearly every branch of fundamental sciences test its theories. Toxicology is unique in the history of science because of health and occupational laws that have influenced toxicology studies since 1900 (Malaj et al., 2014).

HUMAN-INDUCED TOXICITY IN AQUATIC LIFE

The worldwide impact of water contamination on life is observed. In all habitats, water is the source of life for organisms as life cannot exist without it. The quality of the water has started to decline due to alterations in bacteriology, chemistry, and physical properties. Any modification to the biological, chemical, or physical properties of water, whether due to human activity or natural causes, is referred to as water pollution. Water that has been contaminated is deemed unsuitable for normal usage. Pollution can occur discontinuously, at irregular or regular intervals; it can be brief or inadvertent, resulting in unanticipated harm; it can occur continually, as is the case with sewage in cities or manufacturing waste that is released into the water (Kalogianni et al., 2017).

It is thought that aquatic systems are good places to recycle and dispose of hazardous waste and sewage, with the surplus draining into the ocean. However, their assimilative capacity is greatly reduced by the growing load of pollutants and the excessive use of water resources for agriculture, industry, thermal power plants, and potable supplies in order to fulfill the demands of the growing population. Therefore, the biological communities are ultimately responsible for handling the dual stress placed on the watercourses. Fish are among the most significant members of the aquatic community. Water contamination from municipal, industrial, and agricultural sources has grown to be a serious worry for human wellbeing due to the world's population explosion, growing industry, and urbanization. Toxins that are soluble in water and have been released into natural bodies of water via leached soils, the atmosphere, and industrial and urban wastes. Certain pollutants volatilize or break down, but others create insoluble salts that precipitate and become part of the sediments.

When such toxicants are ingested by aquatic creatures, such as fish, their metabolism may produce additional toxic compounds. For instance, microbial activity may transform mercury from industrial effluents into very poisonous methylmercury, which fish may subsequently absorb. It is well known that many aquatic species may concentrate hazardous substances from their surroundings without suffering any visible harm to themselves. As a result, they serve as toxicant amplifiers, increasing the toxicants' dangerously high levels of availability to predators. There have been several documented instances of how pollution in the environment negatively impacts fish and fish consumers. Any undesired alteration to the environment's inherent quality caused by physical, chemical, or biological forces is referred to as pollution in general (Rand et al., 2020).

The high pace of population growth, the quick development of industrial and urban areas, and the modernization of agriculture have all contributed to the large volume of waste material generated, which is gradually degrading precious biological productive resources. Research on the harmful impacts of pollution and its possible risk for aquatic ecosystems is essential given the increasing anthropogenic burden on our aquatic ecosystem. Numerous scientific studies have revealed a negative impact of pollution on the populations of diverse creatures living in the water body. There are many factors that induce toxicity in aquatic life as shown in Fig 1. Among the major alterations in the environment are the decline in some fish populations and the partial elimination of the significance of commercial fishing (Hinton et al., 2011).

SOURCES OF TOXICANTS

In an era of established climate change, the massive release of toxic pollutants into the environment as a result of increased urbanization and industrialization continues to be a topic of study. The toxicants of the environment are a major ecological and public health hazard on a worldwide scale. However, over time, there are threatening consequences for the health of humans, wildlife, and the environment in nations with high levels of anthropogenic activity. Notable origins of hazardous substances in the surroundings are farming, pharmaceutical, atmospheric, industrial, residential wastewater, and geological operations (Okereafor et al., 2017).

Environmental contamination is caused by human activities such as mining, electroplating, smelting, domestic and agro-allied businesses, and geogenic processes, even though these poisonous materials are naturally present within the earth's crust. Pesticide and fertilizer runoff from agriculture, as well as airborne deposition of pesticides, polychlorinated biphenyls, mercury, and polycyclic aromatic hydrocarbons, are frequently mentioned instances of nonpoint sources introducing toxins into aquatic systems. Septic tanks, landfills, hazardous waste sites, pipelines, irrigation, pesticide use, and natural sources like seawater intrusion or natural leaching are just a few of the places where groundwater can get contaminated (Barange et al., 2010). There are many point and non-point sources that cause toxicity that have been described in Table 1 and Fig 1. Because of limited technology, skills, and management, these waste materials accumulate in the ecosystem.

TOXICANTS AND THEIR EFFECTS AS A RESULT OF HUMAN ACTIVITIES

Aquatic habitats become contaminated as a result of anthropogenic activities such as deforestation, filling and construction of canals, dams, roads and bridges, as well as household, industrial, and agricultural operations. The primary causes of water contamination are industrialization, agriculture, and human habitation. The primary cause of the deterioration of water ecosystems is the majority of effluent from agriculture. According to WWAP (2015), 38% of water ecosystems in the EU are severely impacted by agriculture. Unrestricted raw municipal and industrial wastewater poses a serious risk to developing countries (Mateo-Sagasta et al., 2017). The most prevalent unfavorable environmental effects that are caused by human activities related to aquaculture include eutrophication of water, water quality, modification or loss of natural habitats, introduction and spread of diseases, fish species extinction, etc. (FAO, 2006).

