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Assessment of Microplastics in Soil Environment of Dumpyard: A Review of Current Trends and Future Directions

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ABSTRACT: -

The increasing accumulation of microplastics in terrestrial environments, particularly in soils around dumpyards, poses a significant environmental threat. Microplastics, defined as plastic particles less than 5 mm in size, originate from various sources, including degraded plastic waste, industrial processes, and consumer products. This study aims to assess the presence, concentration, and characteristics of microplastics in the soil environment of a dumpyard, evaluating their distribution patterns and potential environmental impacts.Through soil sampling and laboratory analysis, microplastics were extracted, categorized, and identified using microscopy and spectroscopic techniques. Findings revealed a high concentration of microplastic particles in the soil, predominantly polyethylene, polypropylene, and polystyrene. The study also highlights the potential pathways of microplastic contamination from the dumpyard to surrounding ecosystems and the risks posed to soil health, plant growth, and possibly the food chain.This research underscores the urgent need for effective waste management strategies and policy interventions to mitigate microplastic pollution in soil environments. Further studies are recommended to explore the long-term impacts of microplastics on soil ecosystems and human health.

Key Words:- Microplastic pollution, Soil contamination, Terrestrial microplastics, Dumpyard impact.

1 Introduction

Microplastics, small plastic particles measuring less than 5 mm in diameter, have emerged as pervasive pollutants in various ecosystems, raising widespread environmental and health concerns. Initially identified as a major issue in marine environments, microplastics are now recognized as a significant pollutant in terrestrial ecosystems, particularly in soils. Soils in and around dumpyards are especially vulnerable to microplastic contamination due to the accumulation and degradation of plastic waste.

The presence of microplastics in soil environments affects soil quality, disrupts microbial communities, and poses potential risks to plants and animals through soil ingestion or root uptake. Moreover, microplastics may carry toxic additives or absorb harmful contaminants, increasing the potential for adverse environmental impacts. As these particles are fragmented into even smaller sizes, their mobility and bioavailability within soil and across ecosystems increase, complicating waste management and mitigation efforts.

This study focuses on assessing the types, distribution, and concentration of microplastics in the soil of a dumpyard environment. By understanding the extent of microplastic pollution in terrestrial dump sites, we aim to highlight the urgency of addressing this growing environmental issue and to contribute to the development of better waste management practices that can mitigate microplastic contamination in soil ecosystems.

2 Methodology of microplastics in soil

To assess microplastics in soil at a dump yard, start by collecting soil samples from various locations and depths using a core sampler to avoid contamination. Dry the samples and sieve them to isolate particles smaller than 5 mm. Use density separation with a salt solution to separate microplastics, followed by filtration. Examine the filtered particles under a microscope to identify microplastic shapes and colors. Confirm plastic composition using Fourier Transform Infrared (FTIR) or Raman Spectroscopy, allowing polymer type identification. Finally, quantify microplastic concentration as particles per kilogram of soil and analyze spatial distribution to identify contamination hotspots.

