

- J. Chem.* **2023**, 16 (6), 104749. <https://doi.org/10.1016/J.ARABJC.2023.104749>.
8. Thambiliyagodage, C.; Kumara, A.; Jayanetti, M.; Usgodaarachchi, L.; Liyanaarachchi, H.; Lansakara, B. Fabrication of Dual Z-Scheme g-C₃N₄/Fe₂TiO₅/Fe₂O₃ Ternary Nanocomposite Using Natural Ilmenite for Efficient Photocatalysis and Photosterilization under Visible Light. *Appl. Surf. Sci. Adv.* **2022**, 12, 100337. <https://doi.org/10.1016/J.APSADV.2022.100337>.
9. Thambiliyagodage, C.; Nakandala, S.; Siriwardana, B.; Lansakara, B. One Pot Synthesis of α -Fe₂O₃/Turbostratic Carbon Composites and Their Photocatalytic Activity under Sunlight. *Carbon Trends* **2021**, 5, 100130. <https://doi.org/10.1016/J.CARTRE.2021.100130>.
10. Thambiliyagodage, C.; Usgodaarachchi, L.; Jayanetti, M.; Liyanaarachchi, C.; Kandanapitiye, M.; Vigneswaran, S. Efficient Visible-Light Photocatalysis and Antibacterial Activity of TiO₂-Fe₃C-Fe-Fe₃O₄/Graphitic Carbon Composites Fabricated by Catalytic Graphitization of Sucrose Using Natural Ilmenite. *ACS Omega* **2022**, 7 (29), 25403–25421. <https://doi.org/10.1021/ACSOMEGA.2C02336>.
11. Mendis, A.; Thambiliyagodage, C.; Ekanayake, G.; Liyanaarachchi, H.; Jayanetti, M.; Vigneswaran, S. Fabrication of Naturally Derived Chitosan and Ilmenite Sand-Based TiO₂/Fe₂O₃/Fe-N-Doped Graphitic Carbon Composite for Photocatalytic Degradation of Methylene Blue under Sunlight. *Molecules* **2023**, 28 (7), 3154. <https://doi.org/10.3390/MOLECULES28073154/S1>.

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Guest Articles

Microplastics: A Growing Threat to Agricultural Ecosystem

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Introduction

Over the past decades, the demand for plastic products has increased drastically due to their low cost and durability. Also, plastics are used in a wide range of applications across various industries, including packaging, construction, healthcare, textiles, agriculture and more. These plastic materials possess a strong physical structure and complex chemical properties (Monkul and Ozhan, 2021), enabling them to persist in the environment for long periods. This persistent nature raises concerns about their long-term impacts on soil, plant health, and broader environmental issues, particularly when these plastics degrade into microplastics and release plastic additives. Understanding these impacts is crucial for developing environmental sustainability as well as improving agriculture productivity.

According to Bui *et al.* (2020), the amount of plastic produced worldwide has increased tremendously, from 1.5 million tonnes to about 359 million tonnes over the past 70 years and this quantity is expected to double by 2050 (Monkul and Ozhan, 2021). Drzyzga and Prieto (2019) reported that in 2016, 27.1 million metric tons of plastic wastes were collected in the European Union (EU) and 31.1 % were recycled, 41.6% were used for energy recovery, and the remaining 27.3% was disposed of at landfill sites.

The interest of using plastics in agriculture is rapidly increasing as the population growth places a significant pressure on global food production. The use of plastics in agriculture is known as the plasticulture (Lalitha *et al.*, 2010), which comprises various practices aimed at improving crop production and efficiency. Therefore, modern agriculture widely uses plasticulture

techniques to mitigate environmental risks and increase the crop production. (Lalitha *et al.*, 2010).

