CONTAMINATION TRANSFER IN SOIL THROUGH MICROPLASTIC

A DISSERTATION

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Submitted by:

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I, Jyoti Chaudhary, Roll No. 2K19/MSCBIO/30, student of MSc. Biotechnology, hereby declare that the Project Dissertation titled "CONTAMINATION TRANSFER IN SOIL THROUGH MICROPLASTIC" which is submitted by me to the Department of Biotechnology, Delhi Technological University, Delhi is an authentic record of my work, carried during a period from 7-Jan—2021 to 28-May-2021, in partial fulfilment of the requirement for the award of the degree of Master of Science, is original and not copied from any source without proper citation.

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CERTIFICATE

I, **Jyoti Chaudhary**, Roll No. **2K19/MSCBIO/30**, student of MSc. Biotechnology, hereby declare that the project Dissertation titled "**CONTAMINATION TRANSFER IN SOIL THROUGH MICROPLASTIC**" which is submitted by me to the Department of Biotechnology, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Science, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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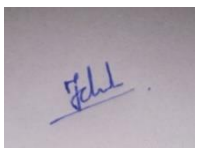

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ABSTRACT

The accumulation of microplastic in the soil have increase the concern for the unknown consequences for soil environment. The continues usage and disposal of microplastic have impacted the health of the soil. The usage of plastic mulch has been increased in agroecosystem for increasing the crop yield but it has destroyed the structure of the soil have affected the crop growth due to which food and human health have been affected. This review has listed the impact caused by the microplastic in the soil and how the problem can be resolved with the upcoming future challenges with prospective for studying. The continuous usage of microplastic should be a concerned in the future.

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CHAPTER 1

INTRODUCTION

A regular usage of plastic from many years in packaging and various other consumer and manufacturing products have resulted in the increase of microplastic in the ecosystem due to which it has caused a persistent environmental problem, as it is way hard to detect the microplastic which also causes it to transfer via air.

Plastic is a synthetic macromolecule composed of monomeric compounds converted from synthetic or natural products. Due to its huge economic and technological importance, their global output (in m^3) is higher than steel and aluminium. However, the huge advantages of this material (light weight, durability and low production cost) have caused increasingly serious environmental problems: 3% of the plastic produced is leaked due to high output value, short product life and unintentional material handling in a plastic bottle and the plastic leaks into the marine environment and accumulates there for its persistence. So far, although there is still a lack of a unified definition, the emergence and accumulation of microplastics and large plastics in the environment have been widely recorded.

Microplastic is composed of hydrogen, carbon and various other chemicals and other toxic chemicals that are dangerous for health of human. Microplastics is smaller than 5mm, they originate from very small particles (particles or abrasives that are present inside detergents and cosmetics) and large pieces (plastic mulch films, industries materials waste, household waste) of plastics that are released into the ecosystem. [1], [2]. They can be easily transported through the food web system. As they are digested and absorbed by the organisms due to their small size and acts as vector for contaminants to other's[3]–[6].

Plastic pollution has increased major threat to our ecosystem as it is the major responsible factor for the decline in the global biodiversity. Plastic products are basically synthetic that are usually form of chemical additives and organic polymers that slightly gives a unique characteristic. The usage of plastic is applied in many fields such as commercial application

because the cost is low, they are easy to manufacture and their flexibility is good. The usage of plastic is continuously but reusing, recycling and reuse strategies are not properly been executed mainly in most of the emergent nations. Approximately, around millions of tonnes of plastic piles were produced globally between the 1950s and 2015. There is a possibility that by 2050 the amount will definitely increase. But the thing is that less than 26 percent of plastic product which is waste is reuse as well as carbonized properly. Remaining is burned in open grounds or released into the ecosystem, from macro to microplastic.

