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Understanding Soil Pollution: Causes and Its Impacts on the Environment and Population

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ABSTRACT

Soil pollution has increasingly become an environmental concern with adverse effects on ecosystems, human health, and agricultural productivity. It ideally occurs when anthropogenic waste and hazardous substances contaminate soil; such pressure disrupts ecological processes concerning food security and water security, among others. This study adopts a qualitative literature review methodology to synthesise the existing research, thus clustering insights into three themes: causes, environmental impacts, and impacts on populations. Findings indicate that industrialisation, unsustainable agricultural practices, poor waste management, and urbanisation are the dominant drivers of soil pollution. Such degradation emits persistent pollutants such as heavy metals, hydrocarbons, and agrochemicals. Fertility is damaged by these contaminants in soil, biodiversity is disturbed, and water is polluted, leading to further consequences in the ecosystems and climate stabilisation. The human population get exposed to toxic substances from soil pollution, giving rise to chronic diseases, food insecurity, and economic losses, with the vulnerable group, especially children, the elderly, and low-income communities, bearing the heaviest burden. The proposed measures by the study emphasise integrated responses involving stricter regulation of industrial and agricultural pollutants, promotion of the use of sustainable agricultural practices, and employment of remediation techniques such as bioremediation and phytoremediation. Public awareness and international cooperation are other essential hands to hold in minimising soil pollution. Since this threat is a big global issue, it needs a multi-sectoral action for safeguarding soil health, food systems, and public well-being.

Keywords: Soil; Pollution; Pollutants; Soil Pollution; Environment; Population; Ecosystem

INTRODUCTION

Soil is one of the most essential natural resources, providing the foundation for plant growth, water filtration, and ecosystem stability. It supports biodiversity, serves as a habitat for countless organisms, and plays a crucial role in agriculture and food production. However, soil is highly vulnerable to degradation when exposed to harmful substances (pollutants) that alter its natural composition. The introduction of these pollutants into the environment, disrupting its natural processes and posing risks, is referred to as pollution. Pollution occurs in various forms, including air, water, and land, all of which are interconnected. Among these, soil pollution is particularly concerning as it directly affects food production, water quality, and overall environmental health (Havugimana et al., 2017; Cachada et al., 2018; Iberdrola, 2021; Münzel et al., 2023).

This form of pollution has emerged as a critical environmental challenge that poses significant threats and affects ecosystem health, human well-being, and agricultural productivity on a global scale. According to Münzel et al. (2023), soil pollution occurs when waste materials of human origin contaminate the soil at concentrations higher than normal, leading to adverse effects on human and ecosystem health. In other words, soil pollution is the contamination of the soil by hazardous substances that can degrade its quality and pose risks to the environment and human health. This phenomenon results from human activities such as industrialisation, urbanisation, agricultural practices, and poor waste management (Havugimana et al., 2017; Khan et al., 2024).

The extent of this problem is so severe that both intense and moderate degradation are already affecting one-third of the world's soil, with extremely slow recovery, taking up to 1,000 years to create just a few centimetres of arable soil (Iberdrola, 2021). As a non-renewable resource, soil is vital to sustaining plant life, biodiversity, and water regulation. However, the increasing contamination of soil threatens its functionality and poses severe risks to food security, biodiversity, and public health. This paper, therefore, examines the underlying causes of soil pollution and its far-reaching impacts on the environment and human population, and outlines potential strategies to mitigate its effects.

THEORETICAL FRAMEWORK

Smith and Ezzati (2005) first proposed the Environmental Risk Transition Theory in the field of environmental health research. It draws its foundation from earlier World Health Organisation (WHO) concepts on the changing nature of environmental risk as societies economically develop.

According to this theory, environmental risks change depending on the stages of development. At low-income stages, communities face traditional risks such as poor sanitation, indoor air pollution, and unsafe water. As situations of industrialisation and urbanisation improve, these environmental health risks begin to wane but are gradually replaced with more complex modern risks like soil pollution, chemical contaminants, and industrial wastes. The transition is one of trade-offs, with some forms of environmental health burdens being diminished; on the other hand, they become more complicated and widespread (Smith & Ezzati, 2005). This framework becomes truly cogent when applied to soil pollution, as it situates the problem within the spectrum of socio-economic change. Soil pollution is not something that stands as isolated; instead, it emerges as a "modern" environmental risk arising from industrialisation, urbanisation, and chemical-intensive agriculture. These are just those drivers beneath which this study is nestled. By applying the theory, the analysis explains how, in industrialising and newly industrialised countries such as Ghana, China, India, Malaysia, South Africa, Turkey, and Brazil, economic growth brings about systemic hazards that disproportionately affect vulnerability (Münzel et al., 2023; European Environment Agency, 2022) and increasing soil contamination. Therefore, the theory provides a conceptual lens to link socio-economic development with the changing environmental health burdens.

The Environmental Risk Transition Theory has been criticised for being too linear and deterministic, assuming all societies eventually follow the same pathway from traditional to modern risks in this process. In truth, many low- and middle-income countries face overlapping risks, where traditional exposures such as poor sanitation co-exist with the new threats of soil and chemical contamination (Cachada et al., 2018). The framework is also criticised for underplaying governance, inequality, and environmental justice concerns that are instrumental in determining how risk burdens are shared among populations. (Levasseur et al., 2021). These critiques imply one assertion: that while the theory does hold water as a framework for perceiving soil pollution as a developmental malady, it must be applied with caution and somehow complemented by concern for equity and sustainability.

