

The harm of difficult to degrade plastics to animals and the surrounding environment

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Abstract. Littering or the disposal of plastic products and particles in the environment is a current global concern. Because plastics are long-lasting and are used extensively, productivity has increased dramatically to 400 million tons per year, and only a small fraction of them is recycled or disposed of correctly. This research aimed at examining the impacts of plastic pollution on soil and marine environment especially on the changes in physical and chemical properties of the soil, the effects on plant growth and marine organisms through ingestion and entanglement. The study also notes that microplastics have negative impacts on the physical characteristics of the soil including fertility and permeability as well as the behavior of macro-organisms like earthworms, and marine life is impacted by species entanglement and ingestion of plastics leading to extensive ecological risks. Furthermore, while biodegradable plastics are more environmentally friendly, they decompose at varying speeds depending on the conditions and microorganisms. The study also highlights the importance of improved waste management, reduction in the use of plastics, enhancement of recycling and biodegradation studies to minimize the adverse effects on the environment in the long run. This work assists in increasing the public's understanding of the global problem of plastic pollution and promotes the need for a universal approach to minimizing the negative impact on the environment.

Keywords: Plastic pollution; Living environment; Biology; Marine.

1. Introduction

Plastic pollution is defined as the presence of plastic products and particles (including plastic containers, bags, and microbeads) in the Earth's environment and with adverse effects on the environment, habitats, and people. Plastic is cheap and durable and therefore it is used in large quantities, which leads to high production.

Currently, the world produces about 400 million tons of plastic per year, and this figure is continuously increasing [1]. About 3 billion tons of plastic were produced globally, while 9% of this amount was recycled and 12% was burned [2]. As per some marine pollution specialists, the quantity of plastic in the sea could equal the weight of the fish by 2050. A report shows that plastic waste kills about one hundred thousand marine animals every year [1]. The level of pollution depends on the various products that are made of plastic. In everyday usage, there is a great need for various types of plastics in the global market such as PE, PP, PVC, PET, and PS. The processes of polymer degradation and accumulation of plastics in the atmosphere are still unknown because there are no appropriate analytical methods or conventional approaches. These variations make the environmental plastic emissions difficult to manage and hence the development of standard procedures is difficult hence slowing the pace of research on the same. There is a dire need to increase the knowledge about toxic plastic emissions.

Pollution by plastics is affecting wildlife in a very negative way especially those that reside in places that are in close contact with human beings or those that exist in areas that plastics are commonly found. These animals are very sensitive to the effects of plastics and other non-food items that they are likely to consume. Although this problem has been researched in livestock, it has not been researched to a great extent in wild animals. In contrast to the livestock, wild ruminants are usually more picky in their diet choice and therefore they do not suffer from conditions such as rumen



impaction due to consumption of non-digestible substances. But they consume the solid waste including the plastic bags which is very dangerous to their health. Foreign materials that get into their tissues cause a number of problems depending on the material and how it got into the body[3].

Domesticated animals living close to human beings or areas with plastic pollution are at high risk of contracting diseases. The use of the plastic bags and other products that are not biodegradable affects the environment by polluting the environment and when the animals consume these products they are bound to have serious health complications. This is especially so with the free-roaming animals where ingesting plastics results in serious health complications or even death [4]. It also affects the food chain and brings in carcinogenic risks for fish, animals, and humans. Some of the chemical used in plastics like Diethylhexyl phthalate, lead, mercury and Cadmium have been found to cause cancer, reproductive problems and neurotoxicity respectively. The issue of plastic pollution and its effect on the fauna is rather global and requires a comprehensive solution. Measures to minimize the use of plastics, enhance the disposal of wastes and enhance people's awareness on the impacts of this problem are important steps that need to be taken to help solve this problem and make the world a better place for humans and animals.

Marine life is especially vulnerable to plastic pollution since 134 species have been found to have ingested plastics. They include fish, sea turtles, seabirds and marine mammals such as the sperm whales and the dolphins[5]. A research done in 2015 showed that 90% of water birds sampled had ingested plastic in their system as compared to only 5% in 1960. If no concrete measures are taken, this percentage could go up to 99% by the year 2050[6]. Microplastics and fibers have been identified in oysters, mussels, large pelagic fish, crisp packets and cigarette butts among other items found in the stomach contents of the fish. Some of the shocking incidents include pulling out a 9-meter-long fishing line and a 4-meter-long rope from the stomach of a dead animal[7]. Plastic ingestion can be disastrous for the marine life and causes decrease in stomach size, blockage of the intestines, ulcers, necrosis and in some cases fatal wounds. There is the need to act now to address the ever increasing problem of plastics in the seas.