Comparing on the basis of number of studies on microplastics there is less studies done on terrestrial ecosystem compared to marine ecosystem. Destruction of terrestrial ecosystem occurs from the breaking down of the microplastic and macro-plastics by physical or chemical procedure through the surrounding circumstances [7]. Microplastics may contain large number of additives which may increase the toxicity of the soil, but, most common type of polymers found on the land are basically polyethylene and polypropylene with less quantity of polyethylene terephthalate and polyvinyl chloride which are not as much harmful to the soil as other additives like phthalic acid esters which is the most common additive of plastic mulch films and which is also used in farming and have already contaminated the food [8], [9]. This contamination has affected many organisms including humans which depend on soil for their survival even affecting the food safety [10], [11]. After the entry of the macro-plastics inside the soil it gets divided into microplastics and then to nano plastics and then a large amount of heavy metals is been absorbed by them and then they release the organism pollutants into soil, like phthalic acid esters which are very harmful for the soil and also for the human health [12]–[14] but the thing to notice over here is that this acknowledgement of microplastics have been reported on the agricultural land where there was no use of any kind of fertilizers or any other agricultural plastics [15]. It is important to study the changes as well as the safety related to the microplastics in soils wherever plastic mulch films have been used. Microplastics can transfer from soil to reach the groundwater [16]. Also, Bläsing & Amelung, 2018 informed about the dangers related to nano-plastics as they can pass through coarse soil and macropores easily. Compared to the micro and macro plastics, nano plastics are more dangerous as they can easily enter the biological membranes [18]. Many researchers have paid attention towards the waste in the soil caused by the plastics and have warned about the plastics (macro, micro and nano plastics) disadvantages which can cause danger to the terrestrial ecosystem [19], [20]. In this

context, we are presenting an overview of the research on microplastics in terrestrial and agroecosystem, including the soil.

CHAPTER 2

TYPES AND USES OF PLASTICS

Plastics are classified on the basis of their strength and for the shape of their instability in order to determine that whether they are thermoplastic or not. The process of the setting of thermoplastic mainly depends on heat crosslinking of the irreversible bonds (covalent bonds) that simply makes not easy to decompose as well as makes them stable. In contrast, thermoplastics can be reused as well as recycled and also no kind of any new bond (chemical bond).

Four types of Thermoplastics are there:

Polyvinyl chloride, Polypropylene, Polyethylene and Polystyrene.

a) CLASSIFICATION OF PLASTIC ON THE BASIS OF SIZE

i) Macroplastic
ii) Microplastic
iii) Nanoplastic

i) Macroplastic

The term macroplastic refers to plastic products with a diameter of ≥ 5 mm. With this size definition, macrophages can be directly distinguished from microplastics (<5mm in diameter). Plastic products with a size of 5mm are often considered as macrophages when released into the environment.

Macroplastic is a visible, gripable plastic, to put it simply, and that won't somewhere have the impact on the food chain particularly.

Macroplastic are degraded directly in the microplastics by various processes such as hydrolysis, optical degradation or mechanical / physical deterioration.

ii) Microplastic

Plastic that are less than 5mm in length plus in all different kind of shapes are termed as microplastics.

iii) Nanoplastic

The definition of a nanoplastic is a particle resulting from the fragmentation of macro and/or microplastics. This definition excludes the use of the term nanoplastics for all manufactured nanomaterials found in our current products (cosmetic, materials, biomedical). They are formed by the degradation of the polystyrene items we use every day - at the nanoscale (RSC Publishing). Nanoplastics are solid particles from synthetic or highly modified natural polymers with sizes from 1 to 1000 nm.

CHAPTER 3

INPUT AND SOURCES IN THE ECOSYSTEM OF PLASTIC

In our ecosystem, Plastics are riskier for the health of organisms as it causes toxicity to the environment, these toxic additives increase the toxicity level of the soil. [8]. Accumulation of Plastics in the agriculture area is by either primary (e.g., electronics materials, adhesives substances etc.) or secondary microplastics (e.g., large plastics materials or waste) [2], [6], [21]. Primary microplastics basically include materials like plastics microbeads and nanoparticles which are used in the industries like the industrials detergents and cosmetics. Also, they can go in soil from the atmospheric deposition. Microplastics that comes from large plastic debris that have been broken down are known to be secondary microplastics [1]. These microplastics enters the soil via municipal waste, plastic mulch films, sewage sludge, atmospheric deposition and plastic-based fertilizers [5], [17], [20], [22]. Also, out of all these, application of compost and the plastic mulch films are probably the most essential [4], [17] because the plastic mulch films enhance the nutrient resources and water efficiency with thermal insulation and harvest cropping [23]. Plastic mulch film reduces the soil erosion and helps in the use of pesticides more efficiently [24]. But as these films are ultra-thin (ca. 8-50 μm thick) they create a problem while extracting the films from the soil at the end of the season. These residual plastic mulch film in the soil fragments by UV irradiation with biodegradation forms the cluster of macro plastics, microplastics and nano plastics [12], [25]. Plastic mulch film made from polyolefins have been studied in detail and reports suggests that the life of polyolefins in soil is almost hundred years [26]

CHAPTER 4

IMPACT OF MICROPLASTICS

Microplastics have impacted soil structure in an extremely prelious way. It has caused loss of the soil structure which, mostly happens or occur when there are particles of plastics present in the soil. Due to the presence of the microplastics in the soil it reduces its capacity of holding the rainwater (infiltration process) and also the irrigation of the groundwater, which negatively results in the decrease of oxygen in the soil [19]. The aggregated structure of the soil is also have been ruined by the left out plastic mulch films causing reduction in soil aeration as well as in water permeability, which causes poor root growth including plant productivity [27]–[29].