Materials and Methods

The study employs a qualitative literature review methodology to explore and analyse soil pollution, its causes and its impact on the environment and population. It was designed to synthesise existing scholarly work on the subject, as proposed by Webster & Watson (2002), cited in Ofosu et al. (2020), to evaluate key themes and provide a comprehensive understanding of the issues.

The data for the study were gathered from scholarly articles available on Google Scholar and ResearchGate, as well as online reports and website publications related to the topic, drawing from the methods adopted by Takyi et al. (2021) and Ofosu et al. (2020) in their various studies. The search focused on key terms such as "soil", "soil pollution", "impact of soil pollution on the environment", "impact on population", "soil pollutants", and other relevant combinations. To manage the large volume of literature and ensure consistency, the study included only works published in English, following the approach of Petticrew and Roberts (2006), as cited in Ofosu et al. (2020).

Relevant sources were selected based on their focus on soil pollution, its causes, and its impacts. The study gave priority to studies and websites that offered detailed insights into the causes and impact of soil pollution. The articles selected formed the primary dataset for the study. The dataset was analysed using thematic analysis to identify recurring patterns, grouping the findings into key themes: causes, environmental impact, and impact on population. The study process is summarised and illustrated in Figure 1 using a flowchart format.

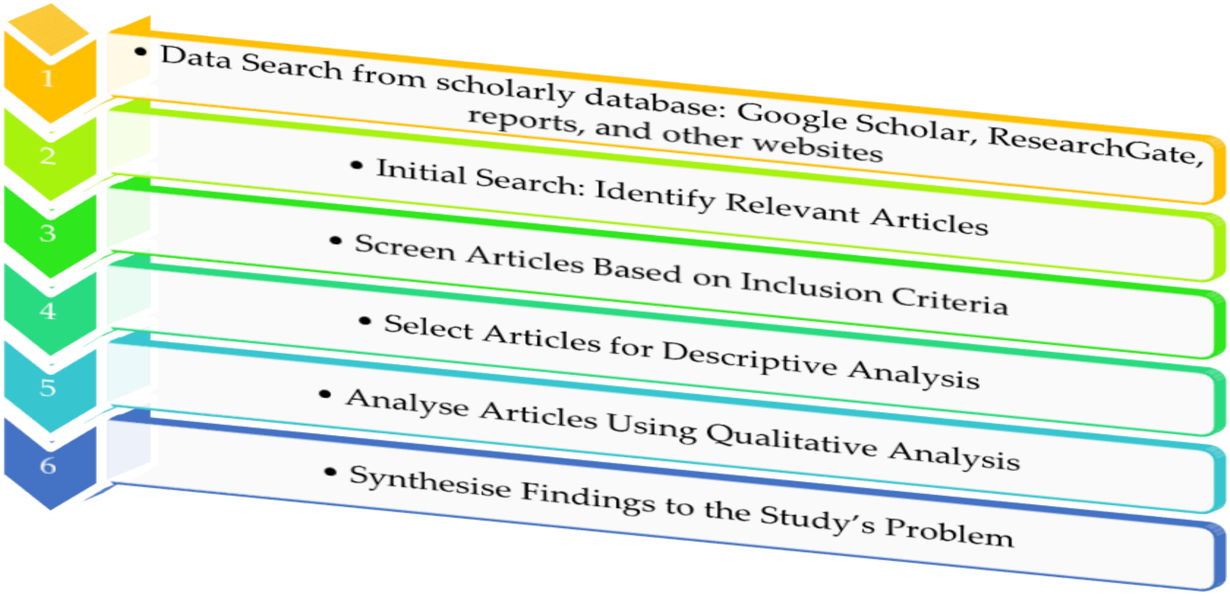

Figure 1. Summary of the literature review process.

Source: Authors construct (2025).

RESULTS

Soil pollution is one of the most widespread environmental issues globally, with profound implications for both the environment and human populations. The results of the qualitative literature review conducted in the study highlight three distinct but interconnected themes that enhance the understanding of soil pollution. These themes are grouped as follows: the causes of soil pollution; the impacts of soil pollution on the environment; and the impacts of soil pollution on the population. Each theme plays a crucial role in deepening our understanding of soil-related challenges and shaping strategies for environmental sustainability.

Causes of Soil Pollution

The causes of soil pollution are diverse and complex, stemming from both natural and anthropogenic sources (Havugimana et al., 2017; Cachada et al., 2018; Environmental Pollution Centres, 2024). According to Iberdrola (2021), the Food and Agriculture Organisation (FAO) distinguishes between two types of soil pollution: "Specific pollution" and "Widespread Pollution". The former occurs in small areas with clearly identifiable causes, typically found in cities and around industrial sites, while the latter covers extensive areas with multiple and often difficult-to-identify sources. Additionally, phenomena such as erosion, loss of organic carbon, increased salt content, compacting, acidification and chemical pollution are all identified as major drivers of current soil degradation (Iberdrola, 2021).

Human activities constitute the primary source of soil pollution and operate through various environmental pathways. It is predominantly linked to industrial, agricultural, and urban activities (Khan et al., 2024). Activities such as mining, military operations, waste disposal, farming, urban development, and industrial processes like energy production significantly contribute to soil pollution (Iberdrola, 2021). These activities release toxic chemicals, including heavy metals, hydrocarbons, and hazardous by-products directly into the soil (Havugimana et al., 2017; Priya et al., 2023). These activities lead to widespread heavy metal contamination through multiple environmental routes, as illustrated in Figure 2.