Heavy metals

The aquatic ecology is contaminated with heavy metals from both man-made and natural sources. Direct discharges into both fresh and marine ecosystems or through indirect routes such as atmospheric deposition and surface run-off are two possible routes of entry. The weathering of rocks and volcanic activity are significant natural sources. Heavy metals are naturally occurring components of rocks and soils that are released into the environment through weathering and erosion. The growth of agriculture and industry encourages the sharp rise in heavy metal pollution. The gradual leaching of heavy metals from soil or rock into water can naturally occur in aquatic systems, generally at low concentrations that have no deleterious impact on human health (Rashid et al. 2019).

In the water system, elevated concentrations of Ag, Cr, Pb, Cd, Cu, Z, Ni, and other heavy metals are often indicative of aquatic heavy metal pollution. Due to industrial and agricultural activities, stormwater and wastewater discharges can release five metals into the environment at excessive concentrations: arsenic, cadmium, copper, mercury, and zinc. These are the five metals with the greatest potential for influence (Alloway, 2013). Given their extreme toxicity and enduring nature in all aquatic environments, they constitute an important class of hazardous pollutants. There are impurities of zinc and copper in fertilizers, and certain fungicides and algaecides include arsenic, cadmium, and mercury (Campbell, 2006).

Certain heavy metals have the potential to change into persistent metallic compounds with high toxicity, which may then magnify in the food chain, endangering human health, and becoming bioaccumulated in the organisms. Aquatic metal exposure has been linked to a number of detrimental effects, such as aberrant fetal development, infertility, and immunological deficiencies (Zhou et al., 2008). Certain heavy metals that are added to water systems, such as lead, mercury, cadmium, nickel, copper, and chromium, may be very harmful to aquatic life at high concentrations. For instance, according to the overview of recent advancements in the field, cadmium is a priority environmental contaminant with consequences for human health and the maintenance of biodiversity in affected ecosystems and the timeliness of a broader, ecosystem-based approach to cadmium research is highlighted. Depending on their quantity, toxic metals including Cu, Zn, Co, Ni, Fe, Cr, Mn, I, and Se widely referred to as micronutrients play a critical role in the physiological and metabolic processes of plants, people, and microbes. However, some toxic metals, like As, Ag, Hg, Cd, and Pb, have no biological significance for plants or animals. Because they are harmful and contain metalloids that cause cancer, toxic metals can cause diabetes, urinary tract issues, cardiovascular disease, skin and lung cancer, and neurotoxicity (Mehmood et al., 2019).

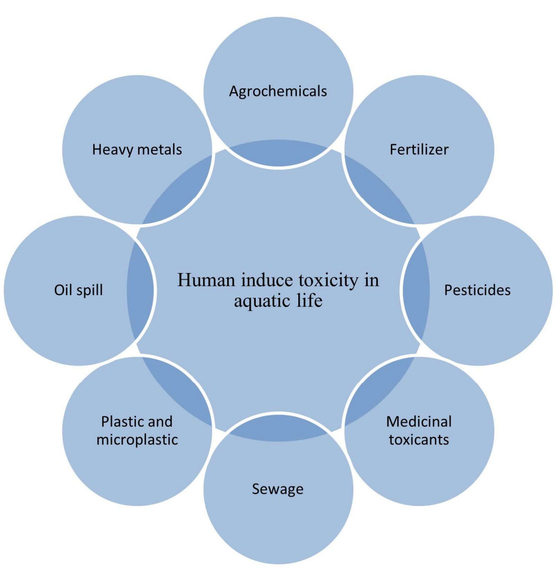

Fig 1. Toxicity inducing factors in aquatic life

Agrochemicals

Mateo-Sagasta et al. (2017) state that the increased demand for food has led to the expansion of agriculture and the clearing of land, both of which have raised the water's pollution levels. The population is growing, which has increased demand for food and increased usage of agrochemicals to improve productivity (Schwarzenbach et al., 2010). Due to the unsustainable use of agrochemicals to enhance output, rivers, lakes, aquifers, and coastal waters are some of the greater pollution masses in the environment. More significantly, because of runoff, direct drift, and leaching, agricultural areas gather an extensive variety of agrochemicals from nearby fields, and these places are the principal receivers of agrochemicals (Rathore & Nollet, 2016).

Fertilizers

Water contamination occurs when fertilizers are given more often than the soil can fix them, when crops absorb them, or when surface runoff removes them from the soil. Overuse of phosphate and nitrogenous fertilizers can enter surface water bodies through surface runoff or seep into groundwater. The use of organic manure in excess in the agricultural fields will cause diffuse water pollution. The majority of the time, manure is not stored in confined areas and can be washed into waterways via surface runoff during heavy rainfall events. The eutrophication caused by adding nutrients of lakes, reservoirs, ponds, and coastal waters is caused by high-nutrient concentration together with other substances. This causes an overabundance of aquatic plant growth, or algae blooms which kill other aquatic plants and animals. Worldwide, eutrophication has been found in around 415 coastal regions, 169 of which are hypoxic. According to the high nitrate content in water for consumption, excessive buildup of nutrients may also increase the adverse health effects such as blue-baby syndrome. The most prevalent chemical contamination in groundwater aquifers worldwide is nitrate, which seeps into the groundwater from agricultural practices (Mateo-Sagasta et al., 2017).