It has been stated by many researcher's that nitrogen cycle, organic carbon, microbial activity of the soil has been badly affected by the impact of microplastics [6], [16], [30]–[32]. It has been manifested by H. Liu et al., 2017, that soil enzyme activity can be stimulated by microplastics and also the agglomeration of the dissolvable nutrients in the soil. In the agroecosystem, the indicators for the measurement of chemical and physical quality of soil has been used as the indicators for evaluating the outcomes of the agricultural plastics. In some studies, it has been reported that plastic mulch films somewhere improve the quality of soil while elsewhere is also decline [12], [19], [27]. But currently no as such integrated quality assessment of soil exists it becomes slightly difficult to confirm that whether the advantages of the plastic mulch film outweigh the disadvantages of these mulch film [33]. Studies has been done which concluded that the accumulation of residual plastic will affect the physical and chemical properties of the soil and also will damage the farming area which will result in the damage to the environment. Microplastic residues can change the habitat of the soil by accumulating the pesticides [25] and also some studies [13], [34] somewhere have concluded about the microbial mass of terrestrial soil environment contents (carbon and nitrogen) on addition or coming in contact with the plastic mulch film decreases, but also it's very important to specify about the findings of above mentioned research were caused by the residual parts of plastics themselves which is plasticizers or pesticides or not. Also, it is important to distinguish between the harmful effect of microplastics and the result may also vary depending on the soil

properties. As this study have not focused on the soil function it is difficult to evaluate the health of the soil.

Some studies have been done where the primary focus was on the negative image of microplastics on soil environment. [16], [35], [36] Nematodes, mites, springtails, proturans, and Pauropoda (meiofauna) like Earthworm, mites, collembola are considered to be good for providing and maintaining the soil quality. The agriculture practices which we are opting have resulted in the loss in meiofauna [37]. Therefore, a constant decrease of the organisms can cause a major disadvantage to the agroecosystem. Lwanga et al., 2016 stated that on accumulation of microplastic inside the body of the organisms (stomach and gut of the organisms) which lives inside the soil damages their internal organs causing the damage to the immune system of the organisms affecting their development of the body and feeding habits. Bandopadhyay et al., 2018 Stated that soil microbial communities are being affected by the plastic mulches which are biodegradable by disturbing the microclimate of the soil, physical structure of the soil, by the contaminants which are there in the film fragments. High level of disturbance within the Soil by microplastics will affect the microbial community composition by creating new ecological diversity in the soil. Which is somehow essential for the future studies as it will help us in finding whether microbial community will be affected in delivery their essential soil functions or not. Coming to the food the chain, microplastics can enter through the food we consume as the agricultural plants are said to consume the nanoparticles of the plastics [40]. It has been stated that polystyrene can be easily assimilated into the raw vegetables' roots and transfer to the shoots by these vegetables' roots. But the comparison of the deposited microplastics that accumulate on the leaves or on the shoots of the plants from the atmospheric environment or through the irrigation of the wastewater that comes from various sector like industrial wastewater, households, etc remains unclear. This exposure of the contaminant from the various microplastics deposition can cause a major health risk to the entire food chain. Microplastics that have been extracted from the plastic mulching film which are starch-based shows negative impact on the growth of wheat while comparing to the polyethylene. The entire procedure for the contamination of crop plants and edible plants by plastic remains unidentified [41].

Some researchers have stated that microplastics (soil microplastics) in terrestrial ecosystem can be transported to the under-groundwater from the land with infiltration of water, disturbances caused by the animals and humans, land sliding's which causes disturbance in the under-ground marine environment [4], [12], [17], [26], [42].