This article will specifically demonstrate the significant threat that plastic pollution poses to ecosystems, particularly in soil environments. Due to factors such as soil texture, organic matter, and low oxidation, plastics, including microplastics, accumulate and degrade at a slow rate. And microplastics can damage soil fertility, permeability, and the behavior of organisms such as earthworms, affecting overall soil health. In addition, although bioplastics are more environmentally friendly, they also degrade at different rates based on bacterial activity. The widespread impact of plastic pollution requires urgent measures to mitigate its environmental consequences. Finally, include prospects for new processing methods for future plastic products.

2. Plastic Pollution

2.1. Impacts on Soil, Marine Ecosystems and Mitigation Strategies

Plastics, one of the essential materials for modern packaging products, present unique challenges in terms of decomposition. Unlike other materials, plastic typically takes decades or even centuries to fully decompose. This resilience is further exacerbated when plastics enter the soil, where their decomposition is impeded by the soil's texture, internal organic matter, light shielding effect, and low oxidation environment. Consequently, plastic debris in soil environments degrades at a significantly slower rate compared to other ecosystems like sand depositions and aquatic bodies. Notably, the presence of microplastics in soil is particularly concerning. Microplastics, which are formed when larger plastic debris breaks down, are often too small to be seen by the naked eye. These minute particles can accumulate in the soil, potentially affecting soil fertility and water permeability. In addition, they can be ingested by organisms in the soil, leading to significant negative changes in their microecological environment. For example, the digestive system of earthworms in the soil does not have the ability to digest plastic, which may lead to changes in their behavior and even population

dynamics, potentially causing a chain reaction on other soil-related organisms and larger ecosystems. By surface-identifying microplastics on tidal flats, Li et al. discovered that "the surfaces of different microplastics exhibit characteristics of polymer molecular chain breakage, such as micropores and cracks"[8]. For instance, earthworms will dig holes differently depending on the presence of microplastics in the soil, which may have an impact on the soil's properties and the worms' capacity to adapt. Lowering the number of earthworm-dependent forest plant communities could worsen the impact on other habitats. These surface changes indicate that microplastics begin to degrade, becoming smaller particle-size microplastics or even nanoplastics. The impact of microplastics on soil is not fully understood, but existing research suggests that the problem is widespread and deserves urgent attention. Microplastics may affect soil fertility, water retention capacity, and the composition and diversity of soil microbial communities. They may also pose a risk to human health, as microplastics can potentially migrate into groundwater and crops, entering the human food chain. Given the severity of the issue, it is imperative to explore effective strategies for mitigating plastic pollution in soil ecosystems. This includes reducing the use of plastics, promoting reuse and recycling, and developing new technologies for plastic degradation. Additionally, more research is needed to understand the ecological impacts of microplastics and how to best manage them to protect soil health and ecological balance.

Plastic pollution poses a dire threat to wildlife, often leading to entanglement, drowning, and limb severance. This toxicity not only hinders animals' eating habits but also causes harm that can extend to fetuses. The constant intrusion into natural habitats seriously disrupts numerous aquatic and terrestrial species, leading to widespread ecological imbalance. The contamination of land, water, and wildlife by plastic waste poses a critical threat to the survival of animals[9].

Due to the serious drawbacks of chemical plastics, the relevant fields have shifted their focus to biodegradable bioplastics. Dinesh Adhikari and his team conducted in-depth research on how three types of bioplastics degrade in soil and their impact on soil microbial biomass and diversity. The research results indicate a crucial relationship between the chemical composition and adhesive properties of plastics and their degradation rate in soil[10]. Based on the primary polymer components, bioplastics exhibit a wide range of biodegradability in soil settings. Certain bioplastics, such as polylactic acid, can linger in soil for a very long time.