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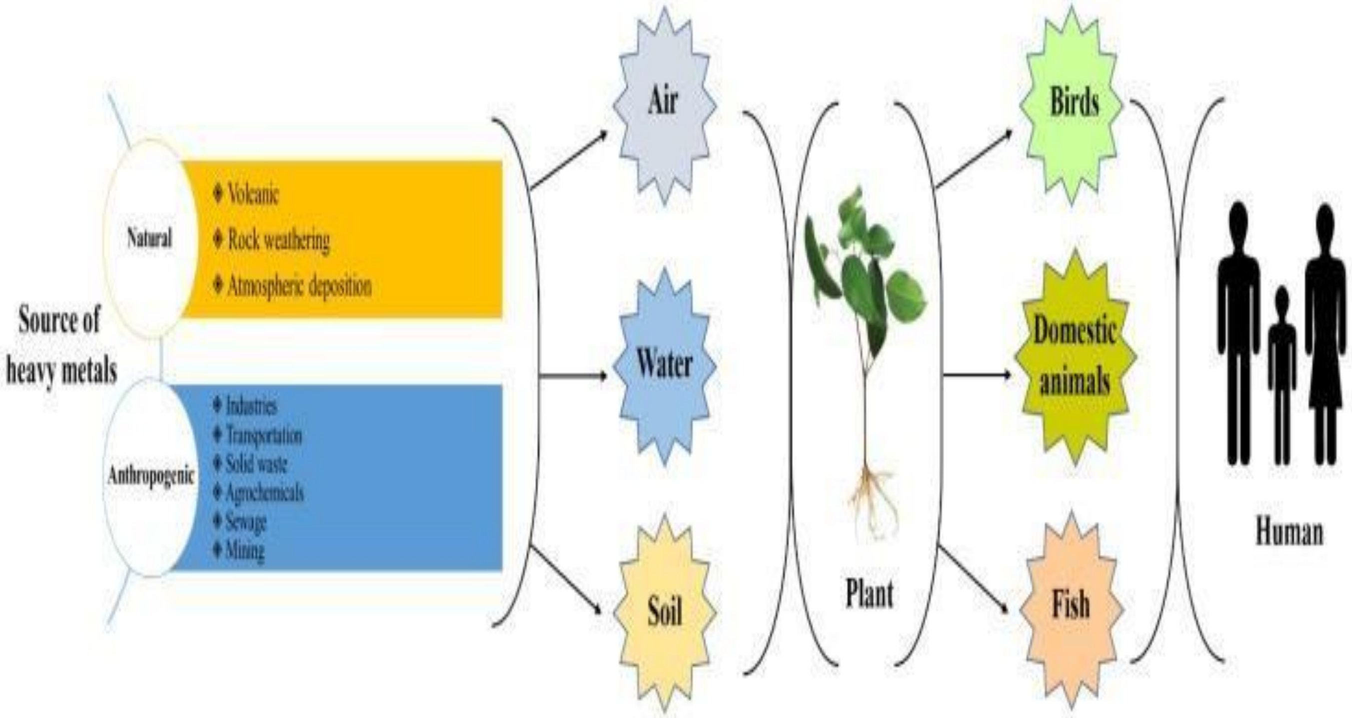
Figure 2. Various sources of heavy metals and their environmental pathways.



Source: Priya et al. (2023).

This figure (Figure 2) illustrates how heavy metals enter the environment from sources such as industry, agriculture, and municipal waste. These pollutants are transmitted through soil, water, and air, ultimately affecting plants, animals, and humans through direct exposure and contaminated food and water.

These substances, often non-biodegradable, persist in the environment, altering the soil's natural composition and reducing its productivity. Mining activities, in particular, have polluted soil for centuries, with many abandoned sites still releasing toxins (Cachada et al., 2018). Although mining areas are relatively small in size, they leave behind waste materials such as tailings and rock debris that contain harmful substances like arsenic and mercury. These toxins seep into the soil and water sources, gradually intensifying their harmful environmental effects (Havugimana et al., 2017; Cachada et al., 2018).

In agriculture, the excessive and unsustainable use of chemical fertilisers, pesticides, and herbicides has been a major contributor to soil pollution (Havugimana et al., 2017). Although these agrochemicals may improve crop yields in the short term, their accumulation in the soil disrupts its nutrient composition and long-term fertility. Similarly, excessive irrigation in poorly drained areas leads to salinisation, rendering the soil less suitable for agriculture.

Moreover, urbanisation and construction activities play a critical role in soil pollution (Khan et al., 2024). Rapid urban development often involves the disposal of construction debris, cement residues, and other pollutants directly into the soil. Construction sites, particularly in urban areas, are major sources of soil pollution due to their widespread presence and the potential for chemicals to travel through the air as fine particulate matter (Environmental Pollution Centres, 2024).

In addition, poorly planned waste disposal systems in urban areas result in the accumulation of hazardous waste, which gradually leaches into the ground (Havugimana et al., 2017; Khan et al., 2024).

Finally, oil spills from tanks and pipelines during transportation and storage contribute to soil pollution by releasing hydrocarbons into the soil, resulting in long-term contamination that is difficult and costly to remediate (Havugimana et al., 2017).

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Table 1. Major Sources of Heavy Metal Contamination in Global Soils.

