Action Group for Campaign Against

One Earth Solar Farm

Scan on your smart phone camera

[redacted]

Q13.0.6 Mr David White

Potential adverse effects on soil health In your RR you indicate that the site could be contaminated, and soil health harmed should cables be left in situ resulting in degradation of soil quality from micro plastics and other potential contaminants during construction, operations and subsequent decommissioning? Are there any reports, or long term studies which have been undertaken to verify the points made, if so please cite the reference material to support your case.

Environmental Risks of Degrading XLPE Cables: Microplastic and Chemical Contamination Pathways

The proposed 4,000-acre One Earth Solar Farm development is planned largely on agricultural land, over 50% of which is grade 3a or higher. A key concern is the developer's assertion that the land can be returned to farming after a 60-year operational lifespan, despite the permanent burial of what could exceed 7,800 tonnes of XLPE cables across the site—equivalent to roughly 4.8 tonnes of plastics, heavy metals, and cable compounds per hectare.

The environmental implications of decaying XLPE (cross-linked polyethylene) cables are increasingly recognized. Recent studies indicate that XLPE degradation can generate microplastics and leach chemical additives into soils and groundwater. XLPE cables contain not only polyethylene but also additives such as antioxidants, cross-linking agents (e.g., peroxides), and sometimes flame retardants. Aging, heat, and environmental exposure can cause these materials to fragment or leach, potentially impacting soil health and water quality.

Even at depths of around one metre, microplastics and chemical additives can migrate through soil layers. Natural soil processes exacerbate this risk: earthworms burrow to depths of up to two metres, transporting microplastics vertically, while many crop root systems extend beyond one metre, providing pathways for chemical and microplastic uptake into the rhizosphere. Evidence shows that such contamination can disrupt soil microbial communities and nutrient cycling, potentially affecting soil fertility and crop productivity.

Several studies support the link between XLPE degradation and microplastic formation:

- **Li et al., 2021**: Synthetic polymers in soil and water can degrade into micro- and nano-plastics, including polyethylene.
- **Academia review on water treeing**: Confirms XLPE degradation through water treeing and oxidative aging, leading to eventual fragmentation.
- **Environmental microplastic surveys**: Microplastics have been found in soils near buried infrastructure, suggesting degraded plastic cables may contribute.

The degradation of XLPE cables thus produces persistent pollutants capable of impacting soil, water, and broader ecosystems. These risks underline the need for careful consideration of environmental impacts in planning and regulatory assessments.

Since the announcement of the One Earth Solar Farm application, we have been systematically studying microplastic pollution, including its sources, transport pathways, and ecological impacts. The following pages provide responses to Planning Inspectorate question Q13.0.6, citing news reports and peer-reviewed studies that substantiate concerns over potential soil and water contamination from decaying XLPE infrastructure.

QR Code Links are included for all articles.

1) **UN Environment Programme Article (inc QR Code Link)**

A concise article underscoring the harmful impact of microplastics in soil:

Introduction

The millions of tons of plastic swirling around the world's oceans have garnered a lot of media attention recently. But plastic pollution arguably poses a bigger threat to the plants and animals – including humans – who are based on land.

Very little of the plastic we discard every day is recycled or incinerated in waste-to-energy facilities. Much of it ends up in landfills, where it may take up to 1,000 years to degrade, leaching potentially toxic substances into the soil and water.

Researchers in Germany are warning (see article 3) that the impact of microplastics in soils, sediments and freshwater could have a long-term negative effect on such ecosystems. They say terrestrial microplastic pollution is much higher than marine microplastic pollution – estimated at four to 23 times higher, depending on the environment.


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22 DEC 2021 | STORY | NATURE ACTION

Plastic planet: How tiny plastic particles are polluting our soil

Photo: Paul Mocan

Originally published in April 2018, this story has been updated to include the latest facts, figures and references.

The millions of tons of plastic swirling around the world's oceans have garnered a lot of media attention recently. But plastic pollution arguably poses a bigger threat to the plants and animals – including humans – who are based on land.

Very little of the plastic we discard every day is recycled or incinerated in waste-to-energy facilities. Much of it ends up in landfills, where it may take up to 1,000 years to degrade, leaching potentially toxic substances into the soil and water.

Researchers in Germany are warning that the impact of microplastics in soils, sediments and freshwater could have a long-term negative effect on such ecosystems. They say terrestrial microplastic pollution is much higher than marine microplastic pollution – estimated at four to 23 times higher, depending on the environment.

a) b)

The researchers conclude that, although little research has been carried out in this area, the results to date are concerning: fragments of plastic are present practically all over the world and can trigger many kinds of adverse effects.

The study estimates that one third of all plastic waste ends up in soils or freshwater. Most of this plastic disintegrates into particles smaller than five millimetres, known as microplastics, and these break down further into nanoparticles (less than 0.1 micrometre in size). The problem is that these particles are entering the food chain.

[redacted]

2) This article; *"Microplastics negatively affect soil fauna but stimulate microbial activity: insights from a field-based microplastic addition experiment"* (Proceedings of the Royal Society B, DOI: 10.1098/rspb.2020.1268) provides empirical evidence that microplastics in soil can have negative ecological effects, particularly on soil fauna. **(inc QR Code Link)**

Here's what the study found:

- **Negative impact on soil fauna**: Introducing low-density polyethylene microplastic fragments into the field significantly altered both the composition and abundance of microarthropod and nematode communities. This shows that even relatively small concentrations of microplastics can disturb the populations of key soil-dwelling invertebrates.
- **Cascading effects on microbial functioning**: While the microplastics had only minor direct effects on microbial biomass and community structure, structural equation modeling revealed that disturbances among soil fauna cascaded through the food web, leading to modifications in microbial functioning. This suggests indirect consequences on vital ecosystem processes such as soil carbon and nutrient cycling.

In summary, the article demonstrates that microplastics in soil are harmful — particularly to soil fauna — and that these disturbances ripple through the ecosystem, potentially altering foundational soil processes like carbon turnover and nutrient dynamics.