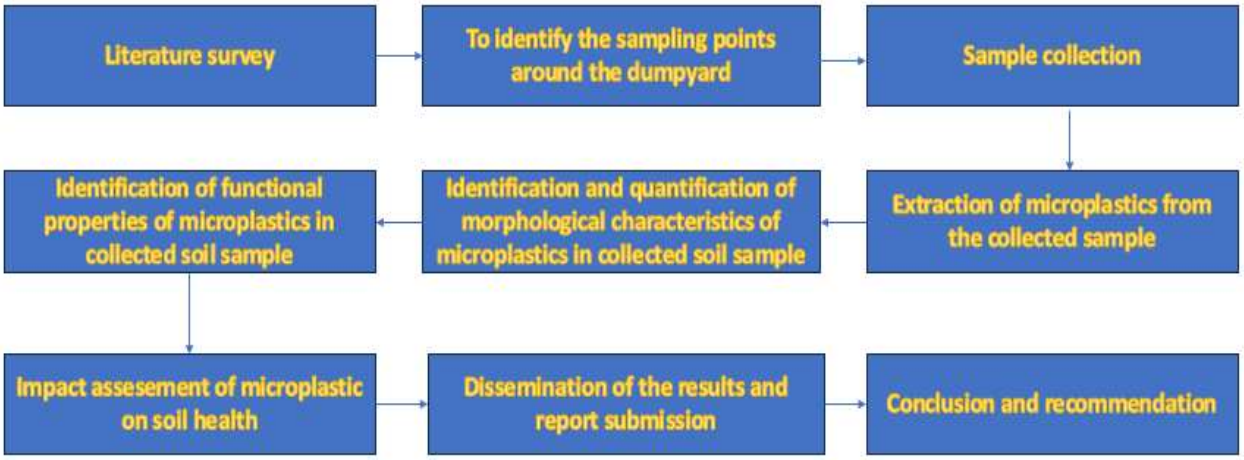

Fig 1:- Methodology of microplastics in soil

3 Literature Study

- **Muhammad Sajjad , Qing Huang , Sardar Khan , Muhammad Amjad Khan , Yin Liu , Junfeng Wang , Faqin Lian , Qingqing Wang , Genmao Guo (2022): -**The paper reviews the environmental impact of microplastics (MPs) in soil, highlighting their anthropogenic origins and the pollution they cause. MPs, which are plastic fragments smaller than 5 mm, alter soil characteristics, affecting porosity, enzymatic and microbial activities, and plant growth. They also serve as carriers for toxic chemicals, potentially contaminating groundwater. The review emphasizes the need for further research on the effects of MPs on soil ecosystems and crop production, and suggests developing new agronomic technologies and biodegradable materials to mitigate this pollution issue.
- **Ling Yang , Yulan Zhang , Shichang Kang , Zhaoqing Wang , Chenxi Wu (2021): -**The paper reviews the presence of microplastics in soil, focusing on their methods of detection, sources, and potential risks. It highlights various techniques used to identify microplastics, including visual inspection and advanced spectroscopic methods. The occurrence of microplastics in different soil types is discussed, revealing widespread contamination linked to agricultural practices and urban runoff. The paper also examines the potential ecological and health risks posed by microplastics, emphasizing their impact on soil organisms and the food chain. Overall, it calls for more research to understand the implications of microplastics in terrestrial environments .
- **Julia N. Möller, Martin G. J. Löder, and Christian Laforsch (2020): -** This review highlights the growing concern of microplastic contamination in terrestrial ecosystems, particularly soils, which are often overlooked compared to marine environments. It discusses various analytical methods for sampling, extraction, and identification of microplastics, emphasizing the need for standardized protocols. The paper calls for further research to develop effective methodologies and frameworks for monitoring microplastics in soils, addressing the challenges posed by soil complexity and the need for reliable detection techniques.
- **Yujie Zhou , Junxiao Wang , Mengmeng Zou , Zhenyi Jia , Shenglu Zhou , Yan Li (2020):-** This paper investigates the sources, distribution, and ecological impacts of microplastics (MPs) in soil ecosystems. It highlights the significant role of agricultural practices and urban waste in MP contamination, emphasizing the urgent need for improved analytical methods and comprehensive studies on their effects on soil health and biodiversity. The research identifies critical gaps in current knowledge and proposes future directions for mitigating MP pollution, including enhanced regulatory frameworks and public engagement strategies.
- **Zhu Ya-di, Shao Tian-jie, Wang Yan-hua and Wang Rui-yuan (2022):-** This paper reviews the growing body of research on soil microplastics, highlighting a significant increase in publications from 2016 to 2021, particularly in China. It identifies key research areas, including the environmental impact of microplastics, their migration behavior in soil, and the need for standardized analytical methods. The authors emphasize the importance of addressing knowledge gaps and suggest future research directions, particularly in ecologically sensitive areas, while also noting the limitations of their bibliometric approach.
- **Fayuan Wang , Quanlong Wang , Catharine A. Adams , Yuhuan Sun , Shuwu Zhang (2022):-** The paper investigates the effects of microplastics on soil properties, emphasizing their implications for soil health and ecosystems.

Soil Structure: Microplastics can negatively impact soil structure, leading to reduced water retention and aeration, which are vital for plant growth .

Nutrient Availability: The presence of microplastics may alter nutrient dynamics and microbial activity, potentially disrupting soil ecosystems .