Source	*AS*	*Cd*	*Cr*	*Cu*	*Hg*	*Ni*	*Pb*	*Zn*
Agriculture and food waste	0~0.6	0~0.3	4.5~90	3~38	0~1.5	6~45	1.5~27	12~150
Farmyard manure	1.2~4.4	0.2~1.2	10~60	14~80	0~0.2	3~36	3.2~20	50~320
Logging and timber	0~3.3	0~2.2	2.2~18	3.3~52	0~2.2	2.2~23	6.6~8.2	13~65
Industry waste munici-pal wastes	0.09~0.7	0.88~7.5	6.6~33	13~40	0~0.26	2.2~10	18~62	22~97
Municipal sludge	0.01~ 0.24	0.02~ 0.34	1.4~ 11	4.9~ 21	0.01~ 0.8	5.0~ 22	2.8~ 9.7	18~ 57
Organic wastes	0~0.25	0~0.01	0.1~ 0.48	0.04~ 0.61	_	0.17~ 3.2	0.17~ 3.2	0.13~ 2.1
Metal processing	0.01~ 0.21	0~0.08	0.65~ 2.4	0.95~ 7.6	0~0.08	0.84~ 2.5	4.1~11	2.7~19
Solid wastes coal ash	6.7~37	1.5~13	149~ 446	93~ 335	0.37~ 4.8	56~279	45~242	112~484
Fertilizer	0~0.02	0.03~ 0.25	0.03~ 0.38	0.05~ 0.58	_	0.20~ 3.5	0.42~ 2.3	0.25~1.1
Marl	0.04~0.5	0~0.11	0.04~ 0.19	0.15~ 2.0	0~0.02	0.22~ 3.5	0.45~ 2.6	0.15~3.5
Commodity impurities	36~41	0.78~1.6	305~ 610	395~ 790	0.55~ 0.82	6.5~32	195~ 390	310~620
Atmospheric deposition	8.4~18	2.2~8.4	5.1~38	14~36	0.63~ 4.3	11~37	202~ 263	49~135
Total	52~112	5.6~38	484~ 1309	41~ 1367	1.6~15	106~544	479~ 1113	689~ 2054

Source: (Nriagu et al., 1988, cited in Havugimana et al., 2017).

Table 1 demonstrates how various human activities contribute to soil heavy metal pollution. Industrial and municipal waste show high levels of lead (Pb: 18-62 mg/kg) and zinc (Zn: 22-97) contamination. Agricultural sources such as manure and fertilisers introduce substantial amounts of copper (Cu: 14-80 mg/kg) and zinc (Zn: 50-320 mg/kg). Atmospheric deposition is also a major pathway for lead, with concentrations ranging from 202 to 263 mg/kg. The total contamination loads reveal particularly severe cumulative impacts for chromium (Cr: 484-1309) and zinc (Zn: 689-2054), clearly illustrating how industrialisation, agricultural practices, and waste mismanagement collectively degrade soil quality through metal accumulation.

However, in addition to human activities, natural factors also influence soil chemistry. For example, a high concentration of seabirds in nesting areas can cause significant changes in soil properties, including eutrophication, salinization, acidification, and nutrient imbalances (Martín et al., 2021), Natural events such as earthquakes, landslides, hurricanes, and floods can also contribute to soil pollution by disrupting the physical and chemical composition of the soil (Havugimana et al., 2017).

Impact on the Environment

The impact of soil pollution on the environment is far-reaching and severe, beginning with the loss of soil fertility. Toxic substances deposited on the surface of the Earth harm our health and well-being and affect food, water, and air quality (Havugimana et al., 2017; Iberdrola, 2021). Contaminants such as heavy metals and agrochemicals disrupt the soil’s natural processes, killing beneficial microorganisms and altering its physical and chemical properties (Havugimana et al., 2017). This degradation reduces soil biodiversity and impairs ecosystem functioning, ultimately lowering agricultural productivity. This not only threatens food security but also weakens the soil’s ability to regenerate naturally. According to Gans et al. (2005), as cited by the European Environment Agency (2023), metal pollution can significantly reduce the diversity of bacterial communities by up to 90%, indicating serious implications for soil health and ecosystem services.

Biodiversity within the soil is particularly vulnerable. Organisms such as earthworms and bacteria, which play a vital role in nutrient cycling and maintaining soil structure, decline significantly when exposed to chemical contaminants. This reduction weakens the capacity of the soil to support both plant and animal life (Cachada et al., 2018).

Another critical environmental consequence of soil pollution is the contamination of water sources. Soil pollution leads to water quality deterioration, particularly in developing countries (Iberdrola, 2021). Pollutants

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from the soil often leach into nearby water bodies or seep into groundwater systems. This creates cascading effects, allowing toxic substances such as nitrates, arsenic, and industrial chemicals to contaminate drinking water supplies and disrupt aquatic ecosystems. It is estimated that about half of all applied nitrogen from agricultural drains into surface and groundwater, significantly increasing nitrate concentrations in water resources (Münzel et al., 2023). The presence and movements of these pollutants through the soil affect both surface and groundwater resources, leading to biodiversity loss and ecosystem imbalances.