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Research articles

Microplastics negatively affect soil fauna but stimulate microbial activity: insights from a field-based microplastic addition experiment

Dunmei Lin, Guangrong Yang, Pengpeng Dou, Shenhua Qian, Liang Zhao, Yongchuan Yang and Nicolas Fanin

Published: 02 September 2020 | https://doi.org/10.1098/rspb.2020.1268

Review history

Abstract

Microplastics are recognized as an emerging contaminant worldwide. Although microplastics have been shown to strongly affect organisms in aquatic environments, less is known about whether and how microplastics can affect different taxa within a soil community, and it is unclear whether these effects can cascade through soil food webs. By conducting a microplastic manipulation experiment, i.e. adding low-density polyethylene fragments in the field, we found that microplastic addition significantly affected the composition and abundance of microarthropod and nematode communities. Contrary to soil fauna, we found only small effects of microplastics on the biomass and structure of soil microbial communities. Nevertheless, structural equation modelling revealed that the effects of microplastics strongly cascade through the soil food webs, leading to the modification of microbial functioning with further potential consequences on soil carbon and nutrient cycling. Our results highlight that taking into account the effects of microplastics at different trophic levels is important to elucidate the mechanisms underlying the ecological impacts of microplastic pollution on soil functioning.

Details References Related Figures

This Issue

09 September 2020
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[redacted]

3) This Science Daily article titled *"An underestimated threat: Land-based pollution with microplastics"* (February 5, 2018) clearly presents evidence that microplastics in soil pose negative impacts, especially on terrestrial ecosystems. **(inc QR Code Link)**

Here's what it highlights:

- **Widespread presence and escalation**: The article notes that microplastics are pervasive across soils, sediments, and freshwater systems globally, potentially more so than in marine environments. In some cases, terrestrial microplastic pollution may be **4 to 23 times higher** than in marine settings.
- **Pathways into soil and ecosystem exposure**: One significant route is through sewage sludge used as fertilizer—since **80–90% of microplastic particles in sewage remain in the sludge**, vast quantities of microplastics enter agricultural soils each year.
- **Direct and indirect ecological harm**:
    - **Vectors for disease**: Microplastics may carry pathogens on their surfaces, potentially facilitating disease transmission across the environment.
    - **Altered behaviour in soil fauna**: Notably, the article mentions that earthworms modify how they burrow when microplastics are present, which can impair their fitness and, by extension, disrupt soil structure and health.
    - **Chemical toxicity**: As microplastics degrade, they can release additives like **phthalates and Bisphenol A (BPA)**—substances known to have hormonal and toxic effects on both vertebrates and invertebrates.
    - **Cellular-level damage from nanoparticles**: Nano-sized plastic particles may cross biological barriers—such as the blood-brain barrier or the placenta—possibly causing inflammation, altering gene expression, and triggering biochemical changes. While long-term impacts remain unclear, the article highlights observed behaviour changes in fish following nanoparticle exposure.

In summary, the article robustly supports the view that microplastics in soil are harmful. They:

1. Accumulate widely—often more in soils than in oceans,
2. Enter ecosystems through common agricultural practices,
3. Disrupt essential soil organisms and soil structure,
4. Leach potentially toxic chemicals, and
5. May penetrate biological systems at the cellular level.

Together, these points illustrate that microplastic pollution in soils is not only pervasive but also poses a multifaceted threat to ecosystem health.


Science News — *from research organizations*

An underestimated threat: Land-based pollution with microplastics

Date: February 5, 2018

Source: Forschungsverbund Berlin

Summary: Tiny plastic particles also present a threat to creatures on land and may have damaging effects similar or even more problematic than in our oceans. Researchers warn: the impact of microplastics in soils, sediments and the freshwaters could have a long-term negative effect on terrestrial ecosystems throughout the world.

Share:

[redacted]

Degradation Mechanisms of Buried XLPE and eventual release of Micro- and Nano-plastics

In addition to micro-plastic pollution, XLPE cables typically contain several additives, some of which are environmentally hazardous:

There is growing evidence that the same polymers commonly used in cable jackets and insulation (PVC, PE/XLPE, PP) fragment into micro- and even nano-plastics under real-world weathering and stress. Direct field studies that *quantify* microplastic release from buried power/telecom cables are still rare, but multiple peer-reviewed papers show fragmentation of these exact polymers and document microplastics from cable waste.

There's **strong mechanistic evidence** (and direct evidence for the same polymers) that cable materials *can* fragment into microplastics when exposed to UV, heat–oxidation, moisture cycles, and mechanical stress.

Sources (inc QR Code Links)

PVC (common cable sheath) fragments to microplastics under environmental weathering. Lab and mesocosm work show PVC films and objects progressively crack, embrittle and generate MPs/NMPs with UV/thermal cycles and drying–rewetting; fragmentation also accelerates release of high-molecular-weight plasticizers.


ACS Publications

OCCURRENCE, FATE, AND TRANSPORT OF AQUATIC AND TERRESTRIAL CONTAMINANTS | July 2, 2024

The Duration of Dry Events Promotes PVC Film Fragmentation in Intermittent Rivers

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Abstract

The majority of microplastics (MPs) found in the environment originate from plastic fragmentation occurring in the environment and are influenced by environmental factors such as UV irradiation and biotic interactions. However, the effects of river drying on plastic fragmentation remain unknown, despite the global prevalence of watercourses experiencing flow intermittence. This study investigates, through laboratory experiments, the coupled effects of drying duration and UV irradiation on PVC film fragmentation induced by artificial mechanical abrasion. This study shows that PVC film fragmentation increases with drying duration through an increase in the abundance and size of formed MPs as well as mass loss from the initial plastic item, with significant differences for drying durations >50% of the experiment duration. The average abundance of formed MPs in treatments exposed to severe drying duration was almost two times higher than in treatments nonexposed to drying. Based on these results, we developed as a proof of concept an Intermittence-Based Plastic Fragmentation Index that may provide insights into plastic fragmentation occurring in river catchments experiencing large hydrological variability. The present study suggests that flow intermittence occurring in rivers and streams can lead to increasing plastic fragmentation, unraveling new insights into plastic pollution in freshwater systems.

