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REVIEW

A review of the effects of environmental hazards on humans, their remediation for sustainable development, and risk assessment

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Abstract In the race for economic development and prosperity, our earth is becoming more polluted with each passing day. Technological advances in agriculture and rapid industrialization have drastically polluted the two pillars of natural resources, land and water. Toxic chemicals and microbial contaminants/agents created by natural and anthropogenic activities are rapidly becoming environmental hazards (EH) with increased potential to affect the natural environment and human health. This review has attempted to describe the various agents (chemical, biological, and physical) responsible for environmental contamination, remediation methods, and risk assessment techniques (RA). The main focus is on finding ways to mitigate the harmful effects of EHs through the simultaneous application of remediation methods and RA for sustainable development. It is recommended to apply the combination of different remediation methods using RA techniques to promote recycling and reuse of different resources for sustainable development. The report advocates for the development of site-specific, farmer-driven, sequential, and plant-based remediation strategies along with policy support for effective decontamination. This review also focuses on the fact that the lack of knowledge about environmental health is directly related to public health risks and, therefore, focuses on promoting awareness of effective ways to reduce anthropological burden and pollution and on providing valuable data that can be used in environmental monitoring assessments and lead to sustainable development.

Keywords Remediation · Anthropogenic · Pollutants · Risk analysis · Sustainable development

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Introduction

Expeditious industrialization has led to a situation where our natural resources (water, soil and air, fossil fuels) are becoming polluted as well as getting exhausted at an alarming rate. There is pressing need to find environment friendly solutions to the problems emanating from the processes generating environmental hazards (EH) for sustainable development roadmap (Tsatsaris et al., 2021; Shahi Khalaf Ansar et al., 2022). Various types of pollutants, organic and inorganic, have found ways to persist in the environment and be a part of the food chain. Heavy metals such as lead (Pb), mercury (Hg), and chromium (Cr); pesticides; organic pollutants; microplastics; and emerging contaminants are posing challenges to the human health. They are responsible for various types of cancer, allergies, and neurological and cardiovascular disorders resulting in a large number of deaths worldwide. So, in order to alleviate the harmful effects of EH, various biological-, plant-, and chemical-based remediation techniques have been developed. In microbial bioremediation, microbes such as bacteria and algae can be utilized for the development of remediation processes (Prüss-Üstün et al., 2006). Other bioremediation techniques such as phytoremediation involves the use of various plants that have the ability to sequester the pollutants from soil and water, thereby lowering their bioavailability (Kavusi et al., 2023). Toxic compounds can also be removed using another bioremediation technique called mycoremediation. There are also some in situ and onsite chemical remediation techniques that have been used for removing hazardous chemicals (Ratnapradipa et al., 2015).

In the race for economic development and prosperity, our earth is becoming more polluted with each passing day. Technological advances in agriculture and rapid industrialization have drastically polluted the two pillars of natural resources, soil and water. Toxic chemicals and microbial contaminants created by natural and anthropogenic activities are rapidly evolving into EH with increased potential to affect the natural environment and human health. This review has attempted to describe the various agents (chemical, biological, and physical) responsible for environmental contamination, remediation methods, and also risk assessment techniques (RA). The main focus is to find ways to mitigate the harmful effects of EHs through the simultaneous application of remediation methods and RA for sustainable development. It is recommended to apply the combination of different remediation methods using RA techniques to promote recycling and reuse of different materials and resources for sustainable development. The report advocates the development of site-specific, farmer-driven, sequential, and plant-based remediation strategies, as well as policy support for effective decontamination. Environmental hazards stress the natural environment. They pollute natural resources such as water, air, and soil. There are numerous classifications of environmental hazards, including (i) anthropogenic-anthropogenic, (ii) human–human exposure, and (iii) microbial-microbial activity. Anthropogenic activities include abrupt recycling of waste (including e-waste), polychlorinated biphenyls (PCBs), polychlorinated diphenyl ethers (PBDEs), and heavy metals. Waste disposal, nano-mineralogy, geochemistry of ultrafine particles in construction debris, poor management of landfills, use of pesticides, and contamination of soils are some of the evolving causes of pollution that affect the human–environment system. All of these activities have negative impacts on the environment and public health. Humans are exposed to various potential risks, including waterborne and airborne diseases, skin diseases, Lyme disease, and musculoskeletal disorders. The most important factor affecting the environment is microbial activity, and the role of the microbiome in wastewater is a source of pathogens that greatly affect public health. This review also focuses on the fact that the lack of knowledge about environmental health is directly proportional to public health risks. However, environmental risks can be identified through a variety of surveys, including health and socioeconomic surveys, site visits, group discussions, and surveys of relevant pathogens. In addition, quantitative microbial risk assessment and stakeholder mobilization will support epidemiological and entomological surveys using a variety of sources. Therefore, this review focuses on promoting awareness of efficient and effective ways to reduce anthropological exposure and pollution and on providing valuable data that can be used in environmental monitoring that will lead to assessments and sustainable development.