Table 1. Point and non-point sources that cause toxicity in aquatic environment.

Point sources	Nonpoint sources	Reference
Industrial and municipal wastewater	Runoff from fields used for farming	Carpenter et al., 2009
Leachate and runoff from garbage disposal sites	Runoff from range and meadow	
Runoff from stables and livestock enclosures	Runoff from places with and without sewers	
Runoff from industrial locations, oil refineries, and mining sites	Decomposing leachate in tanks	Paul & Meyer, 2001
Stormwater sewer overflow	Runoff from the construction site	
overflow from sewers for human waste and drainage	Runoff from mines that have been abandoned	Herbert et al., 2015
Runoff from building sites	Air pollution over a body of water and land activities that produce pollutants	

Medicinal pollutants

In the past 20 years, new agricultural pollutants such as antibiotics, vaccines, growth promoters, and hormones have emerged. The OECD (2012) states that these pollutants can enter water through aquaculture farms, leaching and runoff from livestock, as well as through the application of manure and slurries to agricultural land. As report by Dulio Valeria (2008), the aquatic habitats of Europe are home to over 700 newly identified contaminants, along with their metabolites and transformation products. Agriculture operates as a source of these pollutants as well as a means of spreading and reintroducing emerging pollutants into aquatic habitats through the use of wastewater for irrigation and municipal bio-slides as fertilizer. An estimated 35.9 million hectors of agricultural land use wastewater indirectly. It is important to pay attention to the possible health hazards that could arise from agricultural goods polluted with new contaminants (Thebo et al., 2017).

Pesticides

Pesticides such as insecticides, herbicides, and fungicides are often used in agricultural regions throughout several nations, causing water sources and aquatic ecosystems to become contaminated, according to Schreinemachers & Tipraqsa (2012). These pollutants can either include harmful substances that might wipe out aquatic life, or they can be ingested by aquatic organisms and go through the food web to eventually become toxic to humans. Agricultural fields use millions of tons of pesticides (FAO, 2006). Significant human morbidity and death are caused by acute pesticide poisoning, particularly in low-income nations where impoverished farmers frequently employ extremely dangerous pesticides as shown in Fig 2 (Bhat et al., 2018).

Sewage

Sewage makes up a significant portion of the waste released into aquatic habitats. Wastes from bathrooms, washing machines, kitchens, and feces are among the household, industrial, and municipal wastes that make up sewage. The greatest sinks for the discharge of these pollutants are freshwater sources (Tukura et al., 2009). Approximately 73% of water bodies are contaminated as a result of the direct discharge of 58% of urban wastewater and 81% of industrial waste into water bodies without proper or insufficient treatment (Vargas-Gonzalez et al., 2014). Clean water resources are being depleted and water contamination has increased as a result of sewage releases (AGR, 2012). Large amounts of these wastes are produced every day in densely populated cities, and eventually they are washed out via drainage systems that typically open into adjacent rivers or aquatic systems. It has seen widespread ecological deterioration, including a reduction in the supply and quality of water, frequent and severe flooding, extinctions, and modifications to the distribution and composition of the aquatic biota. The amount and frequency of wastewater effluents entering water bodies, along with the type and concentration of contaminants, determine how harmful sewage is (Akpor & Muchie, 2011). Numerous microbes, heavy metals, nutrients, radionuclides, and personal hygiene and pharmaceutical goods are all found in sewage. Since sewage is mostly organic in nature, its organic load lowers the oxygen content of the receiving waters, which is why sewage is referred to as having a high BOD. The aquatic ecosystems oxygen balance plays a major role in determining how untreated sewage affects surface water, because oxygen is necessary for the system to support biological life. According to Mehmood et al. (2019), low dissolved oxygen levels can affect how certain fish species function and ultimately cause fish populations to die. According to Chigor et al. (2013), sewage effluent that finds its way into surface waters harbors a range of pathogenic organisms that pose a threat to human health and the general public by contaminating water that is used for domestic and other purposes and possibly spreading diseases. Water supplies are contaminated by runoff from specific diseases (WHO 2012; Mateo- Sagasta et al. 2017). Infectious disorders brought on by harmful microbes account for over 25% of all fatalities globally. Approximately 1400 types of microorganisms, including bacteria, protozoa, parasitic worms, protozoan parasites, fungus, and viruses, have been identified by researchers as potentially harmful to human health.