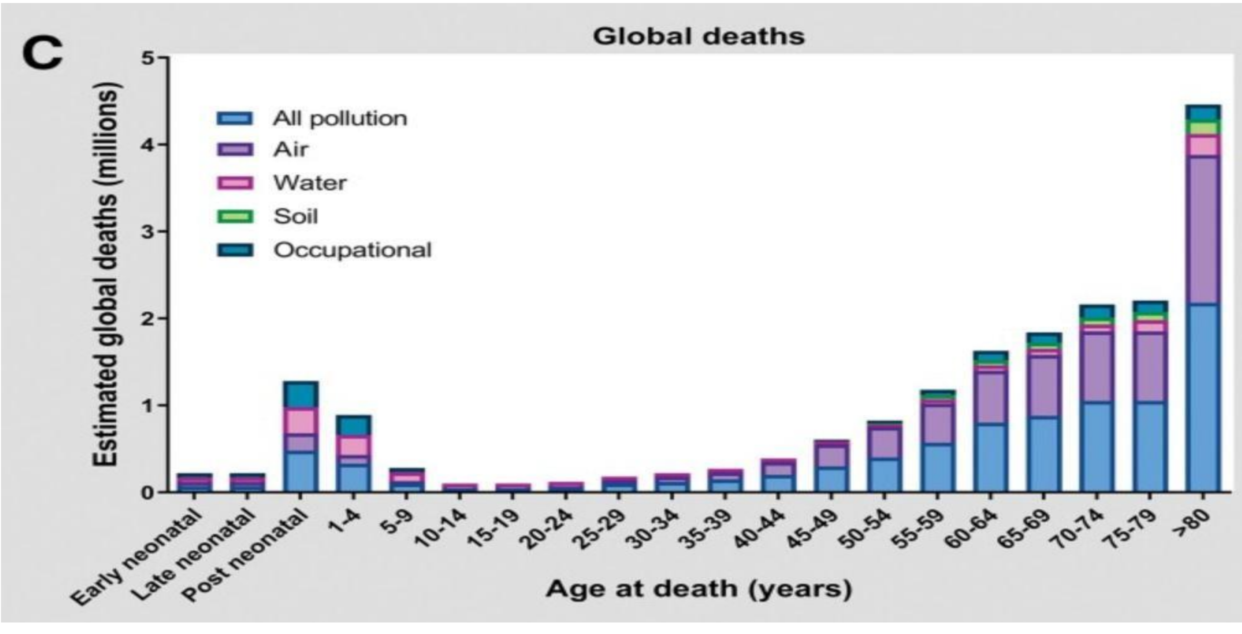
Moreover, polluted soils impact the environment by often releasing greenhouse gases such as carbon dioxide and methane, which contribute to climate change and exacerbate global environmental challenges (Cachada et al., 2018). For example, between 2015 and 2050, land use change and soil degradation are projected to release 69 gigatonnes of CO_2, accounting for about 17% of annual global greenhouse gas emissions (Iberdrola, 2021).

Impact on Population

The impact of soil pollution on the population is both direct and indirect, with health risks being the most immediate concern. Although substantial, the health implications of soil pollution are often underestimated. Polluted soils often expose individuals to hazardous substances, such as heavy metals and carcinogens, through direct contact (consumption of contaminated food and water) and ingestion, inhalation, or dermal absorption of soil particles, especially soil-generated dust (Cachada et al., 2018). When these exposures are prolonged, they can lead to chronic illnesses such as respiratory disorders, kidney damage, and cancer (Havugimana et al., 2017).

According to the European Environment Agency (2022), human exposure to soil pollution is estimated to contribute to over 500,000 premature deaths globally each year. As shown in Figure 3, pollution, including soil, contributed to millions of deaths in 2015, highlighting the urgent need to address environmental health risks across all demographics. The figure illustrates the cumulative impact of pollution from soil, air, water, and occupational sources on global mortality across different age groups. The elderly (80+ years) and children under five years are disproportionately affected. This pattern indicates that pollution-related deaths, including those linked to soil, predominantly occur in vulnerable populations, particularly children and the elderly, underscoring their heightened vulnerability to long-term environmental exposure.

Figure 3. Estimated global deaths by pollution category and age group in 2015.



Source: Münzel et al. (2023).

Additionally, the health impact caused by soil pollution disproportionately affects poorer households, who often have higher chances of living close to industrial sites and being exposed to contaminated soils (Morrens