Environmental hazards and their remediation

At the present time, environmental degradation; climate change; and natural calamities such as soil erosion, famine, floods, and rising sea level are the most common problems that restrain the path towards sustainable development (Li, 2020; Haseeb & Azam, 2021). The anthropogenic activities and climate change are catalysts for environmental hazards and these activities affect human life badly; moreover, they negatively impact the social, economic, and environmental status of the area (Tsatsaris et al., 2021). Most South Asian countries are trying to monitor and regulate environmental hazard to improve sustainable development (Sabir et al., 2020). If we want to achieve sustainable development goals and produce food energy, then we must control environmental hazards.

Bioremediation

Phytoremediation is a type of bioremediation, a solar-powered, completely natural technology that can be used "in situ" to remediate soil and water contaminated with heavy metals. Phytoremediation also has environmental and socioeconomic advantages over other physical and chemical remediation methods (Xu et al., 2023). Phytoremediation is a cost-effective and environment friendly method of wastewater treatment using hyperaccumulating plants (Rezania et al., 2021; Yadav et al., 2018). They translocate pollutants from soils and water bodies to their roots, stems, and leaf parts (Hu et al., 2020a, 2020b; Prasad et al., 2021). Recently, phytoremediation technology has received a significant boost as more and more studies are conducted on the effectiveness of plants in removing pollutants. Based on the localization of aquatic plants, they have been classified as free-floating, emergent, and submerged (Ali et al., 2020; Yadav et al., 2017a, 2017b). Although many excellent review articles have been published on this topic to date, these articles provide somewhat scattered information as some discuss different phytoremediation techniques, i.e., phytoextraction, phytostabilization, phytoevaporation, and rhizodegradation (Maghsoodi et al., 2019; Dolatabadi et al., 2021; Kavusi et al., 2023), while others describe influencing factors (Rahmati et al., 2022; Karimi et al., 2022). Many studies have also focused on uptake and tolerance mechanisms (Asgari Lajayer et al., 2017; Beigmohammadi et al., 2023; Devi et al., 2023). Scientists have shown great interest in improving a cost-effective and environmentally friendly technique known as phytoremediation (in situ remediation of contaminated soils, waters, sediments, and ecosystems by plants) (Aliyari Rad et al., 2023). Phytoremediation of contaminated sites appears to be technically effective for site-specific remediation, and the applicability of this potential technology may enhance its impact from a social perspective. Development of stepwise remediation protocols for contaminated sites containing multiple contaminants and maximally beneficial metal recovery processes from bio-ore developed new transgenic plants with enhanced capacity for metal uptake, transport, accumulation, and detoxification.

Microbial remediation, also a type of bioremediation, refers to the use of indigenous/exotic microbes for remediation purposes (Karimi et al., 2022). Microbial remediation is considered a natural, safe, and effective environmentally friendly technology with low energy consumption and low operating costs (Delangiz et al., 2022). Most importantly, microbial remediation does not pose environmental and health hazards. According to a research study, bacterial species such as *Alcaligenes* sp., *Bacillus firmus*, *Bacillus licheniformis*, *Enterobacter cloacae*, *Escherichia coli*, *Micrococcus luteus*, *Pseudomonas fluorescens*, and *Salmonella typhi* showed adsorption potential of Pb from the contaminated resources (Puyen et al., 2012; Basha and Rajaganesh, 2014; Kang and So, 2016; Jin et al., 2018; Jacob et al., 2018). The fungal biomass of *Lepiota hystrix*, *Aspergillus niger*, *Aspergillus terreus*, and *Trichoderma longibrachiatum* has been reported as a potential biosorbent (Dursun et al., 2003; Jacob et al., 2018; Kariuki et al., 2017). The algal species *Palmaria palmata*, *Spirulina maxima*, *Spirogyra hyaline*, *Cystoseira barbata*, *Cladophora* sp., *Chara aculeolata*, *Nitella opaca*, and *Ulva lactuca* are identified as efficient biosorbents (Ibrahim et al., 2018; Jacob et al., 2018; Sooksawat et al., 2013). The process depends on environmental conditions and the use of nutrients, oxygen, and other additives to stimulate microbial activity for Pb remediation (Gong et al., 2012). This approach is based on the microbes associated with the rhizosphere such as *Bacillus*, *Beijerinckia*, *Burkholderia*, *Enterobacter*, *Erwinia*, *Flavobacterium*, *Gluconacetobacter*, *Klebsiella*, *Pseudomonas*, and *Serratia* (Babu et al., 2013; Sheng et al., 2008; Tak et al., 2013). Babu and co-workers (Babu et al., 2013) inoculated soil with rhizosphere bacteria of *Pinus sylvestris* and found significant increase in biomass, chlorophyll content, number of nodules, and Pb accumulation in *Alnus firma* seedlings. Thus, the above techniques are very useful tools for the remediation of EH from the polluted sites and have gained worldwide acceptance. However, there are still many limitations that need to be addressed and leave room for future work.