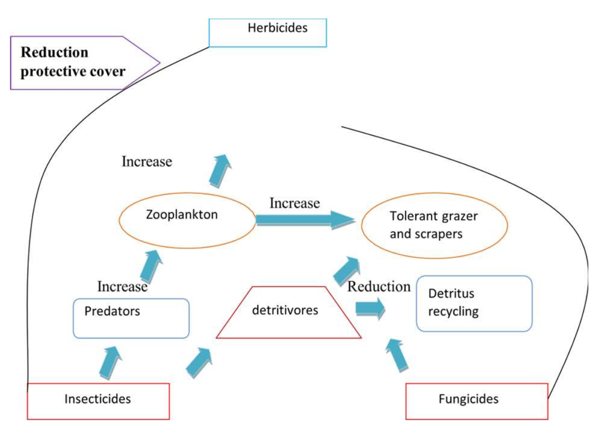

Fig 2. Effects of different pesticides on aquatic

Plastics and microplastics

The buildup of plastic waste is one of the many anthropogenic stresses on aquatic environments that is most noticeable but least researched. Plastics are extremely beneficial to human culture, but because of their longevity, inadequate waste management, and unsustainable use, they accumulate significantly in natural environments. Plastic debris has become a major problem in the marine ecosystem worldwide due to its great mobility (Cole et al., 2011). This includes the polar zone, mid-ocean islands, and the deep sea (Cauwenberghe et al., 2013). There is a lack of clarity on the origins of marine plastics. Rough estimates put the amount of marine litter at 70–80%, with plastics making up the majority, attributable to inland sources that rivers release into the ocean. Rivers transport a lot of plastic, which makes them a major source of marine plastic pollution.

Large amounts of plastic waste are dumped into lakes, rivers, beaches, and other bodies of water (Lechner et al., 2014). Significantly more plastic is used in low-income countries with weak waste management regulations. Plastics are ubiquitous in maritime environments, posing an aesthetic issue as well as a threat to many species who swallow or become entangled in the material. Although plastic pollution in freshwater and marine habitats has been documented as a problem since the 1970s, it has only just been recognized as a global issue. Single-use plastics, such as plastic bags and microbeads, are reportedly a significant contributor to this pollution (Fig 3). As a result, MPs have the potential to spread human pathogens that affect the quality of water through the water. Furthermore, a multitude of chemical additives are contained in and released by plastics, and they also absorb organic pollutants from the surrounding medium. When compounds like MPs are ingested by organisms, they can transfer to them, which might enhance the chemical exposure of the ingesting organism and thus, toxicity (Rochman, 2013; Dekiff et al., 2014).

Oil spills

The release of liquid petroleum hydrocarbons into the environment, primarily in the marine ecosystem, as a result of human activities is known as an oil spill. An oil spill has a negative impact on the environment (Broekema, 2016). This is due to the fact that petroleum hydrocarbons are harmful to all living things, including aquatic and terrestrial ones. Researchers and environmentalists are paying attention to the pollution of maritime habitats. This is because oil spills have a detrimental effect on marine life. According to estimates, a 1% increase in the spill's size will result in an additional US$0.718 million in damage (Allo & Loureiro, 2013). Hazardous waste includes oil spills from damage, accidents during transportation, and other mining and industrial operations. They are thought to be the organic contaminants that affect aquatic environments most frequently. There are several potential origins of oil spills: pipelines (9.3%), non-tank vessels (19.9%), facilities (27.6%), oil tankers (35.7%), and other sources (7.4%). Accidents on board a ship, as well as the deliberate release of oily waste into the water, can all result in marine ship-source oil spills (Knapp & Van de Velden, 2011).

Effect of oil pollution on aquatic life

When marine and coastal animals come into contact with oil, they experience both short-term health issues and long-term physiologic and behavioral alterations. Animals exposed to oil in modest concentrations may have transient bodily injury. Trauma types might include inflammation of the skin, immune system changes, harm to the reproductive or developmental systems, and liver illness. Large amounts of oil can have a broad immediate fatality effect on aquatic life and wildlife, as well as increase the risk of long-term damage like cancer (Ridoux et al., 2004).

Direct effects of oil spills

Ingestion: When oil or dispersing agents are eaten, digestive issues including bleeding, ulcers, diarrhea, and gastrointestinal pain might happen. These problems might make it harder for animals to digest and absorb nourishment, which would eventually lead to a reduction in their general level of fitness and health. There are multiple food chain rungs at which consumption can occur. It is known that vegetation coated in oil particles may be consumed by animals that graze on organisms, such as sea turtles. Carnivorous (animal-eating) species, such as shorebirds that feed clams, mussels, or worms buried in the zone between the tides, may ingest prey creatures exposed to petroleum deposits thrown onto the seashore. When oil gets into the filtering mechanism of baleen whales which have teeth that resemble hairs and are used to collect tiny particles from ocean water it can render them incapable of moving; in severe situations, this fouling of the baleen can result in malnutrition and death. Through bioaccumulation, which is the increasing concentration of poisons present at higher levels of the food chain, top predators may become exposed to significant amounts of contaminants (Carls et al., 2001).