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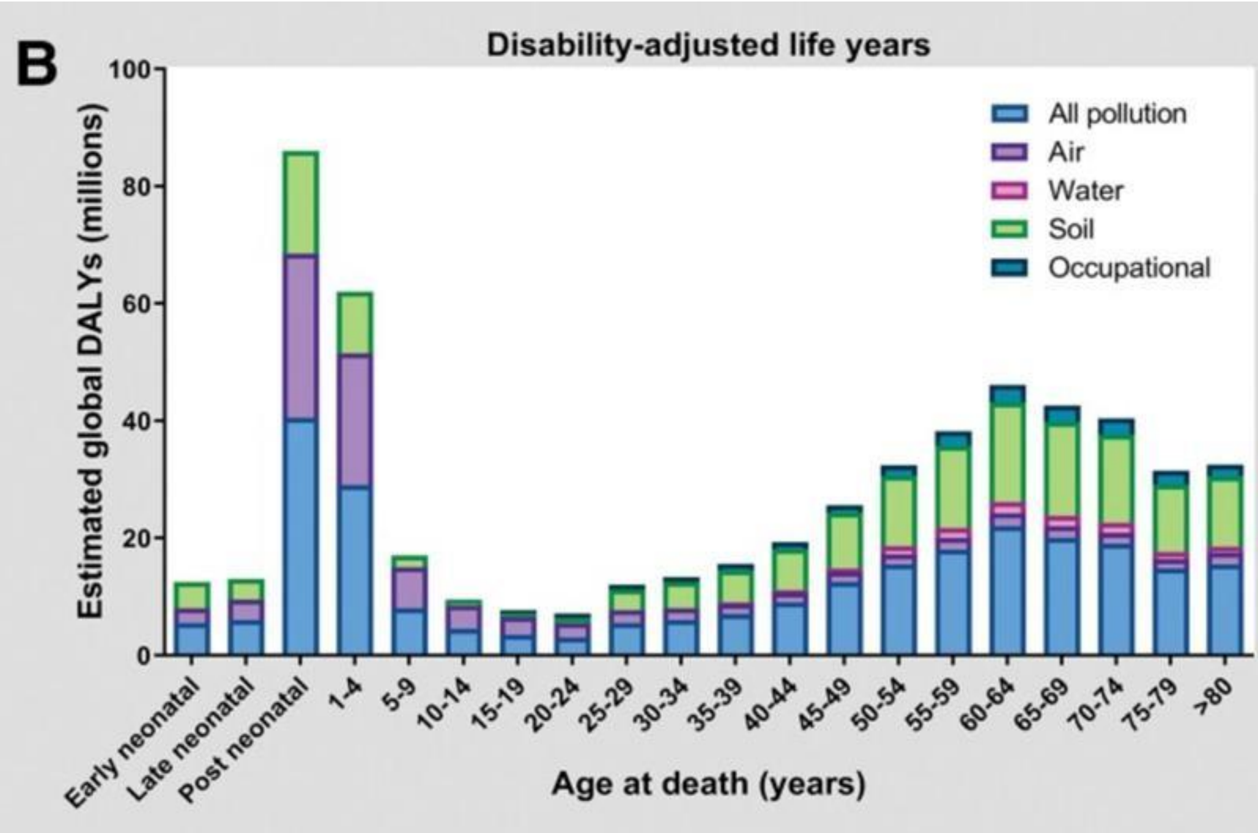
et al. 2013; Levasseur et al., 2021, as cited in European Environment Agency, 2022). The FAO Knowledge Repository (2011) indicates that low and middle-income countries experience the highest rates of environmentally attributable mortality and burden of diseases. The world's most impoverished populations, often from ethnic and religious minority groups in both developing and developed countries, bear a disproportionate burden of the impact of soil pollution (FAO Knowledge Repository, 2011).

Beyond mortality, pollution also contributes significantly to years lived with illness and disability. As shown in Figure 4, children aged 1-4 years and adults over 60 years bear the highest burden of pollution-related disability-adjusted life years (DALYs), with soil pollution playing a major role in these vulnerable groups.

Figure 4. Estimated global DALYs lost due to pollution by age group in 2015



Source: Münzel et al. (2023).

Another major concern regarding the impact of soil pollution on the population is its effect on food security, making the relationship between the two particularly alarming. Soil pollution threatens food security in two primary ways: first, by reducing crop yields due to the long-term degradation of soils by toxic pollutants; and second, by rendering food unsafe for human consumption (European Environment Agency, 2022). Crops grown in polluted soils absorb harmful chemicals, which diminish their nutritional value and introduce toxins into the food chain.

This not only endangers consumers' health but also undermines the economic viability of farming, as farmers struggle to market and sell contaminated produce. This results in a loss of agricultural productivity, leading to increased food prices, which disproportionately affect low-income households and elevate the risk of malnutrition. The economic consequences are substantial, with soil pollution estimated to reduce agricultural productivity by 15% to 25% globally (FAO Knowledge Repository, 2011). In China alone, annual agricultural economic losses due to soil pollution are estimated at USD 20 billion, primarily from reduced productivity and food contamination (FAO Knowledge Repository, 2011).

Beyond direct agricultural losses, the broader economic implications are also considerable. The cost of identifying and assessing potentially polluted soils is high, and remediation costs vary significantly depending on the characteristics and conditions of the site (FAO Knowledge Repository, 2011). Some countries spend tens or even hundreds of millions of dollars each year on soil remediation, while experts estimate that the cost of remediating all polluted soils in some countries could cost hundreds of billions of dollars (FAO Knowledge Repository, 2011).

In addition, soil pollution contributes to social instability and socio-economic challenges, especially in rural areas. Farmers whose livelihoods depend on fertile land face declining incomes as soil pollution reduces crop yields. In many cases, the loss of arable land and the decline in agricultural productivity force rural populations to migrate to urban centres in search of alternative livelihoods. This rural-urban migration increases pressure on already strained urban infrastructure and services, including housing, healthcare, and education, contributing to challenges such as overcrowding, unemployment, and social unrest.

DISCUSSION

The findings indicate that soil pollution is predominantly caused by human activities, with industrialisation and agriculture identified as the leading contributors (Khan et al., 2024). Industrial processes release persistent pollutants into the environment, often due to inadequate waste management systems and weak enforcement of environmental regulations. Similarly, agriculture’s dependence on chemical fertilisers and pesticides reflects a short-term approach to boosting productivity, but it fails to consider the long-term consequences for soil health, biodiversity, and ecosystems.

Urbanisation further compounds these issues by introducing large volumes of waste and pollutants into the soil without proper disposal mechanisms, resulting in a cumulative environmental burden over time (Havugimana et al., 2017). This implies that addressing these root causes requires not only stricter regulations but also the adoption of cleaner technologies and sustainable practices.

Moreover, soil pollution has far-reaching impacts on the environment, affecting everything from plant and animal life to the quality of air and water we rely on. The degradation of soil fertility undermines agricultural systems, threatens food security and disrupts ecosystems (Havugimana et al., 2017; Cachada et al., 2018). The leaching of pollutants into water bodies further creates a ripple effect that affects aquatic ecosystems and contaminates drinking water sources (Iberdrola, 2021). These environmental effects reduce biodiversity and weaken the capacity of ecosystems to recover (Cachada et al., 2018).