Limitations of remediation techniques and sustainable development

To get the maximum utilization of phytoremediation potential (agro-mining), a comprehensive understanding about the fate of metal ions, especially metal uptake and its transportation, trafficking across plant cell membranes along with storage, distribution, sensitivity, tolerance, and its role in rhizosphere interactions under various environmental conditions, is needed. Plant breeders, biotechnologists, physiologists, agronomists, soil scientists, biochemists, and environmentalists need to collaborate to generate solid approaches to develop transgenic plants and enhance the potential of existing crop species to perform better remediation activities of metal toxins. Factors such as higher biomass production, increased utilization of inputs, optimum/enhanced crop growth rates, increased rate of photosynthesis, enhanced metal toxicity tolerance, improved bioavailability of heavy metals with increased sink capacity, and adaptation to a variety of different climatic conditions are all more pronounced in ever-changing environments and scenarios. These factors can make phytoremediation difficult. Recent scientific developments in nanoscience research open the way to cost-effective, eco-friendly, and sustainable remediation approaches. A nanotechnological approach has been successfully used in soil, sediments, solid waste, and a wastewater remediation (Adeleye et al., 2016; Kumar et al., 2019) process. Nano-materials are dynamic, efficient, and broadly applicable with economic expediency (Kumar et al., 2019; Wernisch et al., 2013). Nanoparticles (1–100 nm) provide very high adaptability for both in situ and ex situ remediation approaches (Kumar et al., 2019). Nano-adsorbents, i.e., activated carbon, alginate biopolymer, clay materials, silica, magnetic iron oxide nanoparticles (MNPs), metal oxides, and nano-titanates, have been utilized to remove heavy metals (Kumar et al., 2019; Yadav et al., 2017a, 2017b; Yong-Mei et al., 2010). The researchers showed that nano-materials can enhance the accumulation of metals by improving the cell wall permeability, co-transportation of nano-materials with heavy metals, and transporter gene regulation (Kumar et al., 2019; Srivastav et al., 2018). A targeted approach is needed to realize the potential of remediation technologies because green technologies are an ideal way to save energy and reduce carbon emissions, and they play a critical role in economic and sustainable development. However, political issues affect sustainability by limiting innovation and adoption of green technologies (Desheng et al., 2021). On the other hand, the adoption of green technologies can help to minimize EH levels by using alternative fuels rather than the conventional fossil fuels (Chaves et al., 2021). Europe has proposed a strategic framework for the sustainable development of marine renewable energy (Akbari et al., 2021). The framework predicts crises in emerging sustainability and attempts to find solutions (Stupak et al., 2021). Horizon scanning exercises have been used to explore issues and confirm the need for sustainable development in Asia, as part of the Global Horizon Scanning project (Leung et al., 2020).

Risk assessment

Risk assessment means the determination of the probability that an adverse effect will result from a defined exposure and includes hazard identification, exposure assessment, dose–response assessment, and risk characterization. During the 1970s, risk assessment started to be applied progressively to understand the impacts of stressors on the environment. The initial cause for this is related to the effect of insecticides on eco-friendly species. The term risk evaluation is currently applied in an ever-increasing range of domains such as finance, health care provision, transport, and industrial safety. Despite the wide use of the term risk assessment by researchers, there are significant alterations in the way that risk assessment is carried out depending on the nature of the biochemical, organic, or physical agents involved (stressor) and the nationwide expert necessitating the assessment (Susanto & Meiryani, 2019). Risk assessment includes several procedures including those shown in Fig. 1.