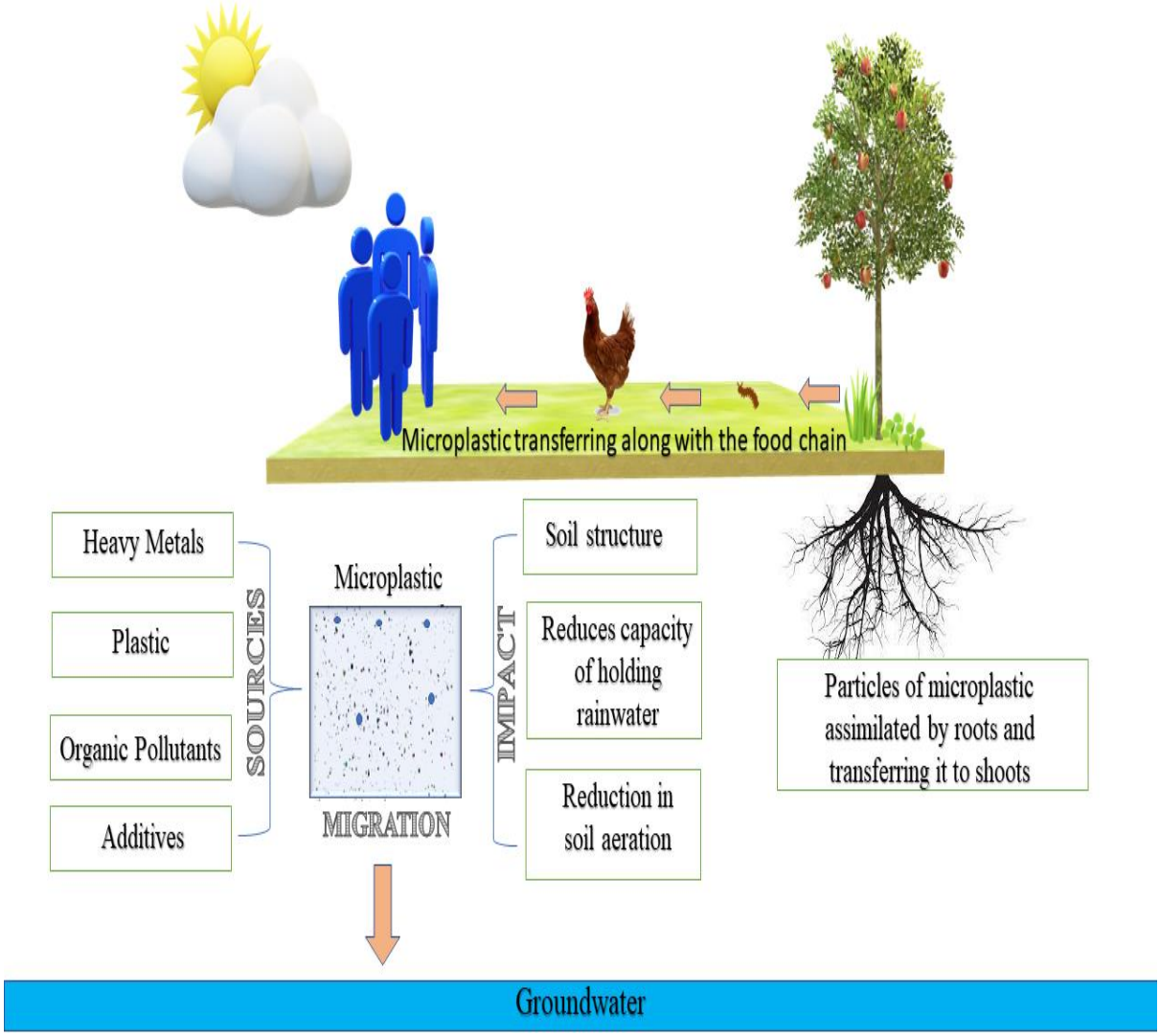

Figure 1: Effect of microplastic on the soil and on the food chain (plant, animal and humans).

CHAPTER 5

HOW TO SOLVE THE ENIGMA

The actual money that is going to be used in eliminating the plastic from the ecosystem will somewhere be prohibited. Therefore, a solution to most plastic contaminations is focused on getting rid of from the inappropriate elements from the plastic from the starting. The garbage finances are difficult to force, but they are often common to the deposit with a variety of fees or wired admirals for shopping bags that are made from plastic and the form for containers of plastic food. Accountability of the so-called producers or EPRs, plans to create infrastructure, copy and create products responsible for copying and recycling as a manufacturer. The perception for the problems that we are going to face from the plastic contamination increases as well as the government and the public are accepted, including the use of new solutions that increase the usage of plastics that are biodegradable in nature.