Additionally, polluted soils contribute to climate change by releasing greenhouse gases such as carbon dioxide and methane (Cachada et al., 2018). This underscores the close relationship between soil health and global climate stability. Therefore, there is a critical need for the implementation of comprehensive and effective environmental policies and restoration programs that address the ecological consequences of soil pollution.

From a population perspective, soil pollution poses significant risks to human health and well-being (Cachada et al., 2018). The presence of harmful chemicals in the soil leads to chronic health conditions, as highlighted by the European Environment Agency (2022), placing a considerable burden on the public health system (FAO Knowledge Repository, 2011). The disproportionate mortality observed among young children and the elderly, as shown in Figure 3, demonstrates that pollution is not only an environmental issue but also a major public health concern that requires cross-sectoral interventions.

Furthermore, polluted soils compromise food safety and security by allowing toxic substances to enter the food chain and reduce agricultural productivity (FAO Knowledge Repository, 2011; Iberdrola, 2021; European Environment Agency, 2022). These challenges disproportionately affect the vulnerable population (European Environment Agency, 2022), particularly in rural areas where livelihoods depend on farming. The resulting economic losses and social instability highlight the urgent need for targeted interventions, including improved agricultural practices, better waste management, and the provision of alternative livelihood opportunities.

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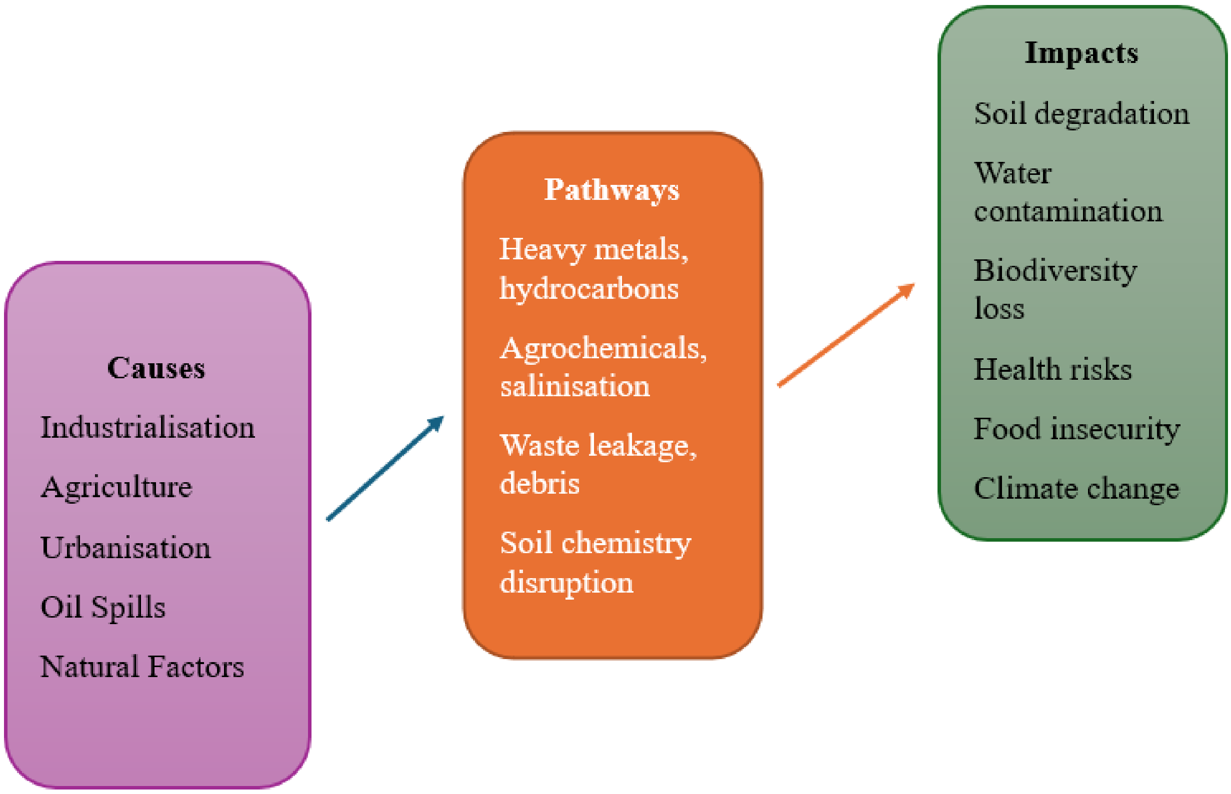
Figure 5. Conceptual map of causes, pathways, and impacts of soil pollution



Source: Authors construct (2025).

Table 2. Overview of findings.