Risk is the possibility of a negative outcome of an action, such as loss of livelihood, property, employment, environment, and its impact on society. The nature and extent of risk must be determined, and the tool for doing so is called "risk assessment". It is an important tool for developing effective disaster risk management strategies and involves identifying, estimating, and ranking the risk (Fig. 2). The approach to risk assessment is determined by a government-elected representative or principal. Risk assessment

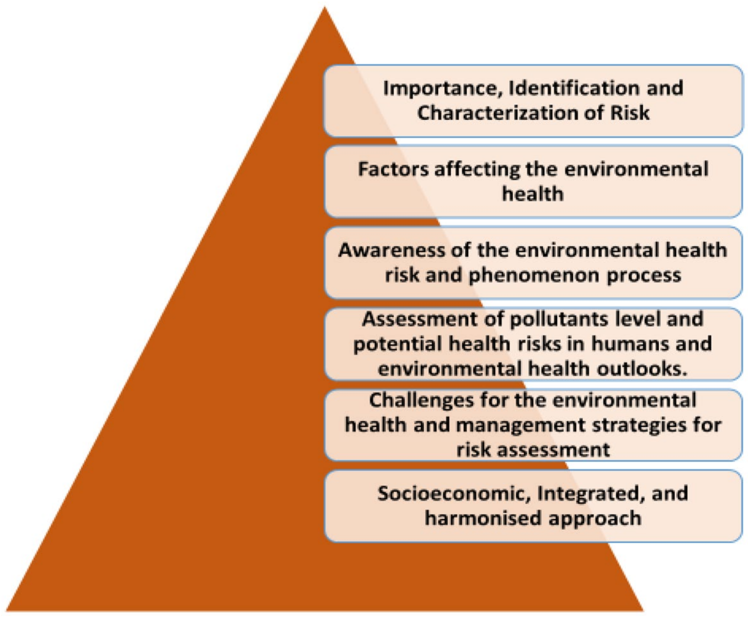

Fig. 1 The pyramid framework for environment risk assessment research

Fig. 2 A paradigm of quantitative microbial risk assessment

is a layered, scientific, and transparent process that can be repeated as needed (Rovins et al., 2015). To proceed with risk assessment, information must be clearly articulated about the understanding of the potential risks and their magnitude, the objectives of the risk assessment, the methods and techniques for risk assessment, the responsibility and authority for initiating the risk assessment, the resources required for risk assessment, reporting, and reviewing the risks.

Three important steps of risk assessment are as follows:

1. Risk identification—assess the existing risks and evaluate them through systematic inventory for data and information framework.

2. Identify the nature, location, intensity, and likelihood of the prevailing hazards.
3. Understand the livelihood and elements at risk.
4. Determine the extent of risk to withstand the hazard.
5. Risk analysis and risk evaluation—estimate the probable loss to the population, property, and business of the society and the cost-effective risk evaluation by setting priorities, resources, and disaster reduction programs.

Classification of risks

Operational risk

Operational risk is the risk resulting from the non-functioning of the internal part of the company and other reasons such as manual errors and system failures. It is the most common risk, and the causes are in accounting, operational activities for goods and services, information technology system, and human resource management system (Susanto & Meiryani, 2019).

Financial risk

This kind of risk is generally faced by investors, because of shares and bonds that cannot afford interest or loan principal amount (Susanto & Meiryani, 2019).

Strategic risk

This risk results from a series of events that can have an unexpected result or can reduce the ability of the manager to apply his/her ideas and strategies (Susanto & Meiryani, 2019).

Factors affecting environmental health

The environment can be referred to as the set of natural, physical, chemical, and biological elements that are external to the human body, as well as the factors that influence related behaviors. Environmental health is influenced by several factors, including air, water, and soil pollution; ultraviolet radiation; occupational hazards; land use patterns; roads and housing; agricultural and irrigation patterns; drug, alcohol, and tobacco use; food availability and nutrition; and the presence of natural water bodies such as rivers, lakes, and wetlands (Prüss-Üstün et al., 2006). As shown in Table 1, there are several vector-borne diseases that pose environmental health risks.

Air pollutants

The introduction of toxic substances and the presence of pollutants above normal levels can degrade air

