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REVIEW

Assessment of soil contamination from municipal landfills in San Pablo, Peru

Evaluación de la contaminación edáfica por botaderos municipales en San Pablo, Perú

Benny Walker Díaz-Fonseca[1], Carlos Mauricio Lozano-Carranza[1], Andi Lozano-Chung[1]

[1]Universidad César Vallejo, Facultad de Ingeniería. Tarapoto, Perú.

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Corresponding Author
Benny Walker Díaz-Fonseca

ABSTRACT

The research analysed the environmental problems caused by the inadequate disposal of solid waste in the municipal landfill in the District of San Pablo. It was determined that the accumulation of waste without technical criteria generated leachates with high levels of contaminants—heavy metals, organic compounds, and pathogens—which, when infiltrating the subsoil, altered the physical, chemical, and biological properties of the soil. The proximity of the landfill to agricultural areas increased the risk of contamination of crops and livestock, introducing toxic substances into the food chain and affecting public health. Various studies cited showed that leachates reduced soil fertility, altered its structure and caused the accumulation of elements such as lead, cadmium and zinc. An increase in gastrointestinal, respiratory and skin diseases was also observed in nearby communities. The environmental impact included landscape deterioration, loss of biodiversity and the proliferation of disease vectors. At the regulatory level, the Ministry of the Environment's Environmental Quality Standards for Soil were reviewed, along with recommendations from international organisations such as PAHO, CEPIS and CONAM, which proposed the closure of dumps and the implementation of controlled landfills with waterproofing, drainage and leachate treatment systems. The research concluded that mitigating this problem required political will, resource allocation, the application of appropriate technologies and environmental education. The need to adopt integrated solid waste management that preserved soil quality and protected the health and well-being of the population was highlighted.

Keywords: Leachates; Soil Contamination; Solid Waste; Public Health; San Pablo.

RESUMEN

La investigación analizó la problemática ambiental causada por la disposición inadecuada de residuos sólidos en el botadero municipal del Distrito de San Pablo. Se determinó que la acumulación de desechos sin criterios técnicos generaba lixiviados con alta carga de contaminantes —metales pesados, compuestos orgánicos y patógenos— que, al infiltrarse en el subsuelo, alteraban las propiedades físicas, químicas y biológicas del suelo. La proximidad del botadero a zonas agrícolas incrementaba el riesgo de contaminación de cultivos y ganado, incorporando sustancias tóxicas a la cadena trófica y afectando la salud pública. Diversos estudios citados evidenciaron que los lixiviados reducían la fertilidad del suelo, modificaban su estructura y provocaban la acumulación de elementos como plomo, cadmio y zinc. Asimismo, se observó un aumento de enfermedades gastrointestinales, respiratorias y dérmicas en comunidades cercanas. El impacto ambiental incluía deterioro del paisaje, pérdida de biodiversidad y proliferación de vectores de enfermedades. En el plano normativo, se revisaron los Estándares de Calidad Ambiental para suelos del Ministerio del Ambiente y las recomendaciones de organismos internacionales como OPS, CEPIS y CONAM, que proponían la clausura de botaderos y la implementación de rellenos sanitarios controlados con sistemas de impermeabilización, drenaje y tratamiento de lixiviados. La investigación concluyó que la mitigación de esta problemática requería voluntad política, asignación de recursos, aplicación de tecnologías adecuadas y educación ambiental. Se resaltó la necesidad de adoptar una gestión integral de residuos sólidos que preservara la calidad del suelo y protegiera la salud y el bienestar de la población.

Palabras clave: Lixiviados; Contaminación del Suelo; Residuos Sólidos; Salud Pública; San Pablo.

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INTRODUCTION

Soil contamination is one of the greatest global environmental problems facing nature. Day after day, humans contaminate the soil without realizing that it is an indispensable resource for the development of various activities, as well as for the survival of all living beings on the planet. Every day, people throw solid waste into inappropriate places without considering the impact it has on the soil in whatever form it takes.