Absorption: Through the epidermis, dispersants or oil can be absorbed, which can harm an animal's kidneys and liver, create anemia, weaken its immune system, stop it from reproducing, and in severe situations, even kill it. Certain species may experience skin irritation, burning, or infections as a result of oil exposure. It's possible for fish and sea turtle embryos to grow more slowly than usual, which would reduce hatching rates and impede growth (Ben-David et al., 2000).

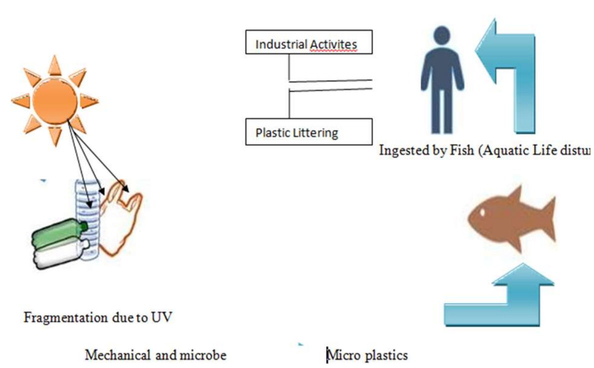

Fig 3. Way of plastics effects on aquatic life (fish)

Inhalation: Emphysema, pneumonia, and lung irritation can result from breathing in volatile compounds, which are vaporized molecules produced by oil that is floating on the surface. All of the following species are vulnerable to this risk: food availability may result in a decline in general health. Manatees, dolphins, whales, and sea turtles all occasionally come to the surface to breathe. In addition, the physiological difficulties these animals experience from the oil exposure may increase their energy needs (Alonso-Alvarez et al., 2007).

Indirect effects of oil spills

Living cycle disturbances may become apparent if certain living forms are more susceptible to the effects of oil than others. The eggs, larvae, and juveniles of many species are more vulnerable to the harmful effects of pollution than adults are. Changes in the percentage of individuals from different life stages within a species can lead to adjustments in the way that habitat is utilized, which can affect food chains at every level. Moreover, a species' capacity to recover from a spill is significantly diminished if a specific life stage is destroyed. Adult sea turtles are more likely to be affected by oil spills when they inhale while at the surface or when they eat food contaminated with oil or tar balls that float and confuse for food. Regardless of their nutritional worth, sea turtles have a tendency of eating floating things. Through absorption, eggs and hatchlings are vulnerable. Two of the five species of sea turtles found in the Gulf of Mexico are threatened, while three species Kemp's Ridley, Leatherback, and Green are endangered. Since these species start their nesting season in the spring, eggs and hatchlings are probably at a higher risk of coming into contact with oil spills during this time of year (Long & Holdway, 2002).

CASE STUDY

History of oil spills in the Gulf of Mexico

There is a vast variety of fauna in the Gulf of Mexico, including several endangered and vulnerable species. The Gulf of Mexico has recently seen six significant oil spills, which have shed light on the best ways to handle these tragedies in order to reduce the negative consequences on species. Numerous federal, state, and local organizations, along with volunteers, are collaborating to reduce the harm that the oil spill that started when the deep-water drilling platform collapsed off the coast of Louisiana on April 22, 2010, will do to animals (NOAA, 2010).

Indonesia bone river effected by heavy metal

The easternmost area of Indonesia, Bone River, has been affected by heavy metal contamination as a result of artisanal small-scale gold mining activities. Residents utilize this river as a source of water because there are no dependable clean water sources close by. Water and sediment samples were taken all the way down to the delta from ASGM and the Bone River. Particle-induced X-ray emission was used to measure the concentrations of As, Hg, and Pb in soil samples, while inductively coupled plasma mass spectrometry was used to measure the concentrations of the same elements in water samples. According to the findings, the quantities of As, Hg, and Pb in water ranged from 66 to 82,500 μg/L, 17 to 2080 μg/L, and 11 to 1670 μg/L, each. These levels exceeded the World Health Organization's safe drinking water recommendations by a factor of one thousand to ten thousand, indicating that Bone River water is not suitable for drinking or cooking (Gafur et al., 2018).

RECOMMENDATIONS

- The toxicity statistics are mostly focused on fish, and the methodologies used to derive water quality standards (WQC) primarily take into account a small number of well- studied species. In the aquatic environment, macrophytes are essential for the movement of materials and energy, but the available data on their contributions to regulatory choices is small. The primary explanation for this is that macrophytes were formerly thought to be less sensitive than mammals. The lack of established protocols for carrying out and analyzing the outcomes of toxicity testing on plants is another factor. Nevertheless, other studies have been conducted and have shown differing results. Lewis (1995) reviewed the application of plants in toxicity testing and identified 39 substances to which plants exhibit greater sensitivity than mammals. Some researchers came to the conclusion that the WQC for the preservation of aquatic life could not completely protect aquatic plants for some heavy metals like Ba and Cd based on the results of the toxicity test on duckweed. Much agree that macrophytes are as much of a traditional and significant indicator as fish and phytoplankton. Lytle & Lytle (2001) demonstrated that toxicant concentrations that shield fish or other invertebrates from harm do not always shield macrophytes from harm. Therefore, in order to provide complete protection for aquatic life, aquatic macrophytes should be included while determining WQC.