Table 1 Vector-borne diseases that produce risk in the environmental health

Disease	Vector born	Type of risk	Location	References
Chikungunya fever	*Aedes albopictus* (vector born disease)	Acute, chronic, headache, myalgia, rash, and arthralgias	Greece	Tsiodras et al. (2016)
Blanched in frozen fruits and vegetables	An outbreak of *Listeria monocytogenes*, ready-to-eat meat/fisheries	Stomach ache	Europe	Koutsoumanis et al. (2020)
AIDS	HIV transmission	HIV epidemic and threat to death	Russia	Lunze et al. (2016)
Asthma, skin and musculoskeletal symptoms	Hairstylist occupational diseases	Increasing pollutants	Manchester, UK	Moda and King (2019)
Lyme disease	Bacterial infection caused by *Borrelia burgdorferi*	Serious neurologic and cardiac complications	USA	Sharareh et al. (2017)
Cerebrovascular disease	Hypertension	Brain damage	Bangalore, India	Bhat et al. (2020)
Contrast-associated acute kidney injury	Age-related disease	Increased relative risk for 90-day death, need for dialysis, or persistent kidney impairment	China	Wang et al. (2020)

quality. According to the World Health Organization (WHO, 1995), the six most important air pollutants are particulate matter (PM), ozone, carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx), and lead. In addition to human health, groundwater, soil, and air are also severely affected by air pollution. Particulate matters < 10 μm (PM10) can enter the lungs and reach the arteries. PM 2.5 μm in size (PM2.5) can cause acute nasopharyngitis, infant mortality, and cardiovascular disease (Azimi-Yancheshmeh et al., 2021). Ozone as a pollutant reduces the growth of plant microflora and alters the species composition of animal species. It also increases DNA damage in epidermal keratinocytes, leading to a weakening of cellular function.

Carbon monoxide affects greenhouse gases, which are highly linked to global warming and climate change. It also causes an increase in soil and water temperature and extreme climatic conditions. Similarly, NOx affects the respiratory system causing coughing, sneezing, and bronchospasm and decreases crop yield, whereas emission of SOx from fossil fuel consumption and industrial activities affects both human and plant health (Manisalidis et al., 2020). On the other hand, increased UV radiations due to ozone layer depletion have serious consequences on living organisms. Reportedly, there is a 15–20% increase in UV exposure due to a 10% reduction in ozone. Adverse effects of increased UV radiations have been reported on plant growth, immunity, and photosynthesis. Aquatic life is also highly affected due to UV radiations (WHO, 1995). Furthermore, drug and alcohol consumption also pose a risk to the environment as it involves constant exploitation of vegetation; but, they cannot be tarnished all at once because they provide revenue to the government.

Water pollutants

Nowadays, the protection and conservation of water is a major issue worldwide (Yang et al., 2023). Water use by urban and rural households, industrial and mining activities, and for agricultural purposes generates huge amounts of wastewater. It contains toxic elements such as nitrogen and heavy metals (Pb, NO_3, Cr, Cu) and poses a serious threat worldwide. These chemical pollutants make water unfit for human consumption and deteriorate various water parameters such as dissolved oxygen, hardness, alkalinity, pH, conductivity, salinity, and turbidity, ultimately affecting human health and the environment (Paschke et al., 2008). Therefore, water pollutants pose a serious threat to human and environmental health. Water pollutants can be divided into dissolved and non-dissolved pollutants. Dissolved pollutants can be further divided into macroscopic, organic, and inorganic pollutants, while non-dissolved pollutants can be divided into suspended, colloidal, and floating pollutants (see Fig. 3).

Assessment of pollutant level and potential health risks to humans and environmental health

There are various organic and inorganic pollutants from different sources such as air, water , soil and foodstuffs that have health risks in humans (Table 2). Some persistent organic matters including polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethanes (DDTs), organochlorine pesticides (OCPs), legacy brominated flame retardants (BFRs), perfluorinated compounds (PFCs), and hexachlorobenzene (HCB) are found in breast milk, potentially risking the health of infants, especially under the age of 6 months. It is seen that infants born in coastal areas suffer from DDTs, PCBs, and HCB. These persistent organic pollutants (POPs) and the presence of PCBs in breast milk adversely affect human health; therefore, to get rid of these pollutants, we need to extend the safer limit at a national level and implement regular surveillances of pollutants (Hu et al., 2020a, 2020b). Moreover, heavy metals were detected in raw cow milk and they affect human health according to the hazard quotients (Boudebbouz et al., 2020). With the help of a survey, POPs were found in soil, water, and *Amaranthus viridis* in the Democratic Republic of the Congo (Ngweme et al., 2020). The estimated daily intake (EDI) of pollutants by leafy vegetables possesses a threat to the potential health risks in a human; hence, it is very important that pesticides and fertilizers are used in a controlled manner, simultaneously focusing on framework and control measures (Ngweme et al., 2020).