In order to improve the on-going situation, British agricultural plastic collectors group form agricultural plastics called agricultural plastics (UKFPR) called plastic tape (UKFPRS) together. UKFPRS Members recycling companies can eliminate plastics for recycling of farmers' recycling that mean that this plan does not benefit. This plan also provides a better quote for farmers who are effectively collected and recycled for farmers on how to reduce pollution in plastic waste.

In October last year, a similar plan for collecting plastics on farms called agriculture, plastics and environment (EPA UK), called UKFPRS ads shortly after its publication last year. The APE UK program applies to the billing of plastics purchased by farmers.

Nevertheless, the element refers to the conversion of a biodegradable, non-recycled material. "It's a way to solve the biggest plastic problems of agriculture." It is a very simple solution and it is more expensive than non-biodegradable plastics. "And it's better. It is better. No.

Webb cannot be recycled with a long-term solution." Ignoring the UK situation affecting the United Kingdom is that we have nothing to recycle facilities and materials simply to recycle facilities or materials.

Microplastics which are steady in nature and are nondegradable remains in ecosystem for more then a decades and leave a long run harm to the atmosphere and ecosystem [3]–[5]. Plastic mulch films inside the field of agricultural are very important meanwhile they can’t be

extracted easily from the soil and causes plastic pollution yet they can't be replaced from the agriculture production. Also, these plastic mulch films increase the yield of crops by approx. 30% hence making a good contribution to the agricultural products security. The government and other departments should limit the use of low-grade plastic mulch film from the market that are having high contaminant and instead, a long run or plastic mulch film that are having low contaminant level and high durability should be promoted. we can take an initiative by avoiding or minimizing the use of product which falls under the food production systems. The use of bioplastic should be initiated as it can be degraded by the micro-organisms but the biodegradable films have high manufacturing cost which becomes a limiting factor for large scale industries compared to the polyethylene films. Our focus should be on to improve the properties of the mulch films and other microplastics products which have low manufacturing cost, limited degradation time of the films and also the optimization of the raw materials used.

"There are alternative natural materials obtained from plants and animals, and next generation biofilms are plastics made from biomass sources," said by CEO of the Watershed Organization Trust.

While the effort to ban the plastics that used only once are commendable, action needs to go from typically from revoking bans and not focusing on them more instead should focus on the minimum usage of plastic.

This is why the traditional principles of resource management of reuse, reduction and recycling will remain in force, according to Lobo.

CHAPTER 6

CONCLUSIONS AND PERSPECTIVES FOR FUTURE WORK

As the quantity of the additives in number is very high in plastic, the particles of plastics that are present in the environment can be regarded as a lifetime particle that can float in the environment. At present, the number of studies as compared to the marine ecosystem regarding the impact of plastics on Terrestrial and Agroecosystem is less due to which considerable uncertainty occurs regarding any conclusion. The evidence of having no effect and effects (demonstrated) is relatively few at this time. The heavy metal contaminants that are present in the soil and with the amount of available nitrogen for the application of biosolids that are present on land gives us a slight possibility to approximate the leading of plastic in Agroecosystem and Terrestrial ecosystem. We could setup an ecotoxicology experiment by using these loading rates to determine whether they pose acceptable ecological risk or not, if the answer is not, then to determine at which concentration of loading can cause a problem. Within the timescale of human lifetime, the degradation of plastic is expected to be limited. On comparing with microplastics and with the structure of soil, there are only few reports on the relationship with contrast to macro-plastic [43] . Eventually, actions can be taken to reduce the emissions of plastic on land which will help the environment to wider range. These actions will help in reaping the benefit of plastics as it is less costly on the long-term with low pollution of plastic in soil, land and water. Ultimately, further studies on plastics are needed in order to specify whether they are actually present inside the solid phases of soilas well as to know the procedure of them affecting the environment in a long-run.

Interact food suppliers and distributors to reduce the use of plastic that are used only for one time in agricultural practices, should adapt for other feasible option, if not feasible:

• We should be supporting as well as encouraging the idea of innovate product and also promote the idea of the development of these innovative approaches.

• we should have an interaction with the suppliers who are supplying us products in order to replace the polymer that are coated with nutrient by some kind of techniques instead of fertilizers.

• We should all collaborate with people of other organizations in order to bring the best engaging practices with the global standard covering the plastics standard keeping in order the ecosystem requirement.

• We should perform periodic on-site checks in order to check the quality and the standard which are required that whether these standards are been followed or not

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