	Key Findings/Themes		
	Causes	**Environmental Impact**	**Impact on Population**
Description	Industrial activities, mining, agriculture, improper waste disposal, and urbanisation primarily cause soil pollution. Factories release heavy metals and toxic chemicals, while the excessive use of fertilisers and pesticides contaminates the soil. Poor waste management and oil spills further contribute	Polluted soil loses its fertility, reducing agricultural productivity and threatening food security. Pollutants leach into surface and groundwater, causing water contamination. The loss of soil biodiversity disrupts ecosystems, while soil degradation contributes to climate change through the release of	Exposure to polluted soil leads to serious health risks, including respiratory diseases, skin disorders, and heavy metal poisoning. Contaminated crops pose food safety risks, while declining soil quality affects farmers' livelihoods. In severe cases, soil pollution forces rural populations to migrate, contributing

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	to the long-term degradation of soil quality.	greenhouse gases.	to economic and social instability.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Soil pollution is a critical environmental issue with wide-ranging impacts on both ecosystems and human populations. Its primary causes include industrialisation, agricultural practices, and urbanisation. The consequences extend beyond ecosystem disruption and food insecurity to include serious public health risks. In addition, the significant economic costs associated with soil pollution are both direct and indirect, highlighting the urgent need for global attention and addressing the issue on a global scale. Moving forward, there is a critical need for integrated approaches that combine pollution prevention, soil remediation, and policy interventions to protect soil health and promote an environment that is just for all populations.

Recommendations

Degraded ecosystems, food insecurity, and public health hazards are just a few of the serious environmental, health, and economic effects of soil pollution. These effects highlight how urgently focused and useful interventions are needed. The following suggestions give communities, governments, and stakeholders ways to reduce soil pollution and advance sustainable development.

Regulating Industrial Waste and Agro-Chemicals: One of the well-tested and time-honoured methods of preventing soil pollution, which requires strengthening today, is the enforcement of regulations on industrial wastes and agro-chemicals. Industrial activities like mining, energy production, and manufacturing liberate into the environment persistent pollutants, which include heavy metals and by-products of intense toxicity. The indiscriminate and unregulated application of chemical fertilisers and pesticides in agriculture admittedly transiently improves productivity, but it deteriorates the quality of the soil and affects ecosystem health in the long run. Therefore, while governments, through regulatory frameworks, can further reduce the contamination level by setting stringent levels to the discharge of polluting agents, such regulation needs to be complemented by measures that allow the industry to adopt cleaner and eco-friendly options, green technologies, waste recycling, and circular economy practices, so that the industrial growth is not only sustainable by themselves but are also encouraged to innovate.

Promotion of Sustainable Farming Methods: Heavy use of agrochemicals in agriculture is one of the biggest sources of polluted soil. Hence, switching to sustainable methods of farming becomes extremely important. Organic agriculture, rotation of crops, agroforestry, and Integrated Pest Management (IPM) practices reduce the use of synthetic fertilisers and pesticides and help maintain soil fertility. These techniques cultivate soil biodiversity and reduce chemical residue in the soil, thereby maintaining ecological balance. These techniques also provide avenues for farmers to adapt to climate change by bridging soil resilience and reducing greenhouse gas emissions. From a policymaker's perspective, supporting farmers through training, subsidies, and easy access to organic inputs is an essential mechanism to ensure all farmers adopt these techniques. Once scaled, these sustainable agricultural practices can provide food security into perpetuity and simultaneously reduce the threats of soil degradation.

Applying Soil Remediation Techniques: Many soils in the world are contaminated and call for active treatment, even after having been subjected to numerous preventive measures. Bioremediation and phytoremediation are simple and economical methods of restoring soils. Bioremediation uses microorganisms to degrade or otherwise neutralise toxic pollutants, while phytoremediation involves using plants to absorb, fix, or detoxify pollutants such as heavy metals. Such methods are suited for large-scale contaminated sites where conventional types of cleaning would be too expensive or disruptive. Alongside restoring soil fertility, remediation aids ecosystem services in compensating for the loss of degraded land, making it suitable once again for agriculture, habitation, or biodiversity conservation. Research and capacity-building aimed at scaling up remediation techniques would offer a strong platform from which to assist governments and local authorities in this pressing issue of legacy pollution, thus lessening health hazards and enabling ecosystem recovery.

Raising Public Awareness and Community Engagement: Creating public awareness and ensuring the education of the public are central to the successful implementation of policies against soil pollution. These communities may be the ones most exposed to contaminated soils, like those positioned near industrial sites or agricultural lands, yet they lack knowledge of the risk. Outreach programs, school campaigns, and community workshops serve the purpose of equipping citizens, by way of information, with the means to adopt safer waste disposal habits, lesser reliance on harmful chemicals, and strengthening environmental protection through their voices. Particularly important is the engagement of local and indigenous people, especially since they usually carry traditional ecological knowledge that could be integrated with contemporary conservation approaches. The assumption of power by local communities also engenders a record of shared responsibility through which the conservation of soil is not simply governmental, but rather, equally a social goal.

Encouraging International Collaboration: Soil pollution does not stop at a border; heavy metals, plastics, chemical residues- one of many wonders- can travel from one side to the other side of a continent through their air, water, and trade. This transboundary feature emphasises the necessity of international cooperation. Multilateral treaties could serve as the basis, along with cross-border monitoring systems and technology-sharing platforms, for coordinating efforts to address soil contamination. Support from the developed countries, in the form of technical help, financial assistance, and best available technologies, must flow to low and middle-income countries for the sake of global soil health. These kinds of exchanges, under the umbrella of the United Nations Sustainable Development Goals (SDGs) and FAO's soil protection initiatives, enhance the global capacity to tackle the problem comprehensively. Since international collaboration treats soil as a shared domain, on which food security, climate stability, and biodiversity solutions are going to be fair, innovative, and far-reaching.

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Funding: This research received no external funding

Data Availability Statement: This study is a qualitative literature review and did not generate new datasets. All data and findings discussed are derived from previously published sources, which are cited in the manuscript. Full references, including DOIs or URLs where available, are provided in the Reference section.

Conflicts of Interest: The authors declare no conflict of interest.

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