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Subjects

Environmental Modeling | Fragmentation | Irradiation | Plastics | Polymer Particles

Keywords

[redacted]


Research | Open access | Published: 21 May 2025

Release of high-molecular-weight plasticizers from PVC: mesocosm experiments under near-natural conditions

Regine Nagorka, Tomasz Gosal, Ulrike Scholz & Stefan Meinecke

Environmental Sciences Europe 37, Article number: 75 (2025) | Cite this article

843 Accesses | Metrics

Abstract

Background

In recent years, rapidly increasing environmental concentrations have been observed for certain high-molecular-weight (HMW) plasticizers, that are mainly used in PVC outdoor products. However, in light of their low solubility, these findings cannot be adequately explained by leaching alone. The study aimed to describe the extent of leaching and fragmentation of standardized PVC objects containing plasticizers influenced by weathering, including mechanical stress through wave action. We investigated the release behavior of the two potentially hazardous plasticizers di(2-propylheptyl) phthalate (DPHP) and tris(2-ethylhexyl) trimellitate (TOTM) from PVC in an artificial wave and pond mesocosm system under outdoor conditions over 181 days.

Results

A rapid release of DPHP and TOTM into the surrounding water was observed in the wave mesocosms (DPHP, 12.3 µg/L; TOTM, 19.8 µg/L after 24 h) with highly fluctuating concentration trends. Maximum sediment levels (DPHP, 4.12 µg/kg dry weight; TOTM, 5.43 µg/kg dry weight) were reached after 56 days. For both, water and sediment, the concentrations dropped from the shore area to the deeper water segments by > 80%. The DPHP test objects also contained a small amount of TOTM, and we observed concentration ratios of DPHP and TOTM in water and sediment samples that were highly similar to their content ratio in the test objects. In contrast, under leaching and weathering conditions in a stagnant pond and a dry gravel bed system, low levels of DPHP and TOTM were revealed in water (< 0.20 µg/L) and sediment (< 0.10 µg/kg dry weight).

[redacted]

The paper reviews how microplastics enter soils outside of buried cable (e.g., degradation of plastics, landfill leachate, geotechnical applications like tire chips or polymer fibers), but highlights their long-term persistence—even after decades or centuries but also discusses how microplastics move vertically and horizontally through soil, influenced by factors like water cycles, soil type, void ratio, and hydraulic conductivity.

Microplastic Contamination in Soils: A Review from Geotechnical Engineering View

Mehmet Murat Monkul [1,*], Hakkı O Özhan [1]

Editor: Jacopo La Nasa[1]

▸ Author information ▸ Article notes ▸ Copyright and License information

PMCID: PMC8659065 PMID: 34883632

Abstract

Microplastic contamination is a growing threat to marine and freshwater ecosystems, agricultural production, groundwater, plant growth and even human and animal health. Disintegration of plastic products due to mainly biochemical or physical activities leads to the formation and existence of microplastics in significant amounts, not only in marine and freshwater environments but also in soils. There are several valuable studies on microplastics in soils, which have typically focused on environmental, chemical, agricultural and health aspects. However, there is also a need for the geotechnical engineering perspective on microplastic contamination in soils. In this review paper, first, degradation, existence and persistence of microplastics in soils are assessed by considering various studies. Then, the potential role of solid waste disposal facilities as a source for microplastics

[redacted]

Consumer plastic items release microplastic particles when stressed (UV, mechanical). A 2024 screening study found both UV and mechanical stress drive fragmentation across common plastics, supporting the general mechanism relevant to cable jackets.

Journal of Hazardous Materials
Volume 477, 15 September 2024, 135256

Screening the release of chemicals and microplastic particles from diverse plastic consumer products into water under accelerated UV weathering conditions

Frank Menger [a,1], Mara Römerscheid [b,1], Stefan Lips [c], Ole Klein [d], Deedar Nabi [e], Jürgen Gandrass [e], Hanna Joerss [e], Katrin Wendt-Potthoff [f], Daria Bedulina [g], Tristan Zimmermann [d], Mechthild Schmitt-Jansen [c], Carolin Huber [b], Alexander Böhme [b], Nadin Ulrich [b], Aaron J. Beck [e], Daniel Pröfrock [d], Eric P. Achterberg [e], Annika Jahnke [b,h], Lars Hildebrandt [d]

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Erratum to "Screening the release of chemicals and microplastic particles from diverse plastic consumer products into water under accelerated U...
Journal of Hazardous Materials, Volume 489, 5 June 2025, Pages 137962
Frank Menger, Mara Römerscheid, Stefan Lips, Ole Klein, Deedar Nabi, Jürgen Gandrass, Hanna Joerss, Katrin Wendt-Potthoff, Daria Bedulina, Tristan Zimmermann, Mechthild Schmitt-Jansen, Carolin Huber, Alexander Böhme, Nadin Ulrich, Aaron J. Beck, Daniel Pröfrock, Eric P. Achterberg, Annika Jahnke, Lars Hildebrandt
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[redacted]

E-waste contexts (which include cables) show abundant microplastics. Work at a formal e-waste recycling base reported microplastics associated with dismantling/aging of plastics like cable polymers, indicating cables are a realistic source when exposed and processed.

Environment International
Volume 169, November 2022, 107515

Full length article

Characteristics of microplastics and the role for complex pollution in e-waste recycling base of Shanghai, China

Lu Zhan, Qi Zhang, Akemareli Bulati, Rui Wang, Zhenming Xu

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https://doi.org/10.1016/j.envint.2022.107515 Get rights and content

Abstract

Plastics used in electric and electronic products cover a wide range, and contain many additives, such as brominated flame retardant and so on. These compounds and microplastics may be released into environment when the electric and electronic products are obsoleted and recycled. This study explores the characteristics of microplastics and the complex pollutions in a formal e-waste recycling base in Shanghai, China. The maximum abundance of microplastics is observed in dust samples of the recycling base and the average abundance is 44277±69032p/50g. 103 kinds of polymers are identified, including 4 kinds of packaging plastics, 32 kinds of engineering plastics, 18 kinds of rubber, and 49 kinds of other polymers. It is found that microplastics show weak adsorption effect for heavy metals. However, microplastics are important carrier of ∑$_8$PBDEs released during the whole recycling processes, and BDE-209 account for more than 50% of PBDEs in microplastics. It is estimated that the microplastics load inside the e-waste recycling base was 4.01 tons based on the measured statistics. This study will

[redacted]

PVC microplastics act as long-term sources of additives (e.g., phthalates) once they form. Showing environmental persistence and leaching once PVC becomes microplastic.