Polythene, polypropylene, polystyrene, polyvinyl chloride and polybutylene are commonly used materials in agricultural plastic production. The most typical applications of plastics in intensive agriculture are plastic mulches, greenhouses and polytunnel covers, packaging and storage materials, and piping for irrigation purposes (Viljoen *et al.*, 2023). As mentioned in Viljoen *et al.* (2023), one of the most common uses of plastics in intensive agriculture is as mulch film and their use has increased rapidly during the last decade (Divya and Sarkar, 2019; Mansoor *et al.*, 2022), providing numerous benefits such as conserving soil moisture, regulating soil temperature and suppressing weed growth (Shah and Wu, 2019).

However, the plastic film mulches commonly used in agriculture, can degrade over time due to several factors including weather, exposure to UV radiation and mechanical stress. This degradation process breaks down the larger plastic (macro-plastics) into smaller fragments known as microplastics by changing their physical properties, color and surface characteristics (Ivleva *et al.*, 2017; Zhang *et al.*, 2021). The lack of recovery of plastic film mulches from the soil, as well as disposal of plastic materials is contributing to their accumulation in the environment.

Initially, the majority of study on microplastics was centered on the maritime environment, where a large number of studies examined the prevalence and abundance of microplastic particles in the ocean and along beaches, as well as the detrimental impacts of microplastics on marine life (Moller *et al.*, 2020). Later scientists became interested in understanding their fate in freshwater lake and river systems, which are also significantly impacted by microplastic contamination and are important routes for the movement of microplastics (Moller *et al.*, 2020). Not only the water ecosystem, but also soil can be contaminated with microplastics due to the fragmentation of discarded plastic materials or by leaching of buried waste existing in the landfills (Monkul and Ozhan, 2021) and the vertical movement of microplastic through soil (Rillig *et al.*, 2017). Therefore, soil can be considered as the largest sink of microplastic (Li and Liu, 2022).

In addition to microplastics, plastic additives

which are added in the plastic manufacturing process to enhance the properties of plastic products also badly impact on environmental health. When plastics break down, these additives can leach into ecosystems, causing toxicity in soil, water, and living organisms (Cao *et al.*, 2023).

Therefore, this review aims to identify the uses and impacts of agricultural plastic mulches, and consequences of microplastics and plastic additives on soil and plants health in agriculture systems.

Uses of Plastic Film Mulches in Agriculture

Mulching is a widely accepted agricultural practice used to cover soil surface with various materials to enhance soil quality (Haapala *et al.*, 2014). The mulching with organic agriculture was widely used in ancient agriculture and there is a history of using lithic mulching materials such as stone, gravel, pebble mulches (Haapala *et al.*, 2014). The organic mulching materials are comprised of animal materials, straws of various cropping materials, grass clippings, dried leaves, saw dust and *etc* (Prem *et al.*, 2020). Moreover, paper mulches were also used in ancient agriculture with different compositions and the quality of the raw materials used in the production method determines the longevity and functionality of paper mulches in agricultural systems. While, the synthetic mulches such as polythene and plastic films are also available in the market for use in crop fields.

Synthetic polythene films were initially used as a mulch for agricultural crops in the late 1950's in the USA, particularly for high-value crops (Emmert, 1957; Lalitha *et al.*, 2010, Schales and Sheldrake 1965; Waggoner *et al.*, 1960). According to Espi *et al.* (2006), the use of plastic mulch films in agriculture began in 1948 and expanded in the early 1950s. Additionally, low density polyethylene (LDPE) was introduced as a substitute for paper in vegetable mulching in early 1950s, marking the beginning of widespread usage of polymers in agriculture.

Although there are several uses of organic mulches on crop production, the use of plastic film mulches in agriculture has expanded considerably during the last decade around the world (Divya and Sarkar, 2019). Currently, it is considered as a common practice of

vegetable farmers (Lalitha *et al.*, 2010). Based on Shah and Wu. (2019), the Polyethylene, Polypropylene, Ethylene-vinyl acetate copolymer, and Poly-vinyl chloride are a few of the plastics being utilized in agriculture. The application of plastic film mulch in agriculture varies widely based on factors such as geographical region, crop type, and farming practices.