- There is less data available for toxicant combination testing, which is the most common case in real life. The processes and dynamics at work when microorganisms are subjected to mixtures are not well understood. Because of the unpredictable interactions between the mixture's components, the toxicity of mixtures is significantly more complicated than that of single substances (Mitchell et al., 2002). Coordination, rivalry, protection, and other interactions are all part of the effect mechanism. According to Zhou et al. (2008), in addition to the physical and chemical characteristics, the combination and concentration of pollutants have a more direct and significant impact on multiple-contamination circumstances. The interaction between different contaminants has a varied response model for each species. Because joint toxicity is more relevant to actual environmental damage, researchers are paying greater attention to it (Otitoloju, 2002). Unfortunately, practically all produced WQC to yet have only targeted one pollutant, which means that the aquatic ecosystem will likely not receive enough protection. Consequently, pertinent studies about combined toxicity have to be conducted. It's one of the methods used to calculate WQC. A technique for determining the risk quotient (RQ) for herbicide combinations with comparable modes of action has been presented. Reliable and relevant WQC are provided for each herbicide in order to compute the RQm. The sum of the WQC ratios and the recorded ambient concentration for every herbicide may be expressed as the RQm. The focus addition model is the source of it.

- Deriving WQC for newly developing pollutants is essential to future aquatic life protection. Recently, chemicals or microbes known as endocrines (ECs) have been found in natural streams, people, and other living things. This type of pollutant has been demonstrated to be dangerous and persistent in the environment, even at very low concentrations, and it may have detrimental effects on human health or the aquatic ecology.

- Chemicals that have drawn a lot of attention include medications, personal care products, polybrominated biphenyl ether, nanomaterials, and endocrine disruptors. Globally, ECs have attracted the greatest interest. Regulating standards, however, do not have any whose scientific foundation is being updated or reassessed. The intricacy of matrices and the often-low concentrations of these substances make all of this study difficult in addition to their variety of chemical characteristics. Furthermore, new and more harmful contaminants have been found on a regular basis. As a result, nations and international organizations work hard to create new WQC and modify those that are already in use. State toxics criteria must be updated under the Clean Water Act of 1972 to conform to federally mandated standards in a timeframe of three to five years.

CONCLUSION

Many of the hazardous materials that are finding their way into freshwaters now were also there a few decades ago, but a rise in human activity has made some of them more prominent recently. Unidirectional transmission and dispersion of toxicants in flowing streams can modify their effects and allow for a certain level of self-purification. Toxicology is also influenced by the receiving water's chemical composition. Pollution's final impact is also influenced by biological variables. The possibility of hazardous compounds building up in tissues makes some pollutants which may exist in water at extremely low ambient concentrations more significant. After contaminants enter flowing rivers catastrophically, drift from undamaged areas upstream may recover the biota of those streams. The main cause of the destruction of aquatic habitats is human activity. Water contamination is mostly caused by increased industrialization and urbanization. The disposal of solid waste, industrial waste, and household garbage is just one example of the massive human contribution to water contamination. The globe is very concerned about water contamination. Reducing the contamination of aquatic habitats requires a strong emphasis on environmental education.

REFERENCES

Akpor OB & B Muchie, 2011. Environmental and public health implications of wastewater quality. African Journal of Biotechnology 10:2379-87.

Alimba CG & C Faggio, 2019. Microplastics in the marine environment: Current trends in environmental pollution and mechanisms of toxicological profile. Environmental Toxicology and Pharmacology 68:61-74. https://doi.org/10.1016/j.etap.2019.03.001

Allo M & ML Loureiro, 2013. Estimating a meta-damage regression model for large accidental oil spills. Ecological Economics 86:167-75. https://doi.org/10.1016/j.ecolecon.2012.11.007

Alloway BJ, 2013. Introduction. In: Heavy metals in soils (Alloway B, ed). Environmental Pollution: Vol 22, Springer, Dordrecht, USA, pp: 3-9. https://doi.org/10.1007/978-94-007-4470-7_1

Alonso-Alvarez C, C Perez & A Velando, 2007. Effects of acute exposure to heavy fuel oil from the Prestige spill on a seabird. Aquatic Toxicology 84:103-10. https://doi.org/10.1016/j.aquatox.2007.06.004

Barange M, RO Boyle, KL Cochrane et al, 2010. Marine resources management in the face of change: from ecosystem science to ecosystem-based management. In: Marine Ecosystems and Global Change (Barange M, JG Field, RP Harris et al., eds): Oxford University Press, Oxford, UK, pp: 253-83. https://doi.org/10.1093/acprof:oso/9780199558025.003.0009

Ben-David M, TM Williams & OA Ormseth, 2000. Effects of oiling on exercise physiology and diving behavior of river otters: a captive study. Canadian Journal of Zoology 78:1380- 90. https://doi.org/10.1139/z00-059

Bhat RA, MMA Shafiq-ur-Rehman, MA Dervash et al., 2018. Current status of nutrient load Dal Lake of Kashmir Himalaya. Journal of Pharmacognosy and Phytochemistry 6:165- 169.