Microplastics (MP) are an emerging problem. They are found in soil and aquatic ecosystems and

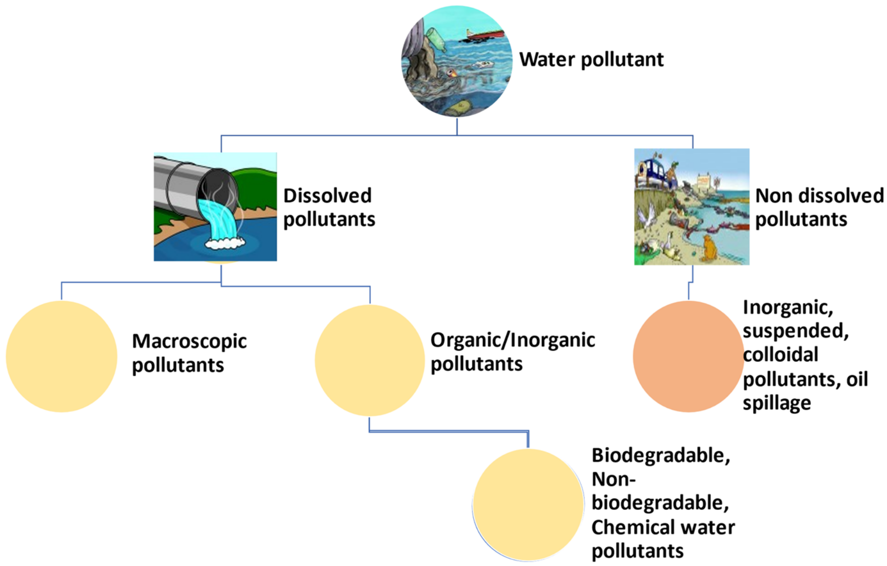

Fig. 3 Classification of water pollutants

therefore have a direct impact on the human food chain and human health (Delangiz et al., 2022; Tian et al., 2022; Zhou et al., 2020). Pharmaceutical compounds and endocrine-disrupting chemicals (EDCs) have been detected by SPE protocol and HPLC–ESI–MS/MS detection, and these compounds pose a risk to water and the environment (Li et al., 2021). Heavy metal pollution is a global problem, as shown in the report covering three decades (1989–2018). Most developing countries contribute to heavy metal pollution, and China alone is responsible for nearly half of the total increase in heavy metal pollution over the past decade. In areas where e-waste is recycled, the major health concern is dust and Pb pollution, but in developing countries, the problem of heavy metal pollution is overlooked (Shi & Wang, 2020). Exposure pathways such as carcinogenic and non-carcinogenic risks were present in local regions and some hotspots (Han et al., 2020). The health effects in an environmental perspective through the World Health Organization's quality of life-based questionnaire demonstrate that the lives of people living in forest areas are better than those living in urban areas (Prüss-Üstün et al., 2006). The concentration of air pollutants such as NO, NO_2, NOx, SO_2, CO, PM2.5, and PM10 is higher in an urban environment than in a forest environment (Tsao et al., 2014), and environmental epigenetics also has an impact on human health and the environment (Tiffon, 2018).

Water quality assessment

Rivers are the basic source of our drinking water and daily needs. In addition, rivers are polluted with pathogens due to sewage treatment plants and treated wastewater, which is the main source of fecal matter. Sewage treatment plants and wastewater are discharged directly into river watersheds and soils. This leads to the proliferation of various microbes in river water that directly affect the quality of drinking water. The various key factors such as (i) climate change and demographic changes, (ii) increasing population, and (iii) increase in sewage treatment plants need to be studied. One way to quantify and reduce human health impacts is through quantitative microbial risk assessment (QMRA) modeling, a probabilistic and deterministic approach that helps to determine the outcome. This involves a continuous assessment of impending changes and pollution regulator procedures. An integrative modeling agenda for a river discharged from a wastewater treatment plant has been established for a longer period of water safety planning that can also be used for all river basins and different categories of pollution sources (Demeter et al., 2021).

Groundwater contamination is a worldwide problem, and onsite groundwater testing can be helpful in conducting groundwater risk assessments. To avoid the groundwater contamination situation in Tunisia, local governments have

Table 2 Pollutant levels reported in the literature and their effect on human health