Toxicity Concerns: Microplastics can adsorb harmful pollutants, increasing toxicity levels in soils and affecting both plant and animal health .

Research Needs: The paper highlights significant gaps in research regarding the long-term effects of microplastics on soil health and agricultural productivity .

Future Directions: It advocates for interdisciplinary research to develop effective management strategies to mitigate the impact of microplastics in soil environments.

- **Jia Li , Yang Song , Yongbing Cai (2020): -** The paper discusses the critical issues surrounding microplastics in soil, focusing on their analytical methods, occurrence, transport, and ecological risks. It highlights the optimization of analytical techniques to detect microplastics effectively. The authors review studies indicating that microplastics can negatively impact soil organisms, such as earthworms, which can facilitate their movement through ingestion and excretion. Additionally, the role of plant roots in the transport of microplastics is examined, emphasizing how root decomposition creates pathways for microplastics to move within the soil. Overall, the paper underscores the need for further research on the ecological implications of microplastics in terrestrial environments.
- **Defu He , Yongming Luo , Shibo Lu , Mengting Liu , Yang Song , Lili Le (2018):-** This review highlights the increasing concern of microplastic pollution in soils, emphasizing its sources, analytical methods, and ecological impacts. Key findings indicate that agricultural practices, particularly the use of sewage sludge and plastic mulching, significantly contribute to soil microplastic contamination. The paper calls for standardized methodologies for assessing microplastics in soils and stresses the need for further research on their environmental fate, toxicity to soil organisms, and potential risks to human health through food chain transfer.
- **Xingdong Shi, Zhijie Chen, Lan Wu, Wei Wei, Bing-Jie Ni (2023):-** This review paper focuses on the presence and implications of microplastics in municipal solid waste landfills. It highlights the lack of research on microplastics in these environments, despite their role as vectors for hazardous contaminants that can harm the ecological system. The paper summarizes current findings on the detection, concentration, and distribution of microplastics in landfills, as well as their formation during the aging process. Additionally, it discusses the potential environmental risks associated with microplastics and offers critical perspectives based on existing studies, aiming to enhance understanding and inform future research efforts.
- **Natalya S. Salikova , María-Elena Rodrigo-Clavero , Saltanat E. Urazbayeva , Aniza Zh. Askarova , and Kuandyk M. Magzhanov (2023): -** This study investigates microplastic pollution from municipal solid waste landfills in the Akmola region, marking the first research of its kind in the area. It highlights the significant presence of microplastics in landfill waste, with an average plastic content of 20.75%, exceeding national averages. The research also explores effective methodologies for separating microplastics from organic contaminants, providing foundational data for future modeling of microplastic behavior in the environment.
- **D Thomas, B Schütze, WM Heinze, Z Steinmetz (2020): -** This paper critically evaluates current sample preparation techniques for analyzing microplastics in soil, highlighting the need for standardized methods. It discusses the challenges posed by soil organic matter and the importance of representative sampling strategies to ensure accurate microplastic quantification. The authors propose best practices for sample preparation and emphasize the necessity for further research to refine analytical methods tailored to the complex nature of terrestrial ecosystems.
- **Collin Joel Weber, Christoph Weihrauch, Christian Opp, Peter Chifflard (2020):-** This paper reviews the emerging field of microplastics in soils, highlighting the need for systematic research and improved sampling strategies. It proposes a five-stage workflow for studying microplastic dynamics, emphasizing the importance of geospatial approaches to understand spatial distributions. The authors call for enhanced methodologies for sample pre-processing and quantification to better assess the environmental impacts of microplastics on soil ecosystems and food chains.
- **Weixin Fan , Chunsheng Qiu , Qian Qu , Xiangang Hu , Li Mu , Ziwei Gao , Xin Tang (2023):-** This review evaluates soil sampling methods for microplastic (MP) analysis, emphasizing the need for standardized protocols. It highlights the importance of sampling design, depth, and preservation techniques to ensure accurate data collection. The study identifies various sampling strategies and equipment, recommending specific practices to minimize contamination and improve reliability. Additionally, it calls for further research to develop practical methods for assessing nanoplastics, which are a growing concern in environmental studies. Overall, the paper contributes valuable insights into enhancing soil sampling methodologies for MP research.
- **Yanhui Li , Jiangjun Yao , Pengcheng Nie , Xuping Feng , Jizan Liu (2021): -** The paper presents a novel method for the rapid detection of microplastics in soil, addressing the growing environmental concern regarding plastic pollution. The authors detail a systematic approach that enhances the efficiency of identifying microplastics, which are often challenging to detect due to their small size and varied composition. The method combines advanced techniques to ensure accurate results, making it a valuable tool for researchers and environmentalists. The study emphasizes the importance of timely detection in mitigating the impact of microplastics on ecosystems and human health .
- **Saqi Zheng , Baiyu Zhou , Nanfei Guo , Naying Li , Jialun Wu , Yong Chen , Zhiyong Han (2024): -** This paper investigates the detection of microplastics (MPs) in municipal solid waste landfills, which are significant sources of MPs. It emphasizes the importance of pretreatment methods due to the complex nature of landfill waste. The authors conducted a literature review and comparative experiments on