Plastic film mulches have been used in agriculture for several decades, offering various benefits such as increasing soil temperature and moisture, controlling weed growth and weed seed germination and nutrient conservation (Divya and Sarkar, 2019, Prem *et al.* 2020). Based on some literature, plastic mulches are impervious to water as well as reduce water evaporation while increasing soil moisture holding capacity (Prem *et al.*, 2020). And also, help in reducing soil nutrient leaching (Prem *et al.*, 2020). On the other hand, there is a minimum disturbance to the soil and this reduces soil disturbance associated with plastic mulches contributes to long-term soil health and sustainability. Because the traditional tillage methods can lead to breakdown of soil aggregates and disruption of beneficial microbial communities. So, plastic mulches are involved in controlling soil erosion (Prem *et al.*, 2020) as it acts as a protective barrier to protect the fertile top-soil layer.

Further, plastic mulches are used to double the agricultural income (Srinidhi and Nazereth, 2018) by boosting crop yield (Divya and Sarkar, 2019). For example, Hu *et al.* (2012), has identified that wheat plant yield and the straw biomass was significantly higher in plots mulched with plastic film compared to non-mulched plots. Additionally, the grain yield and P mass of above ground wheat crops were also significantly higher in plastic film mulched plots.

However, as highlighted by Liu *et al.* (2014), the long-term use of plastic mulching in soil can lead to notable consequences. For instance, it can increase the salt content of the topsoil. A study conducted over a period of 5 to 20 successive years, showed a potential rise in salt content of 122 to 146 %. This limited leaching due to plastic mulches may cause a slow buildup of salts over time in regions where they naturally occur in the soil. The accumulated salts can lead to soil salinity which can negatively impact crop yield and productivity. Therefore, careful monitoring is crucial when using plastic mulches in the long run to

maintain soil productivity.

Moreover, the improper disposal of plastic mulches can act as a source of pollution. As mentioned in Briassoulis *et al.* (2013), burning of agricultural plastics can releases environmental pollutants such as dioxins, furans. Hence, Mitrano (2019) has reported that the microplastic and nanoplastic coming from plastic degradation has a huge impact on various ecosystems. This will lead to accumulation of persistent organic pollutants (Wei and Zimmermann, 2017). In the meantime, releasing these tiny particles into the farming systems poses a major threat to beneficial soil organisms and could potentially enter the food chain (Astner *et al.*, 2019).

Impact of Plastic Film Mulches on Soil

Agricultural plastic mulches can have both positive and negative impacts on soil health. The plastic mulches can result in complex changes in the soil environment through modifying various physicochemical properties. For instance, plastic mulches are applied with the aim of changing soil temperature and moisture levels, control weeds and pests, reducing evaporation, minimizing soil erosion and compaction (Lalitha *et al.*, 2010, Shah and Wu, 2020).

As indicated in Lalitha *et al.* (2010), several types of plastic mulches can serve as a barrier to retain methyl bromide, an effective fumigant and ozone depleter, in the soil. Further, Hu *et al.* (2012), reported that soil water availability is better under plastic mulch compared to non-mulched soils. The use of plastic mulches along with drip irrigation can improve water use efficiency (Lalitha *et al.* (2010). This is because plastic mulches alter the microclimate around the plant by changing the surface radiation budget and conserving soil moisture (Liakatas *et al.*, 1986).

However, though these products have helped to increase agricultural production, there is a high risk of releasing microplastics and their additives to the soil ecosystem during the degradation process in the long term. Hence, the soil may be a significant long-term sink for additives and microplastic particles.

What is Microplastic?

Microplastics are plastic particles which have been identified as a growing pollutant that are widely distributed in the environment (Ferreira *et al.* 2018; de Souza Machado *et al.* 2020). Simply based on literature the presence of these tiny plastic particles, commonly referred to as "microplastics" (Anderson *et al.*, 2016; Browne *et al.*, 2011). Frias and Nash (2019), proposed that the microplastics are "any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water". According to ISO/TR 21960:2020, microplastics have been categorized into two fractions, large (1-5 mm) and small fractions (0-1 mm).