Pollutants	Source of pollutant	Human health risk	Location	References
Nanoparticles (Al, As, Au, Ca, Cd, Co, Cr, Cu, Hg, Na, Fe, K, S, Sn, Si)	Construction wastes	Exposure and hazardous risk	Southern Brazil	Oliveira et al. (2019)
PCBs, PBDEs, and heavy metals	E-waste recycling	Neurological and developmental disorders especially in children	India	Awasthi et al. (2016)
Bi, Cd, Co, Cr, Cu, Li, Ni, Pb, and Zn	Open municipal solid waste landfill	Non-carcinogenic and carcinogenic effects	Central Thailand	Thongyuan et al. (2020)
Cd and Pb	Contaminated garden soils	Inhalation problem	Northern France (Metaleurop Nord smelter)	Pelfrêne et al. (2019)
Plastic pollution	COVID-19 pandemic (coronavirus)	Fever, dry cough, tiredness, and death reported in children < 10 years and adults > 50	Portugal (worldwide plastic pollution)	Silva et al. (2020)
Pb, Hg, Cd, Fe, Ni, Al, and Cu	Raw cow milk	Non-carcinogenic risk	Algeria	Boudebbouz et al. (2020)
Cd, As, and Pb	Heavy metal toxicity, carcinogenicity, bioaccumulation, and complex mechanisms	Non-carcinogenic and carcinogenic effects	China	Han et al. (2020)
POPs including PCBs, OCPs, legacy BFRs, and PFCs	Breast milk	Infants' health risk	China	Hu et al., (2020a, 2020b)
POPs including OCPs, PCBs, and PBDEs	Soil and irrigation water, and *Amaranthus viridis* (*A. viridis*) from different gardening sites	Carcinogenicity	Kinshasa in the Democratic Republic of the Congo	Ngweme et al. (2020)
Pb, Cd, Cu, and Zn	Indoor dust	Children's blood lead poisoning	China	Shi and Wang (2020)
Microplastics	Soil	Exposure to human health	China	Zhou et al. (2020)

taken measures to ensure that municipal wastewater is treated before it is discharged into the sea (Alibi et al., 2021). Therefore, an assessment is required before using groundwater for drinking and irrigation purposes, which must be in accordance with the WHO regulations for drinking water (Abdelhafez et al., 2021).

The Ganga River covers about 21% of India's land area, but the water quality of the Ganga is rapidly deteriorating. Although the water quality of the Ganga is still acceptable during the summer and winter months, it deteriorates severely during the monsoon season; therefore, monitoring and assessing the water quality of the Ganga is a priority (Kumar et al., 2021; Muduli et al., 2021). However, high nitrate and fluoride concentrations in drinking water pose a risk to human health. However, the assessment of non-carcinogenic risk to human health can help to determine the permissible limit for nitrate and fluoride in drinking water. Continuous groundwater monitoring and water assessment reduce human health and public health risk. Public health programs and dissemination of information to all stakeholders can help control human health risk. Regular water assessments help to implement safety measures against waterborne diseases (George & Nagaraja, 2021; Hossain et al., 2021; Jandu et al., 2021; Sharma et al., 2021).

Challenges for the environmental health and risk awareness process

There are several challenges to environmental health. Currently, we are suffering from the pandemic COVID-19. During the pandemic, the use of plastic, PPE, medical masks, and gloves has greatly increased. Therefore, not only is the COVID-19 pandemic a challenge to environmental health, but the precautions taken also pose a significant threat to environmental health (Silva et al., 2020). Humans are exposed to harmful chemicals through food, consumer products, and environmental factors. Therefore, the main challenges are to reduce this chemical exposure and to identify the toxic compounds that enter the environment. One method for doing this is to apply in vitro testing using high-resolution mass spectrometry (HRMS) to study the exposure and health effects of chemical mixtures in biological samples. Various diseases such as heart disease, cancer, unintentional injury, stroke and cerebrovascular disease, chronic respiratory disease, diabetes, typhoid fever, diarrhea, Lyme disease, and jaundice greatly affect human health, and these diseases are rapidly increasing.

A system dynamics approach is typically used to assess risk factors and examine the impact of different entanglements, spreading awareness, and reducing risk. This model replicates historical trends in Lyme disease and is also useful for anticipating Lyme disease and for education programs to increase awareness. This model calculates the risk of exposure to Lyme disease (Sharareh et al., 2017). High concentration of Cd and Pb in vegetable gardens is very dangerous. A soil environment study conducted in northern France to check the condition of kitchen gardens was used to raise public awareness and provide functional guidance (Pelfrêne et al., 2019).

A system dynamics approach is typically used to assess risk factors and examine the impact of different entanglements, spread of awareness, and risk mitigation. This model replicates historical trends in Lyme disease and is also useful for anticipating Lyme disease and for education programs to increase awareness. This model calculates the risk of exposure to Lyme disease (Sharareh et al., 2017). The high concentration of Cd and Pb in the soil pollutes the environment, posing a direct threat to environmental health. A soil environment study conducted in northern France to check the status of vegetable gardens was used to raise public awareness and generate functional evidence for public outreach (Pelfrêne et al., 2019).