ACS Publications

Open Access

CONTAMINANTS IN AQUATIC AND TERRESTRIAL ENVIRONMENTS | September 26, 2022

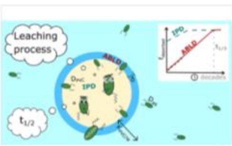
Polyvinyl Chloride Microplastics Leach Phthalates into the Aquatic Environment over Decades

Charlotte Henkel, Thorsten Hüffer, and Thilo Hofmann*

Open PDF Supporting Information (1)

Abstract

Phthalic acid esters (phthalates) have been detected everywhere in the environment, but data on leaching kinetics and the governing mass transfer process into aqueous systems remain largely unknown. In this study, we experimentally determined time-dependent leaching curves for three phthalates di(2-ethylhexyl) phthalate, di(2-ethylhexyl) terephthalate, and diisononyl phthalate from polyvinyl chloride (PVC) microplastics and thereby enabled a better understanding of their leaching kinetics. This is essential for exposure assessment and to predict microplastic-bound environmental concentrations of phthalates. Leaching curves were analyzed using models for intraparticle diffusion (IPD) and aqueous boundary layer diffusion (ABLD). We show that ABLD is the governing diffusion process for the continuous leaching of phthalates because phthalates are very hydrophobic (partitioning coefficients between PVC and water log $K_{PVC/w}$ were higher than 8.6), slowing down the diffusion through the ABL. Also, the diffusion coefficient in the polymer D_{PVC} is relatively high (~8×10^{-14} m^2 s^{-1}) and thus enhances IPD. Desorption half-lives of the studied PVC microplastics are greater than 500 years but can be strongly influenced by environmental factors. By combining leaching experiments and modeling, our results reveal that PVC microplastics are a long-term source of phthalates in the environment.



[redacted]

Cable-specific studies document polymer aging/embrittlement and cracking in XLPE/PVC under heat, moisture, chemicals, radiation, etc.—the precursors to fragmentation. These papers demonstrate that the materials in cables do degrade in situ (brittleness, cracks), which is the pathway to particle generation.

Article | PDF Available

Failure investigation of an underground low voltage XLPE insulated cable

September 2015 · Anti-Corrosion Methods and Materials 62(5):281-287
DOI:10.1108/ACMM-02-2014-1352

Authors:

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Cable-specific studies document polymer aging/embrittlement and cracking in XLPE/PVC under heat, moisture, chemicals, radiation, etc.—the precursors to fragmentation. These papers demonstrate that the materials in cables do degrade in situ (brittleness, cracks), which is the pathway to particle generation.

Investigation of XLPE Cable Insulation Using Electrical, Thermal and Mechanical Properties, and Aging Level Adopting Machine Learning Techniques

Priya Selvamany [1], Gowri Sree Varadarajan [1,*], Naresh Chillu [2], Ramanujam Sarathi [2]

Editor: Ming-Jay Deng

▸ Author information ▸ Article notes ▸ Copyright and License information

PMCID: PMC9033087 PMID: 35458363

Abstract

Hydrothermal and chemical aging tests on a 230 kV cross-linked polyethylene (XLPE) insulation cable were carried out in the present study to evaluate the degradation and aging levels qualitatively. The samples were subjected to water aging at a temperature of 80 °C, and in an aqueous ionic solution of $CuSO_4$ at room temperature. The diffusion coefficient results indicated that the ion migration was not at the same rate in the aging conditions. The diffusion coefficient–D–of the sample immersed in an aqueous $CuSO_4$ solution was lower than the hydrothermally aged specimens. The hydrophobicity of aged specimens decreased considerably compared to unaged samples. The distribution of trapped charges was quantitatively characterized. The presence of shallow trap energy states were observed in unaged XLPE, whereas the deep trap sites were noticed in aged specimens. In addition, the charge trap characteristics were different for positive and negative charge deposition. Various material characterization techniques, viz. dynamic mechanical analysis (DMA),

[redacted]

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NEWS | 21 February 2024

Buried microplastics complicate efforts to define the Anthropocene

Plastic particles in sediments could help to pin down the start of a new geological epoch. But their ability to migrate to older layers is muddying the waters.

By Katharine Sanderson

The presence of microplastics in layers of material that settle at the bottom of lakes might be an unreliable way to determine the onset of the Anthropocene – the geological epoch marking the consequences of human activity on the environment. That is the conclusion of researchers who have shown that tiny plastic particles can infiltrate deep into old sediments.

[redacted]

Addressing the microplastic crisis: A multifaceted approach to removal and regulation

Sina Matavos-Aramyan ✉

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https://doi.org/10.1016/j.envadv.2024.100579 ↗ Get rights and content ↗

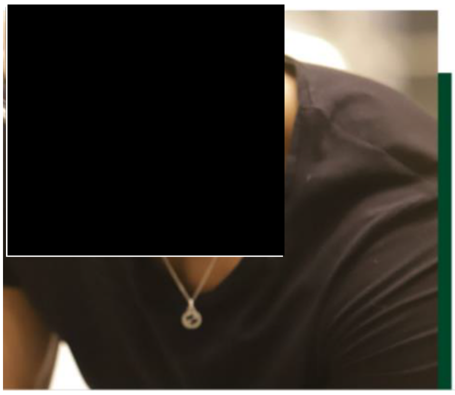
Highlights

- Microplastics' (MPs) growing threat needs collaborative mitigation efforts.
- The review identifies MP knowledge gaps, and proposes research priorities.
- MP crisis requires regulatory, social, and technical solutions.
- MP pollution needs a holistic governance, innovation, engagement.
- Public education of global MP crisis and its impacts must not be overlooked.

[redacted]

The Key to Cable Longevity: Understanding water treeing in power cables

Understanding the aging process in power cables is crucial for the electrification of the Norwegian Continental Shelf (NCS).