Microplastic Impact on Environment Pollution

The substantial amount of plastic waste is incinerated or released to landfills or discharged to the environment, resulting in significant environmental and health consequences (Wang *et al.*, 2020(a)). It is estimated that < 10 % of used plastic is recycled in the USA (Cessi *et al.*, 2014; Osman *et al.*, 2023). Moreover, significant plastic residues still remain in fields even after plastic film mulches have been retrieved from the soil at the end of the growing season (Ding *et al.*, 2021).

As indicated in the Zhang *et al.* (2021), microplastics found in the environment are diverse in terms of their complexity of forms, shapes, sizes, and composition, although polyethylene and polypropylene microplastics are prevalent (Klein *et al.*, 2015). Eco-toxicity depends on the polymer composition and additive content (Zhang *et al.*, 2021). Once microplastic are formed from plastics they can exist in the environment for a long period of time and have a potential to enter marine life due to ingestion. Moreover, there is a potential to disrupt the food chain and harm to species at all levels. Ultimately it can make a huge threat to the ecosystem and human health. As an example, Monkul and Ozhan (2021) has mentioned that the pollution from microplastics poses a threat to marine and freshwater ecosystems, agricultural production, groundwater, plant growth, and even human and animal health.

For instance, chlorinated plastic has the potential to leak dangerous chemicals into the soil around it

(Gondal *et al.*, 2023). These chemicals can then seep into nearby water sources, including groundwater, and the ecosystem. Moreover, studies on microplastics have revealed that synthetic polymer particles can be found in all environments including Arctic Sea ice, waters of remote mountain lakes and even agricultural soils.

Further, the plastic additives can limit the uptake of water and nutrients through roots, and can accumulate in the root, shoot, and leaves (Khalid *et al.*, 2020). Ultimately, this can result in reduced crop productivity and pose a threat to global food security. Hence, agricultural soils need to be protected from further degradation and contamination as preserving soil health is crucial for ensuring sustainable agriculture and safeguard food production for future generations.

Microplastic Impact on Soil and Plant Health

The presence of microplastics in soil ecosystems can have complex and numerous implications and it is important to identify the overall impact of microplastics on soil health and function. Based on Maddela *et al.* (2023), the soil pollution by microplastics is more severe than in the aquatic environment especially where agricultural soils are exposed to high concentrations of microplastic pollution.

Based on the literature, 50-80 % of microplastic exists in soils are less than 1 mm in size (Li and Liu, 2021). Moreover, some have reported that the content of soil microplastic is around 1 % of the soil mass (Huang *et al.*, 2019; Li and Liu, 2021).

Soil microplastics have been shown to negatively impact on soil organisms. For instance, Kim *et al.* (2020) has observed that the microplastics and microplastic additives can be a toxic component for soil nematodes. In addition, microplastics can inhibit the growth of collembolans (Zhu *et al.*, 2018) and the activity of soil microbial communities (Zang *et al.*, 2020).

On the other hand, microplastic particles in size ranging from less than 5 mm in size can alter soil physicochemical properties. Their presence may influence soil structure, water retention, porosity as well as the soil aeration. Some studies have reported that microplastics tend to disrupt soil structure. For instance, Liang *et al.* (2019), has mentioned that microplastic can destroy the soil aggregation structure

by lowering the macro-aggregate contents. Similarly, Rilling *et al.* (2021), reported that the most notable impact of microplastic is the disturbance to the soil structure, since it affects soil aggregate stability and bulk density of the soil. According to Zhou *et al.* (2023), the addition of polyester and polypropylene microplastics has decreased the bulk density in crops such as *Zea mize*, *Glycine max* and *Arachis hypogaea*.

Nevertheless, the changes in soil structure can impact the spatial distribution of mycorrhizal networks and alter the nutrient availability for plants. Therefore, microplastics are thought to affect the cycling of nutrients in the soil.