Socioeconomic, integrated, and harmonized approach

The socioeconomic scenarios, the new framework, and the integrated approach have been developed over the last decade. They will help to inform important research and climate-related decisions. The impact of extreme climate change in countries such as China and Japan can be seen in the disrupted electricity supply, which ultimately affects human health and the environment. The generation of e-waste has increased, but its informal disposal, as in Bangalore, India, has negative human and environmental impacts. In India, e-waste management has improved in recent years (Awasthi & Li, 2018). An assessment of e-waste management by Bangalore residents is helpful to better understand the prospects of environmentally friendly e-waste management (Awasthi & Li, 2018). The use of pesticides in agriculture poses a threat to the environment and to people, including farmers. For example, regular use of organochlorine pesticides and endosulfan has contaminated the soil in Vehari district, Punjab, Pakistan (Ahmad et al., 2019). Therefore, there is a need to improve the technical and environmental knowledge of farmers so that they can use pesticides efficiently to minimize the associated risks (Ahmad et al., 2019). An integrated approach to reducing risk is to use both detailed questionnaires and frequent group discussions (FGDs) to help quantify the population's environmental health burden. These include the amount of medical expenditures, frequency of related expenditures, medical care used (parallel health care vs. government or private clinics), type of illnesses, and length of treatment as an indirect indicator of risk.

Conclusion

Environmental hazards and their elimination; hazard index and RA; and sustainable development, risk assessment, water quality, and pathways to environmental hazards were discussed and reviewed. Among all these issues, environmental hazards are the most serious problems around the world, and they affect human health in many ways. Bioremediation methods such as microbial and phytoremediation are effective in many ways, but still have many limitations. To complement these methods, hazard index and RA can be used simultaneously to achieve sustainability and better remediation results. People's lack of awareness also exacerbates the problem. Identifying and assessing EH risks related to water quality, soil, food, and river water are the best ways to reduce the impact of environmental hazards. Risk assessment can be conducted using surveys, analysis of collected data, public awareness programs, health and social surveys, focus group discussions, field visits, and panel discussions. Risk assessment should also focus on sustainable development. Green technology is the best way to save energy and improve sustainability. Europe has already proposed a framework for sustainable development using renewable ocean energy, which tries to find a solution to reduce natural and anthropogenic calamities. India and other Asian countries need to propose a planned framework to increase sustainability. Moreover, this review highlights the importance of raising people's awareness, discussing public health issues, and efficient ways to reduce anthropogenic disasters, leading to sustainable development. Consequently, socioeconomic surveys, FDGs, waste management, water quality assessment, contaminant detection, and integrated and harmonized approach would generate knowledge on environmental public health high-risk classification, water quality management, and exposure awareness pathway, paving the way for risk assessment, mitigation, and tactics for sustainable development.

Future recommendations

It is proposed to apply a combination of various available techniques with advanced chemical, biological, and genetic engineering methods for highly effective remediation of EH from soils and agricultural lands. The synergistic combination of plant growth-promoting fungi with hyperaccumulator plants could contribute to effective remediation of persistent soil pollutants, and biotechnological techniques can further improve the efficiency of mycoremediation in polluted soils and waters. Hazard index and RA of potentially hazardous substances require experts in specific subject areas such as toxicologists and epidemiologists, whose conflicts of interest must be recognized and managed. Explicit processes need to be developed, and empirically based tools and methods for evaluating and synthesizing findings and formulating conclusions need to be established in all organizations that conduct HI and RA. These processes, tools, and methods will lead to greater transparency, comparability, and validity of assessments. In addition, other stakeholders such as agricultural and even pharmaceutical companies should be engaged at the primary level to accelerate the development of appropriate business models/policies. A fundamental policy change is needed for current contaminated sites and for potential future contaminants.

Further research

There are still many gaps in our understanding of the processes of plant–microbe interactions and metal accumulation by hyperaccumulators. To further our knowledge, phytoremediation research requires more collaborative studies involving experts from different fields such as botany, plant physiology, biochemistry, geochemistry, agricultural engineering, microbiology, and genetic engineering, to name a few. To thoroughly understand the metabolic processes and pathways associated with nanotechnology, transgenic crops, and essential microbes, further research is essential. To achieve additional gains, it seems worthwhile to continue research in these areas in the future. The important constraints to broad-scale practicality, future research needs for improving phytoremediation, policy strengthening, and safe disposal mechanisms for contaminated biomass are also addressed.

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Code availability Not applicable.

Declarations

Ethics approval and consent to participate Not applicable.

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