Vol. 5 Issue- 1, September 2024 (e-ISSN: 2582-8223)

JUST AGRICULTURE
multidisciplinary e-Newsletter

Urban Soil Contamination in India: Challenges and Breakthrough Solutions

Mubashir Sadiq V[1*], Isha[2], Deepanjali Gupta[3], Mohammed Salman CK[4]
[1,] Ph.D. Scholar, Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi.
[2,3], Ph.D. Scholar, Division of Soil Science and Agricultural Chemistry, GBPUA&T, Pantnagar.
[4,] M.Sc. Scholar, Division of Biochemistry, ICAR-IARI, New Delhi.

ARTICLE ID: 56

Introduction

India's cities are growing at an unprecedented rate, but this rapid urbanization comes with a hidden cost: the contamination of urban soils. From industrial waste to vehicle emissions and improper waste disposal, the soil beneath our feet is becoming a toxic mix, posing significant environmental and public health risks. Anthropogenic activities have contributed to the addition of metals/metalloids, organic pollutants, and radionuclides that result in adverse effects on soil functioning, which is known as soil contamination. When contamination becomes severe, it leads to malfunctioning of soil and ultimately to soil degradation, which is referred to as soil pollution. Addressing this growing crisis is essential not only for sustainability but for the health of millions of city dwellers. Here's a closer look at the problem and the innovative strategies being deployed to clean up India's urban soils.

The Growing Problem of Urban Soil Contamination

With India's cities expanding, urban soil is increasingly being polluted by harmful substances. Industrial activities, heavy traffic, and the use of chemicals in everyday life all contribute to this problem. This pollution isn't just an environmental issue—it directly impacts human health. Contaminated soils often harbor toxic metals and organic pollutants that can lead to severe health issues, especially in densely populated areas. Urban soil contamination is often caused by human activities, such as manufacturing, industrial dumping, and local waste disposal. Common contaminants include pesticides, petroleum products, radon, asbestos, lead, chromated copper arsenate, and creosote. Studies have demonstrated that soils in major urban areas contain several metals/metalloids in concentrations much higher than their background values (e.g., Cd-up to 111 ppm; Cr-up to 309 ppm; Zn-up to 1020 ppm). For instance, heavy metals such as Mn, Fe, Co, Ni, Cu, Zn, Cd, Mo, Ni, and metalloids, such as Se and As, with densities >3 g/cm^3 are identified to be causing many kinds of diseases when present in large amounts, while some, such as As, Pb, and Cd, are toxic even at very low concentrations, causing severe health effects and posing threats to terrestrial and aquatic ecosystems. Studies have shown that soils in major Indian cities contain dangerous levels of heavy metals such as cadmium, chromium, and zinc—often far exceeding safe limits. For example, in industrial areas of Uttar Pradesh, soil samples have revealed alarmingly high concentrations of these harmful substances, largely due to human activities. For example, in industrial areas of Ganges plain in Uttar Pradesh, India, reported high concentrations of Cr (161 - 6227 mg/kg), Cu (1.7 - 126 mg/kg), Pb (10-67 mg/kg), Sr (46-150 mg/kg) and Zn (43-687 mg/kg) that were due to anthropogenic sources. These contaminants can cause a range of diseases, affecting both terrestrial and aquatic ecosystems.

Innovative Solutions to Urban Soil Contamination

To combat this growing threat, India is turning to innovative and sustainable remediation techniques. Here are some of the key methods being explored and implemented:

Phytoremediation: Harnessing the Power of Plants

Phytoremediation is an eco-friendly technique that uses certain plants to clean up contaminated soil. These plants, known as hyperaccumulators, absorb and concentrate heavy metals and other pollutants from the soil. Plants can: retain pollutants, uptake pollutants, decompose pollutants, and turn contaminated soils into green areas. The mechanisms of phytoremediation involve absorption, translocation, stabilization, and volatilization of contaminants by plants. In India, species like sunflowers, mustard, and vetiver grass have shown great potential in urban soil cleanup efforts. For instance, *Bidens pilosa* L. can be utilized to remove cadmium, while *Pelargonium roseum* is effective in removing nickel and lead. The plants can remove up to 95% of contaminants, making them a powerful tool in the fight against soil pollution. The choice of plants depends on the specific contaminants present, with different species targeting different toxins. The phytoremediation efficiency can be enhanced by the addition of microorganisms, chelating agents, and biochar in soils, and by genetic engineering and nanotechnology. For example, Indian mustard varieties have been effective in absorbing nickel and zinc, while other plants are being explored for their ability to remove metals from roadside soils. This method is not only cost-effective but also sustainable. Some examples of phytoremediation include:

JUST AGRICULTURE
multidisciplinary e-Newsletter

- Phytostabilization: Immobilizing HMs in contaminated soils
- Phytoextraction: Removing toxins from soil by harvesting the roots and shoots
- Rhizofiltration: Using plant roots to eliminate pollutants from wastewater
- Phytovolatilization: Converting pollutants into less hazardous volatiles
- Hydraulic control: Using trees to act like pumps, drawing groundwater up through their roots to keep it from moving and reduce the movement of contaminated groundwater

Bioremediation: Microbial Allies in Soil Cleanup

Bioremediation involves using microorganisms to break down pollutants in the soil. This method is particularly effective for organic contaminants like oil spills and pesticides. It can be used in place of or alongside mechanical cleanup methods, and can reach depths below ground level where plant roots can grow. Bioremediation is a technique that can be used to clean up contaminated urban soil. In urban areas, microbial consortia—groups of microorganisms working together—can be introduced to contaminated sites to enhance the breakdown of harmful substances. The Pseudomonas bacteria obtained, especially aeruginosa and fluorescence have the property of degrading hydrocarbons derived from petroleum, by feeding on carbon compounds in an exponential manner. This approach can reach contaminants deep underground, making it a versatile option for urban soil remediation. Here are some bioremediation methods:

- **Bioventing:** This technique uses aeration to stimulate microflora, which can help break down pollutants into harmless substances.
- **Bio-reactor:** This method combines contaminated soil with water and other additives in a large bio-reactor, where microorganisms can degrade contaminants.
- **Rhizoremediation:** This process involves plants and the microflora associated with them, such as endophytic bacteria, rhizosphere bacteria, and mycorrhizae. These microflorae can help break down organic compounds.

Soil Washing: A Chemical-Physical Cleanup

Soil washing is a more intensive method that involves separating contaminants from the soil using water or chemical solvents. This technique is especially useful for removing heavy metals and other toxic substances from severely polluted sites. While it requires significant investment, soil washing has been successfully implemented in some Indian cities, offering a viable solution for heavily contaminated areas. Soil washing eliminates hazardous contaminants by washing the soil with a liquid wash solution. During this process, fine-grained soils, such as silts and clays, are washed away along with contaminants, which are more prone to bind to fine soils. A typical in situ soil washing procedure involves chemical washing using micro or macronutrient salts mixed into the soil followed by washing with water and waste water treatment.

Electrokinetic Remediation: A High-Tech Approach

Electrokinetic remediation is a cutting-edge technique that uses electric currents to mobilize and remove contaminants from soil. This method is particularly effective in soils with low permeability, where traditional methods might struggle. By applying an electric field, contaminants are moved towards electrodes, where they can be collected and treated. It can be used in-situ or ex-situ, and has several advantages over other methods, including: Minimal soil disruption, Safe and easy to operate, can treat both inorganic and organic contaminants, and minimum post-treatment waste volume. However, EKR also has some limitations, including: Poor ion transport, Higher cost, slow compared to other techniques, limited to low-permeability soils, and treatment time can take one or more years. Research in India is exploring the potential of this technology, especially for cleaning up soils contaminated with heavy metals.

Conclusion: A Call for Action

India's rapid urbanization brings numerous benefits but also significant environmental challenges, particularly in the form of urban soil contamination. The growing pollution of urban soils, driven by industrial activities, vehicle emissions, and improper waste disposal, is a looming crisis that threatens both environmental and public health. The contamination of soils with toxic metals, organic pollutants, and radionuclides not only degrades soil quality but also poses serious health risks to the urban population. This issue is particularly severe in industrial areas, where the concentration of hazardous substances far exceeds safe limits, endangering ecosystems and human health alike. To address this escalating problem, India is turning to innovative and sustainable soil remediation techniques. Phytoremediation, which utilizes plants to absorb and neutralize contaminants, offers a cost-effective and eco-friendly solution, while bioremediation leverages the power of microorganisms to break down harmful substances. Soil washing and electrokinetic remediation, though more intensive, provide effective methods for dealing with heavily polluted soils, especially those contaminated with heavy metals. These cutting-edge strategies underscore the importance of tackling urban soil contamination head-on. By integrating these methods into urban planning and environmental policies, India can mitigate the risks associated with soil pollution and promote sustainable urban growth. The health of millions of city dwellers and the vitality of the urban environment depend on proactive measures to clean up and protect the soil beneath our feet.