In addition to that, microplastics can create various physiological toxicities to plants. For instance, plant biomass reduction, intracellular oxidative stress burst, inhibition of photosynthesis process, retardation of water and nutrient absorption, seed germination (Zhou *et al.*, 2023). However, the impact of different types of microplastic under different plants are limited (Zhou *et al.*, 2023).

As indicated in Qi *et al.* (2018), the low-density polyethylene (LDPE) and biodegradable (BD) microplastics have a negative impact on plant growth and reproduction of *Triticum aestivum*. Moreover, plant culm diameter, plant height, leaf area, root shoot ratio, has unfavorable impacts with LDPE microplastics (Li *et al.*, 2021).

Wu *et al.* (2020) observed that polystyrene microplastics have decreased the shoot biomass and rice yield of *Oryza sativa* (Rice). Meng *et al.* (2021) has reported that the exposure of 0.5 % LDPE microplastics lead to reduced leaf chlorophyll content in *Phaseolus vulgaris* (Common bean), while the addition of 1 % of LDPE microplastics has significantly increased the leaf area of *P. vulgaris*. The Boots *et al.* (2019) has reported that the biodegradable polylactic acid microplastics, causes for decrease the seed germination and shoot height in *Lolium perenne* (Perennial ryegrass).

Therefore, results show that microplastics can alter crop production and growth of different crop types in a range of agricultural systems. However, most studies have been limited to greenhouse and laboratory conditions. Hence, it is essential to investigate the impact of microplastics under real field conditions with

different crops to ensure food safety and security in the long term.

Conclusion:

The extensive use of plastic film mulches has contributed significantly to improving crop productivity by enhancing soil moisture retention, regulating temperature, and suppressing weed growth. However, their long-term environmental implications cannot be ignored. The degradation of plastic mulches results in the formation of microplastics, which persist in the soil and pose serious risks to soil health, plant growth, and broader ecological systems.

To mitigate these impacts, there is an urgent need for sustainable alternatives to conventional plastic mulches, such as biodegradable materials, improved waste management strategies, and policies promoting responsible plastic use in agriculture. Addressing the challenges posed by microplastics is crucial for ensuring food security, and safeguarding environmental health.

References:

- Anderson, C.A., Park, B.J., Palace, V.P., 2016. Microplastics in aquatic environments: implications for Canadian ecosystems. *Environ. Pollut.* 218, 269–280.
- Astner, A.F., Hayes, D.G., O'Neill, H., Evans, B.R., Pingali, S.V., Urban, V.S. and Young, T.M., 2019. Mechanical formation of micro-and nano-plastic materials for environmental studies in agricultural ecosystems. *Science of the Total Environment*, 685, pp.1097-1106.
- Boots, B., Russell, C.W., Green, D.S., 2019. Effects of microplastics in soil ecosystems: above and below ground. *Environ. Sci. Technol.* 53 (19), 11496–11506.
- Briassoulis, D., Babou, E., Hiskakis, M., Scarascia, G., Picuno, P., Guarde, D. and Dejean, C., 2013. Review, mapping and analysis of the agricultural plastic waste generation and consolidation in Europe. *Waste Management & Research*, 31(12), pp.1262-1278.
- Browne, M., Crump, P., Niven, S., Teuten, E., Tonkin, A., Galloway, T., Thompson, R., 2011. Accumulation of microplastic on shorelines