Broekema W, 2016. Crisis-induced learning and issue politicization in the Eu: the Braer, sea empress, Erika and prestige oil spill disasters. Public Administration 94:381-98. https://doi.org/10.1111/padm.12170

Brown TM & H Takada, 2017. Indicators of marine pollution in the North Pacific Ocean. Archives of Environmental Contamination and Toxicology 73:171-5. https://doi.org/10.1007/s00244-017-0424-7

Campbell PGC, 2006. Cadmium-a priority pollutant. Environmental Chemistry 3:387-8. https://doi.org/10.1071/EN06075

Carls MG, MM Babcock, PM Harris et al., 2001. Persistence of oiling in mussel beds after the Exxon Valdez oil spill. Marine Environmental Research 51:167-90. https://doi.org/10.1016/S0141-1136(00)00103-3

Carpenter SR, NF Caraco, DL Correll et al., 2009. Non point pollution of surface waters with phosphorus and nitrogen. Ecological Applications. 8: 559-68. https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2

Cauwenberghe LV, A Vanreusel, J Mees et al., 2013. Microplastic pollution in deep-sea sediments. Environmental Pollution 182:495-9. https://doi.org/10.1016/j.envpol.2013.08.013

Chigor VN, T Sibanda & AI Okoh, 2013. River and three source water dams along its course in the Eastern Cape Province of South Africa. Environmental Science and Pollution Research 20:4125-36. https://doi.org/10.1007/s11356-012-1348-4

Cole M, P Lindeque, C Halsband et al., 2011. Microplastics as contaminants in the marine environment: a review. Marine Pollution Bulletin 62:2588-97. https://doi.org/10.1016/j.marpolbul.2011.09.025

Dekiff JH, D Remy, J Klasmeier et al., 2014. Occurrence and spatial distribution of microplastics in sediments from Norderney. Environmental Pollution 186:248-56. https://doi.org/10.1016/j.envpol.2013.11.019

FAO. 2016. The state of world fisheries and aquaculture contributing to food security and nutrition for all. Rome, United Nations.

Gafur NA, M Sakakibara, S Sano et al., 2018. A case study of heavy metal pollution in water of bone river by artisanal small-scale gold mine activities in eastern part of Gorontalo, Indonesia. Water 10:1-10. https://doi.org/10.3390/w10111507

Hinton T, O Simon, E Mottin et al., 2011. Effects of dietary uranium on reproductive endpoints-fecundity, survival, reproductive success-of the fish Danio rerio. Environmental Toxicology and Chemistry 30:220-5. https://doi.org/10.1002/etc.381

Herbert ER, P Boon, AJ Burgin et al., 2015. A global perspective on wetland salinization: ecological consequences of a growing threat to freshwater wetlands. Ecosphere, 6: 1–43. https://doi.org/10.1890/ES14-00534.1

Kalogianni E, A Vourka, I Karaouzas et al., 2017. Combined effects of water stress and pollution on macro invertebrate and fish assemblages in a Mediterranean intermittent river. Science of the Total Environment 603:639-50. https://doi.org/10.1016/j.scitotenv.2017.06.078

Knapp S & M Van de Velden, 2011. Global ship risk profiles: safety and the marine environment. Transportation Research Part D: Transport and Environment 16:595-603. https://doi.org/10.1016/j.trd.2011.08.001

Lechner A, H Keckeis, F Lumesberger-Loisl et al., 2014. The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. Environmental Pollution 188:177-81. https://doi.org/10.1016/j.envpol.2014.02.006

