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Review article

Unearthing Earth's secrets: Exploring the environmental legacy of contaminants in soil, water, and sediments

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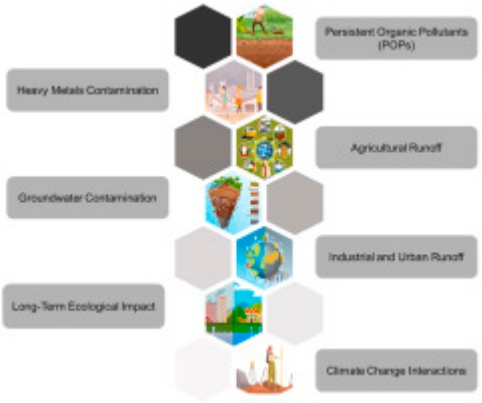
Abstract

The Earth's history is documented in human civilizations, soil layers, river movement, and quiet sediments throughout millennia. This investigation explores the significant legacy of environmental toxins in these key planet components. Understanding how ancient activity shaped the terrain is crucial as mankind faces environmental issues. This interdisciplinary study uses environmental science, archaeology, and geology to uncover Earth's mysteries. It illuminates the dynamic processes that have built our globe by studying pollutants and soil, water, and sediments. This research follows human actions, both intentional and unintentional, from ancient civilizations through contemporary industrialization and their far-reaching effects. Environmental destiny examines how contaminants affect ecosystems and human health. This study of past contamination helps solve modern problems including pollution cleanup, sustainable land management, and water conservation. This review studies reminds us that our previous activities still affect the ecosystem in a society facing rapid urbanisation and

industrialization. It emphasises the importance of environmental stewardship and provides a framework for making educated choices to reduce toxins in soil, water, and sediments. Discovery of Earth's secrets is not only a historical curiosity; it's a necessary step towards a sustainable and peaceful cohabitation with our home planet.

Graphical abstract



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Introduction

In a time when environmental sustainability and the health of our world are of utmost importance, it becomes imperative to investigate the ubiquitous presence of toxins in our soil, water, and sediments. A fascinating and perceptive analysis, "Unearthing Earth's Secrets: Exploring the Environmental Legacy of Contaminants in Soil, Water, and Sediments" explores the complex network of human activity and its long-lasting effects on Earth's fragile ecosystems. Embedded in the complex web of Earth's natural ecosystems is a deep history of pollutants in the planet's soil, water, and sediments. By delving into this heritage, we can better comprehend and manage the far-reaching effects of human actions on Earth's ecological systems (K P et al., 2023). Fundamental to this investigation is the branch of science known as environmental chemistry, which studies the make-up, activities, and interactions of contaminants in Earth's many matrixes. Industrial operations, agriculture, and urbanisation are common anthropogenic sources of contaminants that seep into the environment and leave permanent marks on the things they come into contact with. Lead, mercury, and cadmium are just a few examples of the heavy metals and organic pollutants that fall under this category. Other examples include hydrocarbons, pesticides, and persistent organic pollutants (POPs) (Ingrao et al., 2023) (Li et al., 2022). Soil, a living storehouse

of nutrients and microbes, becomes a quiet graveyard for these pollutants. If we want to know how they affect agriculture, human health, and terrestrial ecosystems, we need to know how they settle into soil, where they go, and how much of them are bioavailable. The weight of pollution also falls on water, the elixir of life. Hazards to aquatic biota and human populations are posed by contaminants that are intricately entangled in the hydrological cycle and spread over large areas, impacting aquatic ecosystems and drinking water supplies. Encapsulating a record of pollutants, sediments tell the tale of human impact on Earth's landscapes across time and serve as archives of environmental history.

A wide variety of scientific approaches and technology are used to decipher these complex tales. The analytical chemistry, spectroscopy, chromatography, and cutting-edge imaging methods that look into the distribution and chemical makeup of pollutants. The effects of these pollutants on species are studied by ecotoxicologists and environmental biologists, who analyse the genetic, behavioural, and physiological reactions. The geographical analysis and modelling provide light on the dynamics and routes of pollutant movement across several environmental compartments, offering a comprehensive view. Social, economic, and policy spheres are all touched by the effects of this investigation (Tarafdar et al., 2023). To lessen the effects of pollutants, researchers from different fields must work together, come up with new ways to clean up the mess, and establish policies that take into account both people's needs and the environment. The search for Earth's hidden environmental pollutants is more than just a scholarly exercise; it is a shared obligation to protect our world for the sake of present and future generations.