- worldwide: sources and sinks. *Environ. Sci. Technol.* 45 (21), 9175–9179.
- Bui, X.T., Nguyen, P.T., Nguyen, V.T., Dao, T.S. and Nguyen, P.D., 2020. Microplastics pollution in wastewater: Characteristics, occurrence and removal technologies. *Environmental Technology & Innovation*, 19, p.101013.
 - Cao, X., Liang, Y., Jiang, J., Mo, A. and He, D., 2023. Organic additives in agricultural plastics and their impacts on soil ecosystems: Compared with conventional and biodegradable plastics. *TrAC Trends in Analytical Chemistry*, p.117212.
 - Cessi, P., Pinardi, N. and Lyubartsev, V., 2014. Energetics of semienclosed basins with two-layer flows at the strait. *Journal of Physical Oceanography*, 44(3), pp.967-979.
 - De Souza Machado AA, Horton AA, Davis T, Maaß S (2020) Microplastics and their effects on soil function as a life-supporting system. In: He D, Luo Y (eds) *Microplastics in terrestrial environments: emerging contaminants and major challenges*. Springer International Publishing, Cham, pp 199–222
 - Ding, F., Flury, M., Schaeffer, S.M., Xu, Y. and Wang, J., 2021. Does long-term use of biodegradable plastic mulch affect soil carbon stock. *Resour. Conserv. Recycl.* 175(105895.10), p.1016.
 - Divya, V.U. and Sarkar, N.C., 2019. Plastic mulch pollution and introduction of biodegradable plastic mulches: A review. *Agricultural Reviews*, 40(4), pp.314-318.
 - Drzyzga, O. and Prieto, A., 2019. Plastic waste management, a matter for the ‘community’. *Microbial biotechnology*, 12(1), p.66.
 - Emmert, E.M., 1957. Black polyethylene for mulching vegetables. In *Proc. Amer. Soc. Hort. Sci* (Vol. 69, pp. 464-469).
 - Espí, E., Salmerón, A., Fontecha, A., García, Y. and Real, A.I., 2006. Plastic films for agricultural applications. *Journal of Plastic Film & Sheeting*, 22(2), pp.85-102.
 - Ferreira GVB, Barletta M, Lima ARA et al (2018) High intake rates of microplastics in a Western Atlantic predatory fish, and insights of a direct fishery effect. *Environ Pollut* 236:706–717.
 - Frias, J.P. and Nash, R., 2019. Microplastics: Finding a consensus on the definition. *Marine pollution bulletin*, 138, pp.145-147.
 - Gondal, A.H., Bhat, R.A., Gómez, R.L., Areche, F.O. and Huaman, J.T., 2023. Advances in plastic pollution prevention and their fragile effects on soil, water, and air continuums. *International Journal of Environmental Science and Technology*, 20(6), pp.6897-6912.
 - Haapala, T., Palonen, P., Korpela, A. and Ahokas, J., 2014. Feasibility of paper mulches in crop production—a review. *Agricultural and food science*, 23(1), pp.60-79.
 - Hu, B., Jia, Y., Zhao, Z.H., Li, F.M. and Siddique, K.H., 2012. Soil P availability, inorganic P fractions and yield effect in a calcareous soil with plastic-film-mulched spring wheat. *Field Crops Research*, 137, pp.221-229.
 - Ivleva, N.P., Wiesheu, A.C. and Niessner, R., 2017. Microplastic in aquatic ecosystems. *Angewandte Chemie International Edition*, 56(7), pp.1720-1739.
 - Khalid, N., Aqeel, M. and Noman, A., 2020. Microplastics could be a threat to plants in terrestrial systems directly or indirectly. *Environmental Pollution*, 267, p.115653.
 - Kim, S.W., Waldman, W.R., Kim, T.Y. and Rillig, M.C., 2020. Effects of different microplastics on nematodes in the soil environment: tracking the extractable additives using an ecotoxicological approach. *Environmental Science & Technology*, 54(21), pp.13868-13878.
 - Klein, S., Worch, E. and Knepper, T.P., 2015. Occurrence and spatial distribution of microplastics in river shore sediments of the Rhine-Main area in Germany. *Environmental science & technology*, 49(10), pp.6070-6076.
 - Lalitha, M., Thilagam, V.K., Balakrishnan, N. and Mansour, M., 2010. Effect of plastic mulch on soil properties and crop growth-A review. *Agricultural Reviews*, 31(2), pp.145-149.
 - Liakatas, A., Clark, J.A. and Monteith, J.L., 1986. Measurements of the heat balance under plastic mulches. Part I. Radiation balance and soil heat