[redacted]

[redacted]

Study of the Accelerated Degradation of the Insulation of Power Cables under the Action of the Acid Environment

by Marius Florian Preduș [1,*], Cristinel Popescu [2], Eugen Răduca [1] and Cornel Hațiegan [1,*]

[1] Department of Engineering Sciences, Faculty of Engineering, Babeș-Bolyai University, 320085 Cluj-Napoca, Romania

[2] Department of Engineering Sciences, Faculty of Engineering, Constantin Brâncusi University, 210135 Târgu-Jiu, Romania

[*] Authors to whom correspondence should be addressed.

Energies **2022**, *15*(10), 3550; https://doi.org/10.3390/en15103550

Submission received: 29 March 2022 / Revised: 23 April 2022 / Accepted: 9 May 2022 / Published: 12 May 2022

(This article belongs to the Special Issue Control and Monitoring of Renewable Energy Power Systems)

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Abstract

Over operation time, there are a number of internal and external factors that change the characteristics of dielectric materials that are part of the electrical equipment. In areas with high pollution, an important requirement is the acidic chemical compounds in the soil in which the power cables are laid, which penetrate the insulation by infiltration, resulting in changes in the parameters of electrical insulation and causing a decrease in operating time. The paper is focused on the analysis, through a series of experimental determinations, of the effects of stresses to which the power cables laid in acidic environments are subjected, by simulating the operating conditions in the laboratory, obtaining concrete results. It also describes the direct current test installation used in the laboratory and presents the two stages of testing the cable sample inserted in the electrolyte, the first being a stage of accelerating the degradation of the insulation by supplying higher voltages to require insulation, and the second stage being the testing in the absence of the electric field, under the direct action of the chemical compounds from the installation tank. Given that in alternating current, the electric field causes an additional heating of the dielectric due to energy losses by electric polarization, the test is performed in direct current, precisely to be able to monitor the variation of insulation resistance in relation to temperature and losses through conduction currents, as a result of the Joule–Lenz effect and not as a result of the dielectric polarization process. At the same time, the power of the direct current source used is lower compared to that of an alternative current test source and does not contribute to the generation of electrical discharges during testing.

[redacted]

Long-term outdoor/marine weathering creates secondary micro- and nano-plastics from several commodity polymers (incl. PVC). A Nature-journal study under realistic conditions documented severe surface/bulk degradation and formation of sub-micron particles

npj | materials degradation

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nature > npj materials degradation > articles > article

Article | Open access | Published: 26 July 2023

An advanced analytical approach to assess the long-term degradation of microplastics in the marine environment

Carbery Maddison, C. I. Sathish, Daggubati Lakshmi, O'Connor Wayne & Thava Palanisami

npj Materials Degradation 7, Article number: 59 (2023) | Cite this article

Abstract

Determining the hazards posed by microplastics (MPs, <5 mm) requires an understanding of plastic degradation processes when exposed to environmental weathering forces. However, despite their perceived risks, limited information exists on the natural weathering progression of microplastics in marine environments. Our findings from environmentally realistic conditions reveal that long-term marine weathering resulted in significant degradation of plastic surfaces and bulk-phases, which varied by time and plastic polymer type. Plastics displayed biofouling, and an altered surface morphology, thermal stability and chemical signature. Secondary micronanoplastics (MNPs, <1 μm) were formed from weathered plastic surfaces, supported by a significant reduction in the size of PCL and PVC pellets. Using real world data, we reveal that plastic surfaces can degrade at a rate of up to 469.73 μm per year, 12 times greater than previous estimates. Our time-series data contributes valuable information towards developing plastic specific risk assessment frameworks and future plastics policy.

[redacted]

This document titled **"Review of Water Treeing in Polymeric Insulated Cables"** (from the *Proceedings of the Nordic Insulation Symposium*) supports the fact that cables deteriorate over time, particularly due to **water treeing**. In summary, the paper clearly demonstrates that polymer-insulated cables deteriorate as water trees develop and expand, culminating in insulation breakdown and overall decay of cable performance.

Review of water treeing in polymeric insulated cables

Amar Abideen[1], Frank Mauseth[1], Øystein L. Hestad[2] & Hallvard Faremo[2]

[1]*NTNU, Dept. of Electric Power Engineering, Trondheim, Norway*
[2]*SINTEF Energy Research, Trondheim, Norway*

Abstract

Since discovering the water treeing phenomenon (WT) in polymeric cables in the early 1970s, water treeing has been extensively studied. Historically, different theories were proposed to describe this phenomenon's mechanism. The two most prominent theories link the initiation of WTs to (i) mechanical damage and (ii) Stress-induced electrochemical degradation (SIED). Additionally, different investigations in the past have shown that the water trees growth is correlated to different operation conditions e.g. voltage, frequency and mechanical stresses. This paper aims to review the two prominent water treeing initiation theories. Then, discusses the factors influencing the water tree growth.

1. Introduction

Since the 1960s, extruded cross-linked polyethylene (XLPE) has conventionally been used as insulation for HV cables laid in wet environments [1]. Only a few years after deployment, such cables were reported to have a high failure rate. Further investigation revealed water ingress into the insulation, which causes tree-like water structures that leads to insulation breakdown [2]. Fundamentally, there are two types of water trees depending on the shape, namely: bow-ties and vented water trees. Typically, vented water trees are observed to

challenging to determine or agree upon particular water treeing initiation mechanism, it is generally accepted that during the cable lifetime, the insulation system is subjected to different aging factors that can contribute to the initiation and growth of water trees and eventually lead to the breakdown of the cable insulation system.

The mechanisms involved in water treeing initiation and growth are of complex nature. Thus, it is difficult to categorize different factors based on their contribution either on the water tree initiation or growth specially when different factors can coincide leading to presence of water trees. In this paper, the water treeing mechanisms are presented either as an initiation or growth mechanism based on the convention set by the authors of earlier work.