Lewis MA, 1995. Use of freshwater plants for phytotoxicity testing: A review. Environmental Pollution 87:319-36. https://doi.org/10.1016/0269-7491(94)P4164-J
Long SM & DA Holdway, 2002. Acute toxicity of crude and dispersed oil to Octopus pallidus (Hoyle, 1885) hatchlings. Water Research 36:2769-76. https://doi.org/10.1016/S0043-1354(01)00520-6
Lytle JS & TF Lytle, 2001. Use of plants for toxicity assessment of estuarine ecosystems. Environmental Toxicology and Chemistry 20:68-83. https://doi.org/10.1002/etc.5620200107
Malaj E, PC Von Der Ohe, M Grote et al., 2014. Organic chemicals jeopardize the health of freshwater ecosystems on the continental scale. Proceedings of the National Academy of Sciences 111:9549-54. https://doi.org/10.1073/pnas.1321082111
Mateo-Sagasta J, SM Zadeh& H Turral et al., 2017. Water pollution from agriculture: a global review. Food and Agriculture Organization of the United Nations, Rome and the International Water Management Institute on behalf of the Water Land and Ecosystems Research Program, Colombo.
Mehmood MA, H Qadri, RA Bhat et al., 2019. Heavy metal contamination in two commercial fish species of a trans-Himalayan freshwater ecosystem. Environmental Monitoring and Assessment 191:104. https://doi.org/10.1007/s10661-019-7245-2
Mitchell EJAK, JE Burgess & RM Stuetz, 2002. Developments in ecotoxicity testing. Reviews in Environmental Science and Biotechnology 1:169-98. https://doi.org/10.1023/A:1020842718996
Dulio, Valeria. (2008). NORMAN, List of emerging substances, Network of Reference Laboratories, Research Centres and related Organisations for Monitoring of Emerging Environmental Substances.
NOAA (National Oceanic and Atmospheric Administration), 2010. Other significant oil spills in the Gulf of Mexico.
OECD, 2012. Water quality and agriculture: Meeting the policy challenge, OECD studies on water, OECD Publishing. http://dx.doi.org/10.1787/9789264168060-en
Okereafor GU, AF Mulaba-Bafubiandi & V Mavumengwana, 2017. Possible heavy metals transportation and ground erosion during heavy rainfall in rural Mangweni (Tzaneen, Limpopo Province, South Africa). Journal of the Southern African Institute of Mining and Metallurgy 17(7):2204. doi:10.3390/ijerph17072204.
Otitoloju AA, 2002. Evaluation of the joint-action toxicity of binary mixtures of heavy metals against the mangrove periwinkle Tympanotonus fuscatusvar Radula (L.). Ecotoxicology and Environmental Safety 53: 404-15. https://doi.org/10.1016/S0147-6513(02)00032-5
Paul MJ & JL Meyer, 2001. Streams in the urban landscape. Annual Review of Ecological Systamatics 32:333-65. https://doi.org/10.1146/annurev.ecolsys.32.081501.114040
Pope CN, D Schlenk & FJ Baud, 2020. History and basic concepts of toxicology. In: An Introduction to Interdisciplinary Toxicology (Pope CN & J Liu eds). Academic Press, London, UK, PP:3-15. https://doi.org/10.1016/B978-0-12-813602-7.00001-6
Rand GM, PG Wells & LS McCarty, 2020. Introduction to aquatic toxicology. In Fundamentals of aquatic toxicology (Rand, GM ed), CRC Press, Florida, USA, pp: 3-67. https://doi.org/10.1201/9781003075363-2
Rashid A, RA Bhat, H Qadri et al., 2019. Environmental and socioeconomic factors induced blood lead in children: An investigation from Kashmir, India. Environmental Monitoring and Assessment 191:76. https://doi.org/10.1007/s10661-019-7220-y
Rathore HS & LM Nollet, 2016. Handbook of pesticides. In: Methods of Pesticide Residues Analysis. (Leo MLN &HS Rathore, eds): CRC Press, Florida, USA, pp: 628.
Ridoux V, L Lafontaine, P Bustamante et al., 2004. The impact of the "Erika" oil spill on pelagic and coastal marine mammals: Combining demographic, ecological, trace metals and biomarker evidences. Aquatic Living Resources 17:379-87. https://doi.org/10.1051/alr:2004031
Rochman CM, 2013. Plastics and priority pollutants: a multiple stressor in aquatic habitats. Environmental Science & Technology 47:2439-40. https://doi.org/10.1021/es400748b
Schreinemachers P & P Tipraqsa, 2012. Agricultural pesticides and land use intensification in high-, middle- and low-income countries. Food Policy 37:616-26. https://doi.org/10.1016/j.foodpol.2012.06.003
Schwarzenbach RP, T Egli, TB Hofstetter et al., 2010. Global water pollution and human health. Annual Review of Environment and Resources 35:109-36. https://doi.org/10.1146/annurev-environ-100809-125342
Thebo AL, P Drechsel, EF Lambin et al., 2017. A global, spatially explicit assessment of irrigated croplands influenced by urban wastewater flows. Environmental Research Letters 12:074008. https://doi.org/10.1088/1748-9326/aa75d1
Tukura BW, JA Kagbu & CE Gimba, 2009. Effects of pH and seasonal variations on dissolved and suspended heavy metals in dam surface water. Chemistry Class Journal 6:27-30.
Vargas-Gonzalez HH, JA Arreola-Lizarraga, RA Mendoza-Salgado et al., 2014. Effect of sewage discharge on trophic state and water quality in a coastal ecosystem of the gulf of California. The Scientific World Journal 1-7. https://doi.org/10.1155/2014/618054
WHO, 2012. Animal waste, water quality and human health. World Health Organization, Geneva.
WWAP. 2015. The United Nations World Water Development Report 2015: Water for a sustainable world. United Nations World Water Assessment Programme (WWAP). Paris, United Nations Educational, Scientific and Cultural Organization.
Zhou Q, J Zhang, J Fu et al., 2008. Biomonitoring: an appealing tool for assessment of metal pollution in the aquatic ecosystem. Analytica Chimica Acta 606:135-50. https://doi.org/10.1016/j.aca.2007.11.018