- flux. *Agricultural and Forest Meteorology*, 36(3), pp.227-239.
- Liang, Y., Lehmann, A., Ballhausen, M.B., Muller, L. and Rillig, M.C., 2019. Increasing temperature and microplastic fibers jointly influence soil aggregation by saprobic fungi. *Frontiers in Microbiology*, 10, p.2018.
- Li, B., Huang, S., Wang, H., Liu, M., Xue, S., Tang, D., Cheng, W., Fan, T. and Yang, X., 2021. Effects of plastic particles on germination and growth of soybean (*Glycine max*): A pot experiment under field condition. *Environmental Pollution*, 272, p.116418.
- Li, H. and Liu, L., 2022. Short-term effects of polyethylene and polypropylene microplastics on soil phosphorus and nitrogen availability. *Chemosphere*, 291, p.132984.
- Liu, E.K., He, W.Q. and Yan, C.R., 2014. 'White revolution' to 'white pollution'—agricultural plastic film mulch in China. *Environmental Research Letters*, 9(9), p.091001.
- Maddela, N.R., Kakarla, D., Venkateswarlu, K. and Megharaj, M., 2023. Additives of plastics: Entry into the environment and potential risks to human and ecological health. *Journal of Environmental Management*, 348, p.119364.
- Meng, F., Yang, X., Riksen, M., Xu, M. and Geissen, V., 2021. Response of common bean (*Phaseolus vulgaris* L.) growth to soil contaminated with microplastics. *Science of the Total Environment*, 755, p.142516.
- Mitrano, D., 2019. Nanoplastic should be better understood. *Nat. Nanotechnol.*, 14(4), p.299.nash
- Möller, J.N., Löder, M.G. and Laforsch, C., 2020. Finding microplastics in soils: a review of analytical methods. *Environmental science & technology*, 54(4), pp.2078-2090.
- Monkul, M.M. and Özhan, H.O., 2021. Microplastic contamination in soils: A review from geotechnical engineering view. *Polymers*, 13(23), p.4129.
- Mansoor, Z., Tchuenbou-Magaia, F., Kowalczyk, M., Adamus, G., Manning, G., Parati, M., Radecka, I. and Khan, H., 2022. Polymers use as mulch films in agriculture—a review of history, problems and current trends. *Polymers*, 14(23), p.5062.
- Osman, A.I., Hosny, M., Eltaweil, A.S., Omar, S., Elgarahy, A.M., Farghali, M., Yap, P.S., Wu, Y.S., Nagandran, S., Batumalaie, K. and Gopinath, S.C., 2023. Microplastic sources, formation, toxicity and remediation: a review. *Environmental Chemistry Letters*, 21(4), pp.2129-2169.
- Prem, M., Ranjan, P., Seth, N. and Patle, G.T., 2020. Mulching techniques to conserve the soil water and advance the crop production—A Review. *Curr. World Environ*, 15, pp.10-30.
- Qi, Y., Yang, X., Pelaez, A.M., Lwanga, E.H., Beriot, N., Gertsen, H., Garbeva, P. and Geissen, V., 2018. Macro-and micro-plastics in soil-plant system: effects of plastic mulch film residues on wheat (*Triticum aestivum*) growth. *Science of the Total Environment*, 645, pp.1048-1056.
- Rillig, M. C.; Ziersch, L.; Hempel, S. Microplastic Transport in Soil by Earthworms. *Sci. Rep.* 2017, 7 (1), 1–6.
- Schales, F.D and Sheldrake, R. (1965). *J. Am. Soc. Hort. Sci.*, 88: 425-430
- Serrano-Ruiz, H., Martin-Closas, L. and Pelacho, A.M., 2021. Biodegradable plastic mulches: Impact on the agricultural biotic environment. *Science of The Total Environment*, 750, p.141228.
- Shah, F., Wu, W., 2019. Soil and crop management strategies to ensure higher crop productivity within sustainable environments. *Sustainability* 11, 1485. <https://doi.org/10.3390/su11051485>.
- Srinidhi, A. and Nazareth, D., 2018. Beating plastic pollution in agriculture—World Environment Day special. Handbook of biodegradable polymers. Harwood Academic, Amsterdam, pp.473-511.
- Viljoen, S.J., Brailsford, F.L., Murphy, D.V., Hoyle, F.C., Chadwick, D.R. and Jones, D.L., 2023. Leaching of phthalate acid esters from plastic mulch films and their degradation in response to UV irradiation and contrasting soil conditions. *Journal of Hazardous Materials*, 443, p.130256.
- Waggoner, P.E., Miller, P.M. and De Roo, H., 1960. C. Plastic mulching: principles and benefits. *Bulletin. Connecticut Agricultural Experiment Station*, 634.