2. Water migration in polymers

Since polymers are inherently not watertight, the ingress of water into the insulation is inevitable. The water ingress into polymers can be characterized using Henry's law in conjunction with Fick's law for the diffusion of water in the bulk polymer [4]. First, Henry's law states that the water concentration $\rho_{(w,s)}$ at the polymer surface is proportional to the water vapor pressure above the surface $p_{(w,s)}$ i.e.

$$\rho_{(w,s)} = S \cdot p_{(w,s)} \quad (1)$$

[redacted]

Note: We have many more studies and reports available...

Ignoring the many studies showing a high level of vertical movement of micro-plastics and other chemicals produced by the degradation of XLPE cables, part of the applicant's argument contend that the proposed cable burial at a depth of 0.9 metres will not impact crop growth. However, this assertion overlooks the fact that numerous crop species possess root systems that extend well beyond this depth. For instance, maize (Zea mays) and barley (Hordeum vulgare) typically develop effective root zones ranging from 50 to 100 cm. Additionally, the presence of a second, deeper root mass in approximately 20% of plant species further complicates the issue. Therefore, the proposed cable depth may intersect with critical root zones, potentially affecting crop health and productivity.

In UK agriculture, quite a few crops can send roots down to **0.9 m and deeper**, especially on deep sandy or loamy soils where compaction doesn't limit penetration. The actual depth varies with soil type, management, and water availability, but here are the main examples:

Arable Crops

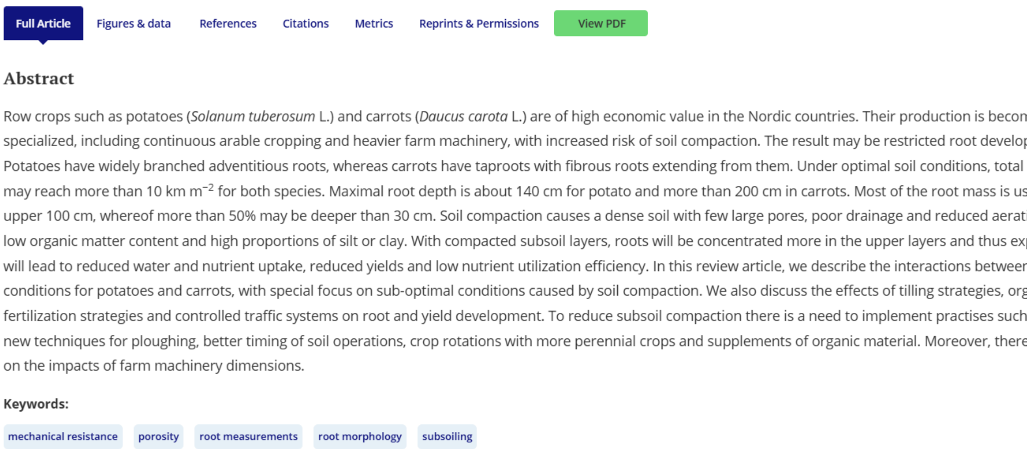
- **Sugar beet** – can root down to 1.5–2.0 m in good soils.
- **Oilseed rape** – rooting depth often 1.2–2.0 m; strong taproot system.
- **Maize (forage or grain)** – typically 1.0–1.5 m.
- **Winter wheat** – usually 1.0–1.5 m, though effective rooting is often shallower if soils are compacted.
- **Barley (spring and winter)** – can reach ~1.0 m in light soils.
- **Oats** – also capable of reaching 1.0–1.5 m.

Forage / Grassland Crops

- **Lucerne (alfalfa)** – very deep rooting, often >2.0 m; one of the deepest-rooting UK crops.
- **Red clover** – ~1.0–1.5 m.
- **Perennial ryegrass** – typically 0.6–1.0 m, but can exceed 1.0 m in sandy soils.

[redacted]

Typical Example Study (inc QR Code Link)


Full Article | Figures & data | References | Citations | Metrics | Reprints & Permissions | View PDF

Abstract

Row crops such as potatoes (*Solanum tuberosum* L.) and carrots (*Daucus carota* L.) are of high economic value in the Nordic countries. Their production is becon specialized, including continuous arable cropping and heavier farm machinery, with increased risk of soil compaction. The result may be restricted root develop Potatoes have widely branched adventitious roots, whereas carrots have taproots with fibrous roots extending from them. Under optimal soil conditions, total may reach more than 10 km m^{-2} for both species. Maximal root depth is about 140 cm for potato and more than 200 cm in carrots. Most of the root mass is us upper 100 cm, whereof more than 50% may be deeper than 30 cm. Soil compaction causes a dense soil with few large pores, poor drainage and reduced aerat low organic matter content and high proportions of silt or clay. With compacted subsoil layers, roots will be concentrated more in the upper layers and thus ex will lead to reduced water and nutrient uptake, reduced yields and low nutrient utilization efficiency. In this review article, we describe the interactions betweer conditions for potatoes and carrots, with special focus on sub-optimal conditions caused by soil compaction. We also discuss the effects of tilling strategies, org fertilization strategies and controlled traffic systems on root and yield development. To reduce subsoil compaction there is a need to implement practises such new techniques for ploughing, better timing of soil operations, crop rotations with more perennial crops and supplements of organic material. Moreover, there on the impacts of farm machinery dimensions.

Keywords:

mechanical resistance | porosity | root measurements | root morphology | subsoiling

Studies Showing Microplastic Effects on Impact on Soil Biota
Importance of Worms in Agriculture (**Earth Worms go down past 2metres in depth**)

1. **Soil Structure & Aeration**
   - Burrowing creates channels that improve **air circulation**, **drainage**, and **root penetration**.
   - This reduces compaction, making soils easier to work.
2. **Nutrient Cycling**
   - Worms consume organic matter and excrete it as **worm casts**, which are rich in **nitrogen, phosphorus, potassium**, and other nutrients in plant-available forms.
   - This accelerates **decomposition** and makes nutrients more accessible to crops.
3. **Water Infiltration & Retention**
   - Their tunnels act like natural irrigation channels, improving **water infiltration** during rainfall and reducing surface runoff.
   - Soils with healthy worm populations can hold more water, buffering against drought.
4. **Microbial Activity & Soil Biodiversity**
   - Worms mix organic and mineral soils, stimulating microbial communities that aid in disease suppression and fertility.
   - They increase soil biodiversity, which stabilises agroecosystems.
5. **Crop Yields**
   - Numerous studies show that worm-rich soils produce **higher yields**, sometimes comparable to applying synthetic fertilisers.