Exploration like this is a reflection of humanity's desire to learn about and protect Earth's complex biosphere. The path ahead calls for steadfast determination, rigorous scientific inquiry, and a balanced partnership between human achievements and the protection of Earth's natural integrity (Tarafdar et al., 2023) (He et al., 2023). This review's thorough investigation pushes us to think about the effects of our choices, which motivates us to work together to protect the planet for present and future generations. The review reveals the complex web of environmental legacy left by contaminants, ranging from the bioaccumulation of hazardous compounds to the modification of microbial ecosystems. Fig. 1 is a schematic picture of how the decontamination of water and other resources on Earth may look. This review article focuses mainly on environmental contaminants through the years and how they evolved and became a thread to humans and the environment based on the recent research on mitigation strategies and challenges discussed in detail.

Section snippets

Environmental contaminants over the years

A horizontal timeline that starts in the pre-industrial age and goes into the present and future, covering multiple centuries (Tarafdar et al., 2023). This timeline gives the historical background of environmental contamination a clear visual representation (He et al., 2023). Separate the timeline into portions that correspond to different sorts of pollutants (Wu et al., 2023) (Yin et al., 2023a). You may, for instance, create divisions for industrial pollutants (such chemicals and heavy

Soil as a Recorder of History

Construct a vertical depiction of soil layers to highlight the various strata that have formed over millennia (You et al., 2020). With the oldest layers at the bottom and the newest at the top, each layer symbolises a distinct historical era. Put markers beside the strata to indicate important historical occurrences or breakthroughs that aided in the soil's contamination. This could involve the introduction of chemical pesticides, the construction of industries, or the usage of leaded gasoline (

Water: a liquid archive

To illustrate the numerous reservoirs where environmental pollutants, build up over time, depict a variety of water bodies, including rivers, lakes, oceans, and groundwater. Utilise symbols or colour coding to distinguish between various contaminants, such as organic pollutants, heavy metals, and microplastics, to highlight the variety of contaminants that can exist in water bodies (Michael-Igolima et al., 2022). An overarching perspective on the practical applications of water resources, as

Sediments as silent storytellers

This subtopic primarily emphasises the importance of sediment as a basic building

block of Earth's terrestrial and aquatic landscapes. Sediments have been accumulated throughout millennia in a variety of habitats, such as lake bottoms, riverbeds, and ocean floors. These assemblages of rock and soil act as silent emissaries of the planet's past, recording both man-made and natural occurrences. The first part of the subtopic acknowledges the complex pathways by which pollutants enter sediment.

Archaeological insights

Start your diagram by including a chronology or historical context that highlights important times or incidents connected to human activity and pollutant release. This may encompass historical periods such as the industrial and agricultural revolutions, as well as pivotal occasions in the evolution of environmental laws (Sun et al., 2023).Draw attention to archaeological sites that have been found to have traces of past human activity and pollution deposition. To symbolise these locations

Environmental consequences and modern challenges

The environment has been permanently impacted by human activity, ranging from resource extraction and agriculture to urbanisation and industrialization (Shepherd et al., 2023). Heavy metals, hazardous chemicals, plastics, and other pollutants have all found their way into soil, water, and sediment systems and are producing a host of problems for the environment and public health. These contaminants, which exist as a legacy of the past and a current concern for the present and future, are the

Mitigation and Remediation Strategies

First, a broad spectrum of pollutants, such as heavy metals, industrial chemicals, plastics, and new toxins, are acknowledged as having entered our environment. These contaminants have affected soil, water, and sediments, changing ecosystems and endangering human health (Deivayanai et al., 2024).It explores techniques like phytoremediation, which extracts, stabilises, or eliminates contaminants from the environment using plants (see Fig. 14.). It also covers the application of chemical and

Sustainable land management practices

At its core, this subtopic underscores the profound interdependence between land management practices and the health of ecosystems, both terrestrial and aquatic. It acknowledges that the land is not just a canvas upon which human activities unfold but a dynamic and interconnected part of Earth's life support system (Luo et al., 2023).

The choices we make in land management have profound and enduring effects on the environment. This commences by recognizing the diverse set of practices that

Prospects for sustainable management strategies and future detection methods in remediation

In the field of environmental remediation, minimising the effects of pollutants in soil, water, and sediments requires the development of sustainable management solutions. The field of remediation techniques is changing in a way that emphasises sustainability, emphasising both long-term environmental harmony and efficient cleaning. Proactive remediation is made possible by the goal of improving monitoring and identifying toxins via the development of future detection systems. Strategies for

Conclusion

Investigating the environmental legacy of Earth with regard to pollutants in sediments, water, and soil provides important new understandings into the widespread effects of human activity on natural ecosystems. This investigation emphasises how urgently thorough and proactive remediation plans are needed to treat current pollution and stop further environmental deterioration. Because contaminants provide a variety of issues, a variety of strategies are required. It is essential to comprehend

CRediT authorship contribution statement

Gautham Devendrapandi: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Ranjith Balu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **K. Ayyappan:** Formal analysis. **Ramamoorthy Ayyamperumal:** Methodology, Formal analysis, Data curation. **Salh Alhammadi:** Formal analysis. **Mahimaluru Lavanya:** Formal analysis. **R. Senthilkumar:**

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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