- Wang, Q., Bai, J., Ning, B., Fan, L., Sun, T., Fang, Y., Wu, J., Li, S., Duan, C., Zhang, Y. and Liang, J., 2020. Effects of bisphenol A and nanoscale and microscale polystyrene plastic exposure on particle uptake and toxicity in human Caco-2 cells. *Chemosphere*, 254, p.126788.
- Wei, R., Zimmermann, W., 2017. Microbial enzymes for the recycling of recalcitrant petroleum-based plastics: how far are we? *Microb. Biotechnol.* 10 (6), 1308–1322.
- Wu, X., Liu, Y., Yin, S., Xiao, K., Xiong, Q., Bian, S., Liang, S., Hou, H., Hu, J. and Yang, J., 2020. Metabolomics revealing the response of rice (*Oryza sativa* L.) exposed to polystyrene microplastics. *Environmental Pollution*, 266, p.115159.
- Zang, H., Zhou, J., Marshall, M.R., Chadwick, D.R., Wen, Y. and Jones, D.L., 2020. Microplastics in the agroecosystem: are they an emerging threat to the plant-soil system?. *Soil Biology and Biochemistry*, 148, p.107926.
- Zhang, K., Hamidian, A.H., Tubić, A., Zhang, Y., Fang, J.K., Wu, C. and Lam, P.K., 2021. Understanding plastic degradation and microplastic formation in the environment: A review. *Environmental Pollution*, 274, p.116554.
- Zhou, W., Wang, Q., Wei, Z., Jiang, J. and Deng, J., 2023. Effects of microplastic type on growth and physiology of soil crops: Implications for farmland yield and food quality. *Environmental Pollution*, 326, p.121512.
- Zhu, D., Chen, Q.L., An, X.L., Yang, X.R., Christie, P., Ke, X., Wu, L.H. and Zhu, Y.G., 2018. Exposure of soil collembolans to microplastics perturbs their gut microbiota and alters their isotopic composition. *Soil Biology and Biochemistry*, 116, pp.302-310.

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Guest Articles

Salt Stress: An Invisible Threat to Global Food Production

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Introduction

Imagine living in a world where once fertile farmlands turn dry and lifeless, and the crops we rely on struggle to grow. This is not something that will happen far in future, it is happening right now due to increasing soil salinity. Salt stress is a growing crisis that's making it harder for farmers to grow food, pushing both them and consumers into a tough spot. Despite its seriousness, this issue is still overlooked, even as fertile lands slowly turn into salty wastelands. If we don't take action, salt stress will continue to threaten agriculture and put countless livelihoods at risk.

The consequences of ignoring salt stress are severe, potentially leading to widespread food shortages,

economic instability, and rising social unrest. Climate change and unsustainable agricultural practices will only make the situation worse. Addressing salt stress is no longer just an agricultural issue; it is a critical global challenge that requires urgent attention to ensure food security for a growing population.

How Does This Salty Stress Occur

Salt stress occurs when excessive salts accumulate in the soil, hindering plant growth. According to Munns and Tester (2008) and Zörb *et al.* (2019), sodium ions (Na⁺) are the primary contributors to soil salinity, while Cl⁻, Mg²⁺, SO₄²⁻, and HCO₃⁻ play a minor role.

Salt stress arises from various sources. Natural