The degradation rate of bioplastics is highly correlated with the bacterial mass present in the soil. According to Giulia B in 2014, it was found that "while it is true that there is a direct relationship between total bacterial bio-mass and bio-plastic degrading bacteria, the specific species of bacteria are not yet fully identified"[11]. This infers that where there is a high bacterial biomass in the soil, bioplastics are degraded at a faster rate.

When looking at the nature of the material, one must note that, unlike the organic matter that is a part of the soil, plastics can have a great impact on the soil structure and its composition. During the degradation of plastics, microplastics are found to be dispersed in the soil mixtures. These microplastics change some of the physical characteristics of the soil such as the bulk density, pore size and water-holding capacity. As a result, they are capable of preventing the formation of shrinkage cracks in the soil and reducing the rate of evaporation of water. This can lead to changes in the mechanical properties of the soil and other related changes which are apparent indications of the effect of plastics on the environment.

To investigate how changes in soil structure affect plants growing nearby, Marzan Ferdous and his colleagues experimented. They chose the green amaranth plant, renowned for its rapid growth, to observe reactions promptly. In this study, plastic was cut into small pieces using scissors and added to the soil in varying quantities. This allowed for a comparison of different levels of plastic degradation and content on plant germination and growth. When comparing the growth rates of the green Amaranth to the control group, it was evident that the presence of plastic in the soil significantly reduced the growth rate. Specifically, the experimental group exposed to the highest concentration of plastic exhibited the slowest growth rate. In contrast, the two experimental groups with lower plastic

content were able to partially mitigate the negative effects of plastic degradation but still lagged behind the control group in terms of growth rate. These findings highlight the adverse impact of plastic pollution on plant growth and underscore the need for effective plastic waste management to protect ecological health[12]. It is currently unclear how plastic debris has a negative impact on plant growth, but it is speculated that if there is plastic around, plants may need to obtain more nutrients to grow well. There is currently a view that plastic debris can hinder the growth and extension of plant roots and hairs in the field, leading to lower plant growth status compared to ordinary plants, and their health status is far below normal levels[13]. In addition, broken plastics occupy more space in soil pores, thereby reducing their water and gas retention capacity. This hinders the ability of amaranth roots to absorb sufficient water and nutrients, thereby slowing down plant growth. In addition, the interference of mixed plastic fragments on natural soil conditions hinders the growth of amaranth. Changes in soil structure can also affect ventilation processes, which can interfere with plant respiration and slow down plant development. In the ecological city, where plastic pollution prevails, animals, alongside plants, are also affected. These animals depend on each other for survival, but plastic pollution poses a threat to their existence. Marine plastic debris, a significant anthropogenic issue, has yet to be fully quantified for its environmental and ecological impact. The extent of damage done to the environment and marine life by plastic debris has not been quantified, but available data suggest that 80% of marine plastic litter originates from land while 20% originates from water, thus the research has given us some of the sources of marine plastic debris[14].

Lobelle and Cunliff conducted research on the biodegradation of marine plastic debris. They retrieved plastic materials from the marine environment and immersed them in salt water in laboratory setting. Research has found that microbial biofilms developed on the surface of the plastic and lowered its hydrophobicity and buoyancy but no biodegradation was found. This means that although some of the physical characteristics of the plastics may alter as a result of microbial action, the plastics remain plastic. Therefore, the study suggested that microorganisms in marine environments are, to a great extent, unable to degrade plastics. This shows how long plastic pollution lasts in water bodies before degrading, which is a long time. The problem of plastic waste in the ocean remains a threat to the lives of aquatic animals. One of the problems is that the animals often confuse the plastic debris with the food they need to consume. Fish, birds, and marine mammals have been recorded to consume plastics, which may cause internal injuries, blockages, and death in the process. This issue is global and plastic consumption is a major concern for animals[14]. Swallowed plastic not only has no nutritive value but also brings toxic substances into the animal's body worsening the health complications.

Another problem is entanglement, where animals can get entangled in plastic waste and drown, suffocate or die from physical injuries. This may make it difficult for the animals to capture their prey or escape from their predators hence leading to low chances of survival. Stress resulting from entanglement can also reduce reproductive capabilities, which will be detrimental to the already endangered species. Therefore, it can be concluded that plastic pollution remains a chronic issue in marine environments that poses a threat to marine species and affects the balance of marine ecosystems and the overall level of marine life.