various digestion solutions to assess their impact on microplastics detection. The study aims to establish a comprehensive identification method for MPs, highlighting that the choice of pretreatment can significantly influence detection outcomes. Overall, the research underscores the need for optimized methods to improve the accuracy of microplastics studies in landfill environments.

- **Joanne S. Hanvey, Phoebe J. Lewis, Jennifer L. Lavers, Nicholas D. Crosbie, Karla Pozo and Bradley O. Clarke (2017): -** This paper reviews analytical methods for quantifying microplastics in sediment samples, highlighting the need for standardized techniques. It identifies significant inconsistencies in sampling, extraction, and quantification methods across studies, which hinder comparability. The authors advocate for improved quality assurance practices and harmonization of terminology to enhance the reliability of microplastic data in environmental research.

- **F Radford, LM Zapata-Restrepo, AA Horton, MD Hudson, PJ Shaw, ID Williams (2021): -** This research investigates methods for extracting microplastics from soils, addressing the urgent need for standardized techniques. It evaluates the efficiency of organic matter removal using hydrogen peroxide, potassium hydroxide, and Fenton's reagent, finding hydrogen peroxide to be the most effective. The study also tests density separation methods with sodium chloride, zinc chloride, and canola oil, concluding that canola oil is optimal for microplastic recovery, particularly in soils with low organic matter. The findings emphasize the necessity of tailoring extraction methods to specific soil characteristics to improve microplastic quantification in environmental studies.

- **Cao Junhao, Zhao Xining, Gao Xiaodong, Zhang Li, Hu Qi Kadambot H.M. Siddiqu (2021): -** This review discusses the increasing prevalence of microplastics (MPs) and nanoplastics (NPs) in agricultural soils, highlighting their sources, effects on soil health, and potential risks to the food chain. It evaluates various extraction and identification methods, emphasizing the need for standardized procedures to improve accuracy and efficiency. The paper calls for further research on the transport mechanisms of MPs in soil and their degradation by microorganisms to mitigate environmental impacts and enhance food security.

- **Mengting Liu , Yang Song , Shibo Lu , Rong Qiu , Jiani Hu , Xinyu Li , Moritz Bigalke , Huahong Shi, Defu He (2019): -** This study presents a novel method for extracting microplastics (MP) from soil using sodium bromide (NaBr) solutions in a circulation device. The method effectively separates various types of MP, achieving high recovery rates, particularly for high-density plastics, while being cost-effective and environmentally friendly. The research highlights the prevalence of MP in different soil types, emphasizing the need for further quantitative studies on soil microplastic pollution.

- **Shaoliang Zhang , Xiaomei Yang , Hennie Gertsen , Piet Peters , Tamás Salánki , Violette Geissen (2018): -** This study presents a novel, low-cost method for extracting and identifying microplastics, specifically LDPE and PP, from soil using distilled water. The methodology includes flotation, ultrasonic treatment, and a heating identification technique that distinguishes microplastics from organic matter. Results indicate that microplastics are prevalent in agricultural soils, with effective recovery rates and a reliable empirical model for quantification, highlighting the environmental impact of plastic use in agriculture.