Risks if Worms Are Impacted by Microplastic Pollution

Research over the past decade has started to reveal worrying effects of microplastics on worms (especially *Lumbricus terrestris* and *Eisenia fetida* used in studies):

1. **Reduced Growth & Reproduction**
   - Worms ingest microplastics while feeding on soil and organic matter.
   - This can cause gut blockages, reduce nutrient absorption, and lower reproduction rates.
2. **Soil Structure Degradation**
   - If worm populations decline, **soil porosity decreases** and compaction increases.
   - Poor drainage and reduced aeration can stress crops and increase flooding risk.
3. **Slower Nutrient Cycling**
   - Less worm activity = slower organic matter breakdown = reduced natural fertility.
   - Farmers may become more dependent on synthetic fertilisers.
4. **Changes in Microbial Communities**
   - Studies show that microplastics alter soil microbiota directly, but loss of worms exacerbates this by reducing microbial diversity and disrupting natural balances.
   - This could increase vulnerability to soil-borne crop diseases.
5. **Soil–Plant Feedback Loops**
   - Poor worm activity leads to **weaker soils**, which in turn reduces crop root penetration and resilience.
   - Long-term, this reduces soil carbon storage capacity, worsening climate change impacts.

What Could Happen at Scale

If microplastic pollution significantly reduces earthworm populations in farmland soils:

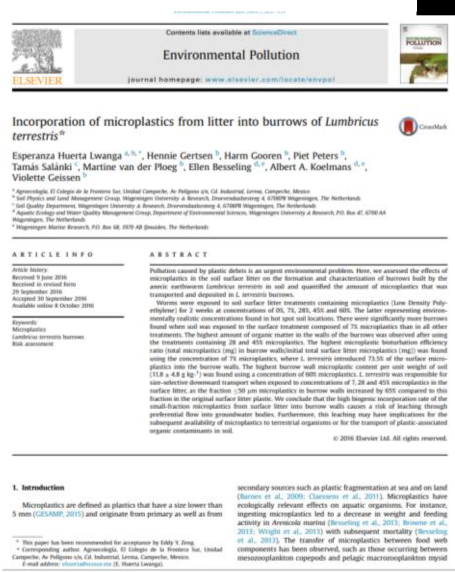
- Agricultural yields could drop globally (especially in low-input farming that depends heavily on natural fertility).
- Soil degradation could accelerate, increasing erosion and decreasing resilience to droughts and floods.
- The cost of farming would rise as synthetic fertilisers and soil amendments are used to replace lost natural functions.
- Over decades, soils could become less sustainable, undermining food security.

In short: **earthworms are vital for productive, sustainable agriculture**, and microplastic pollution threatens their ability to do this work. Even a moderate decline in their numbers could ripple through soil systems, leading to poorer harvests, weaker soils, and higher farming costs.

citable studies (lab, mesocosm, field, and syntheses) on how microplastics affect earthworms and knock-on soil functions. I've grouped them by what they show:

1) Earthworms ingest and move microplastics through soil (changing soil structure & exposure pathways)

- **Field/mesocosm:** Earthworms incorporated surface litter microplastics into burrows and casts, redistributing them vertically and laterally through the profile. NaturePortal de El Colegio de la Frontera Sur
- **Preferential flow risk:** Burrow networks can facilitate **leaching** of microplastics to deeper layers/groundwater under certain conditions. CSIRO PublishingSemantic Scholar
- **Nanoplastics too:** *Lumbricus terrestris* bioturbation transports nanoplastics spatiotemporally, not just larger MPs. PMC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Incorporation of microplastics from litter into burrows of *Lumbricus terrestris*☆

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ABSTRACT

Pollution caused by plastic debris is an urgent environmental problem. Here, we assessed the effects of microplastics in the soil surface litter on the formation and characterization of burrows built by the anecic earthworm *Lumbricus terrestris* in soil and quantified the amount of microplastics that was transported and deposited in *L. terrestris* burrows.

Worms were exposed to soil surface litter treatments containing microplastics (Low Density Polyethylene) for 2 weeks at concentrations of 0%, 7%, 28%, 45% and 60%. The latter representing environmentally realistic concentrations found in hot spot soil locations. There were significantly more burrows found when soil was exposed to the surface treatment composed of 7% microplastics than in all other treatments. The highest amount of organic matter in the walls of the burrows was observed after using the treatments containing 28 and 45% microplastics. The highest microplastic bioturbation efficiency ratio (total microplastics (mg) in burrow walls/initial total surface litter microplastics (mg)) was found using the concentration of 7% microplastics, where *L. terrestris* introduced 73.5% of the surface microplastics into the burrow walls. The highest burrow wall microplastic content per unit weight of soil (11.8 ± 4.8 g kg^{-1}) was found using a concentration of 60% microplastics. *L. terrestris* was responsible for size-selective downward transport when exposed to concentrations of 7, 28 and 45% microplastics in the surface litter, as the fraction ≤50 μm microplastics in burrow walls increased by 65% compared to this fraction in the original surface litter plastic. We conclude that the high biogenic incorporation rate of the small-fraction microplastics from surface litter into burrow walls causes a risk of leaching through preferential flow into groundwater bodies. Furthermore, this leaching may have implications for the subsequent availability of microplastics to terrestrial organisms or for the transport of plastic-associated organic contaminants in soil.