2.2. Suggestions for Plastic Pollution Management

Different approaches to the management and mitigation of global ocean plastic pollution have been proposed by scientists, and the first one is the mechanical removal of the plastic waste from the water bodies but the authors admit that this is just the first step. After accumulating into piles, plastic waste has to be recycled and different approaches to recycling have to be approved by the government. The plastic recycling method is broken down into many stages and one of them is the re-extrusion (primary recycling) in which the plastic waste is melted and converted to resin particles but it has to be relatively clean plastic hence it is used. This method is common in industries that produce clean plastic waste such as the packaging industry. Mechanical recycling (secondary recycling involves sorting of plastics by type followed by crushing, cleaning and re-extrusion. However, this process is

most suitable for single polymer plastics as the pollution or complexity in the waste makes its effectiveness poor. Chemical recycling (three cycles of recycling) involves the process of depolymerization of plastics into monomers or petrochemicals which are then used to form new plastics. The methods include pyrolysis which involves heating plastics in an inert atmosphere, gasification which is heating in air but not enough to cause combustion and hydrogenation which involves the addition of hydrogen to purify the product. Chemical recycling is more flexible and can deal with less clean plastics; however, it is usually expensive and economically unviable. Energy recovery (fourth-level recycling) is the process of burning plastics in order to produce heat, steam or energy. However, this process emits undesirable emissions and needs costly measures to control pollution. On the other hand, biodegradable plastics are expected to be another solution to the problem. However, the use of petroleum-based plastics is still prevalent because they are relatively cheaper than bio-based plastics and they are very durable. It is not advisable to use biodegradable plastics for long-life applications like in electronics, building construction, etc., because they do not possess the breathability and resistance characteristics required for food packaging. However, increasing the quality of bioplastics can minimize the use of conventional plastics in the market [14]. There is a necessity to enhance research on the marine environment and plastic waste, the monitoring of the situation in the long term and the definition of the areas that require cleaning most of all. The government should come up with better protection policies, better legislation, and enhance public awareness to fight plastic pollution. In particular, education and media promotion are viewed as ways to increase awareness of the problem and to motivate volunteers to work effectively during the clean-up actions.

3. Conclusion

The problem of plastic pollution is becoming more acute and affects ecosystems, wildlife, and people's health. As global production of plastics increases and reaches around 400 million tons per year, the majority of them end up in the environment where they break down into microplastics and persist in the environment. Plastics degrade slowly in soil and marine environments because of factors such as the texture of the soil, low oxidation and the absence of microorganisms that can decompose plastics. This study mainly focuses on the impact of plastic waste on land and oceans, which can affect the environment, wildlife, and soil quality. For instance, microplastics in soil can alter the water holding capacity, fertility, and microbial richness of the soil and in aquatic environments, plastics can lead to entanglement, ingestion, and death of many species. Marine life is suffering the worst effects and there is a forecast that by the year 2050, the quantity of plastic in the sea may be as much as the weight of fish. The importance of this study lies in raising awareness about plastic pollution and demonstrating its impact on everyone. It shows how the microscopic particles, which are often not easily seen, infiltrate important ecosystems, thus changing the soil and marine habitats. This has a ripple effect on the food chain since plastics can impact earthworms to large marine mammals and end up in the human food chain. This research shows the chronic and in many cases, the irreversible effects of plastics on species and ecosystems, and thus urges for awareness to be created. It focuses on the decrease of plastic consumption, proper disposal, and the increase of recycling and bioplastic usage as the solutions. However, there are some constraints in the ability to evaluate the extent of the problem of plastic pollution. One of the main drawbacks is that there are no unified protocols for investigating the degradation of plastics, and even more so microplastics, in various conditions. Also, the issues of plastic waste management are challenging, for example, the economic aspect of chemical recycling and the biodegradation of certain types of bioplastics. Currently, there is little information on the consequences of microplastics on the ecological and health of the soil and agriculture in the long run. The future prospects suggest that a more complex strategy should be employed, that is focused on the enhancement of the research on the technology of plastic degradation, on the increase of production of bioplastics that are more sustainable, and on the development of the infrastructure for recycling. This current plastic problem will be solved by policies that seek to minimize the use of plastics, coupled with public sensitization on the effects of plastics on our environment for the sake of the next generations.

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