- **A Kononov, M Hishida, K Suzuki, N Harada (2022): -** This study presents a novel method for extracting microplastics (MPs) from agricultural soils using a combination of canola oil and unsaturated sodium chloride solution. The method demonstrated high recovery rates (over 95%) for low-density polyethylene (LDPE) and polypropylene (PP), while recovery for polyvinyl chloride (PVC) was lower (78.7%). Compared to traditional density separation methods, this approach is more efficient, less sensitive to soil properties, and environmentally friendly, making it a promising technique for assessing MP contamination in agricultural settings.

- **F Prosenc, P Leban, U Šunta, M Bavcon Kralj (2021): -** This study evaluates methods for extracting and identifying microplastics (MPs) in soil and compost, focusing on density separation and oil-based extraction techniques.

Density separation with $ZnCl_2$ showed high recovery rates (>98%) for various MP polymers, while the oil-based method was less efficient, particularly in compost.

The HS-SPME-GC-MS method successfully identified multiple MP types, demonstrating potential for descriptive quantification based on linear relationships between particle numbers and signal responses.

The findings highlight the need for effective extraction methods to assess MP pollution in terrestrial environments, contributing valuable insights to environmental research.

- **Costanza Scopetani , David Chelazzi , Juha Mikola , Ville Leiniö , Reijo Heikkinen , Alessandra Cincinelli , Jukka Pellinen (2020): -** The paper presents an innovative olive oil-based method for extracting, quantifying, and identifying microplastics in soil and compost samples. This technique is significant as it offers a more environmentally friendly alternative to traditional methods, which often involve harmful solvents. The study details the effectiveness of this method in isolating microplastics, highlighting its potential for widespread application in environmental monitoring. The authors emphasize the importance of accurately assessing microplastic pollution in soil and compost, as it poses risks to ecosystems and human health. Overall, the research contributes valuable insights into sustainable practices for microplastic analysis.

- **Weixin Fan , Chunsheng Qiu , Qian Qu , Xiangang Hu , Li Mu , Ziwei Gao , Xin Tang (2023): -** The paper discusses the sources and identification of microplastics in soils, highlighting agricultural film and organic fertilizers as primary contributors. It reviews various extraction and detection techniques, including physical and chemical methods, to isolate microplastics from soil samples. The authors

emphasize the need for improved detection technologies and standards to address the growing issue of microplastic contamination in soils. They also call for better management practices in organic fertilizer production to minimize plastic content and propose future research directions to enhance understanding and remediation of microplastics in the environment

- **Babita Thakur, Jaswinder Singh, Joginder Singh, Deachen Angmo, Adarsh Pal Vig (2023): -** This study focuses on the identification and characterization of microplastics found in agricultural soil near industrial areas. It emphasizes the growing concern of microplastic pollution and its detrimental effects on soil health. The researchers utilized the density floatation method with saturated NaCl solution, which involved pre-digesting soil samples with H2O2 to remove organic matter. Various microplastic types, such as polypropylene and polystyrene, were identified using ATR-FTIR analysis. The crystalline structure of the extracted microplastics was examined through X-ray diffraction. The floatation method was effective, recovering about 80% of microplastics from the soil samples.

4 Conclusion

This study highlights the significant presence of microplastics in the soil environment of dumpyards, underscoring the increasing threat of plastic pollution in terrestrial ecosystems. The findings reveal that soils in dumpyards contain high concentrations of microplastics, particularly polyethylene, polypropylene, and polystyrene, which can persist in the environment for decades. These microplastics can disrupt soil health, interfere with nutrient cycles, and pose risks to plants, animals, and potentially human health through bioaccumulation and trophic transfer.

The study's results emphasize the urgent need for improved waste management practices, including better plastic waste segregation, recycling, and policies to reduce plastic production and usage. Additionally, remediation techniques should be explored to reduce the concentration of microplastics in contaminated soils. Further research is necessary to fully understand the long-term effects of microplastics in soil ecosystems and to evaluate potential risks to food security and human health. Addressing microplastic contamination in dumpyards is critical for protecting soil health, ensuring sustainable land use, and safeguarding ecosystem integrity for future generations.

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