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1. Introduction

Microplastics are defined as plastics that have a size lower than 5 mm (GESAMP, 2015) and originate from primary as well as from secondary sources such as plastic fragmentation at sea and on land (Barnes et al., 2009; Claessens et al., 2011). Microplastics have ecologically relevant effects on aquatic organisms. For instance, ingesting microplastics led to a decrease in weight and feeding activity in *Arenicola marina* (Besseling et al., 2013; Browne et al., 2013; Wright et al., 2013) with subsequent mortality (Besseling et al., 2013). The transfer of microplastics between food web components has been observed, such as those occurring between mesozooplankton copepods and pelagic macrozooplankton mysid

☆ This paper has been recommended for acceptance by Eddy Y. Zeng.
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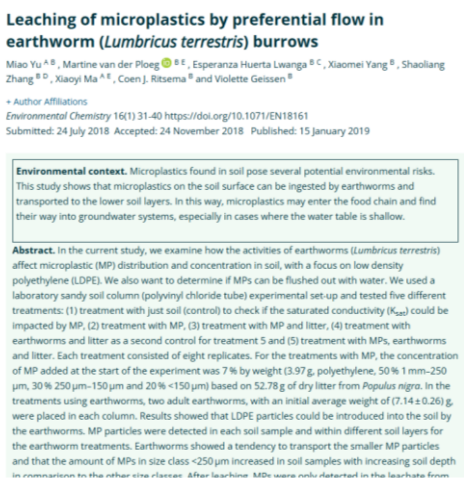
2) Direct biological effects on earthworms (growth, reproduction, oxidative stress)

- **Reduced reproduction & growth:** Multiple lab studies with *Eisenia* spp. and enchytraeids show decreased cocoon/juvenile numbers and stunted growth at environmentally relevant concentrations and across polymer types (PE, nylon, PVC).
- **Physiological stress:** Changes in survival/respiration and detoxification enzymes (e.g., GST), indicating oxidative and inflammatory stress responses. MDPI
- **Co-stressors:** Combined exposures (e.g., microplastics + chlorpyrifos) can exacerbate toxic effects in *L. terrestris*.
- **Biobased/"biodegradable" plastics aren't automatically safer:** Long-term tests with bio-based polymers still showed adverse effects on *Eisenia andrei*.


Leaching of microplastics by preferential flow in earthworm (*Lumbricus terrestris*) burrows

Miao Yu[A,B], Martine van der Ploeg[B,E], Esperanza Huerta Lwanga[B,C], Xiaomei Yang[B], Shaoliang Zhang[B,D], Xiaoyi Ma[A,E], Coen J. Ritsema[B] and Violette Geissen[B]

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Environmental context. Microplastics found in soil pose several potential environmental risks. This study shows that microplastics on the soil surface can be ingested by earthworms and transported to the lower soil layers. In this way, microplastics may enter the food chain and find their way into groundwater systems, especially in cases where the water table is shallow.

Abstract. In the current study, we examine how the activities of earthworms (*Lumbricus terrestris*) affect microplastic (MP) distribution and concentration in soil, with a focus on low density polyethylene (LDPE). We also want to determine if MPs can be flushed out with water. We used a laboratory sandy soil column (polyvinyl chloride tube) experimental set-up and tested five different treatments: (1) treatment with just soil (control) to check if the saturated conductivity (K_{sat}) could be impacted by MP, (2) treatment with MP, (3) treatment with MP and litter, (4) treatment with earthworms and litter as a second control for treatment 5 and (5) treatment with MPs, earthworms and litter. Each treatment consisted of eight replicates. For the treatments with MP, the concentration of MP added at the start of the experiment was 7 % by weight (3.97 g, polyethylene, 50 % 1 mm–250 μm, 30 % 250 μm–150 μm and 20 % <150 μm) based on 52.78 g of dry litter from *Populus nigra*. In the treatments using earthworms, two adult earthworms, with an initial average weight of (7.14 ± 0.26) g, were placed in each column. Results showed that LDPE particles could be introduced into the soil by the earthworms. MP particles were detected in each soil sample and within different soil layers for the earthworm treatments. Earthworms showed a tendency to transport the smaller MP particles and that the amount of MPs in size class <250 μm increased in soil samples with increasing soil depth

3) Soil system consequences (microbes, enzymes, fertility proxies)

- **Microbiome shifts:** MPs alter soil microbial communities and functions; some studies report increased respiration but reduced bacterial diversity—changes that can destabilise nutrient cycling.
- **Across taxa & endpoints:** A 2023 meta-analysis found MPs generally **decrease growth and reproduction of soil fauna** and shift microbial metrics, with effects depending on polymer, shape, and dose.

4) Syntheses and reviews (what the weight of evidence says)

- **Global meta-analysis (114 studies):** Differential but overall negative effects of MPs on soil properties, microbes, enzymes, and fauna; earthworm endpoints (growth/reproduction) frequently impaired.
- **Agroecosystems review:** Summarises pathways relevant to farms (e.g., sludge/manure inputs), with evidence for negative impacts on earthworms and potential implications for productivity. Wiley Online Library
- **Recent reviews (2024):** Broad overviews of MP impacts on earthworms and soil biota, including synergy/antagonism with other stressors.

Other sources of information

[redacted]

News Articles (we can supply many more articles on request)

News | Opinion | Sport | Culture | Lifestyle

The Guardian UK

Environment · Climate crisis · Wildlife · Energy · **Pollution**

Plastics

This article is more than **5 months old**

Microplastics hinder plant photosynthesis, study finds, threatening millions with starvation

Researchers say problem could increase number of people at risk of starvation by 400m in next two decades

The world's staple crops such as wheat, maize and rice are under threat from pervasive particles. Photograph: jodie777/Getty Images/iStockphoto

[redacted]

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The Guardian UK

Environment · Climate crisis · Wildlife · Energy · Pollution

Environment

This article is more than **4 years old**

Microplastic pollution devastating soil species, study finds

Researchers in China saw big reductions in organisms that play a crucial role in recycling carbon and nitrogen

[redacted]

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Environment

This article is more than **4 years old**

Microplastic pollution devastating soil species, study finds

levels, said lead author of University of Missouri paper

A worker sprinkles fertilizer around young grapefruit trees in the Indian River Citrus District on Florida's east coast. Photograph: UCG/Universal Images Group/Getty Images

Fertilizers that shed microplastics are increasingly spreading on America's cropland, research shows, raising new worry about the soil contamination and safety of the US food supply.

A peer-reviewed University of Missouri paper found common types of controlled-release fertilizers are often encapsulated with plastic and can be so small that they could be considered microplastics. Those are designed to break down into even smaller pieces of plastic once spread in fields.

[redacted]