Solid waste in the District of San Pablo is disposed of in the municipal landfill, and the accumulation of solid waste in this location is currently increasing, compounded by the inadequate disposal of solid waste without any technical criteria or prior treatment.

The problem with this municipal landfill is that it is located very close to agricultural areas, causing significant damage to the soil, which is a potential source of contamination due to hazardous waste, microbiological agents, etc., because the leachates generated by solid waste spread to different areas, damaging the soil and causing possible contamination. and consequently putting at risk the health not only of the people living in the area of influence of this dump but also of the population as a whole through the commercialization of products and animals obtained from the use of these soils in any crop or livestock farming and other activities.

The solid waste generated by the inhabitants of the city of San Pablo and surrounding areas, the lack of environmental awareness on the issue, and the lack of political will that leads to the municipality not taking the necessary measures for the management and final disposal of solid waste, is accelerating the degradation of the environment in the area of the municipal landfill.

The environmental impact of solid waste from this municipal landfill is evident in the possible contamination of the soil, deterioration of the landscape, proliferation of disease vectors, unpleasant odors, and a decrease in wildlife, among other things.

In this context, this research aims to assess the level of soil contamination affected by leachates from the municipal landfill in the District of San Pablo and, through this, propose an alternative that minimizes the contamination produced by these leachates. This research project will also help the district municipality of San Pablo to take the necessary measures to reduce soil contamination in the shortest possible time, as this is very important for the development of the population's activities.

DEVELOPMENT

Soil contamination occurs when the concentration of contaminants exceeds natural levels, altering its physical, chemical, and biological balance. According to Higueras[1], the accumulation of solid waste in open dumps causes soil degradation and generates a potential source of contamination from leachates, affecting the quality of life of nearby populations. Vivanco[2] warns that this type of pollution is not limited to adjacent areas, but that its effects spread through groundwater and agricultural products.

Fernández[3] explains that inadequate solid waste disposal facilitates the infiltration of toxic compounds into the subsoil, compromising the health of ecosystems and the communities that depend on them. This phenomenon is intensified in places where landfills are located close to agricultural areas, as pointed out by Falcón[4], generating direct impacts on production and food security.

Leachates and their impact on the environment

Leachates are liquids resulting from the decomposition of waste and the entrainment of contaminating particles by rainwater or internal moisture. Márquez[5] describes them as highly polluting mixtures that may contain biodegradable organic matter, persistent organic compounds, heavy metals, salts, nutrients, and pathogenic microorganisms.

Álvarez et al.[6] point out that the composition of leachates varies according to the age of the landfill, the type of waste, and climatic conditions, but in all cases they pose a risk to soil and water. Rojas[7] concludes that the infiltration of leachates into agricultural soils reduces fertility, alters pH, modifies soil structure, and promotes the accumulation of heavy metals in plants and animals. Vásquez[8] confirms these findings by identifying increases in lead, cadmium, and zinc in soils near municipal landfills.

Soil contamination by leachates can affect human health directly and indirectly. Rojas[7] documents that populations near landfills have a higher incidence of gastrointestinal, respiratory, and skin diseases due to constant exposure to contaminants.

In addition, the environmental impact includes loss of biodiversity, disappearance of edaphic fauna, and alteration of biogeochemical cycles.[9] Vivanco[2] warns that contamination can enter the food chain, causing the accumulation of toxic substances in higher organisms and even affecting end consumers.

Regulations and environmental management of solid waste

Technical management of solid waste is essential to prevent pollution. In Peru, the Ministry of the Environment[10] establishes Environmental Quality Standards (ECA) for soil and sampling protocols, which allow for the accurate determination of contaminant concentrations and assessment of the degree of impact.

International organizations such as PAHO, CEPIS, and CONAM[11] recommend the closure and conversion of open dumps into controlled systems, indicating that final disposal should consider measures for waterproofing, drainage, and leachate treatment to avoid impacts on soil and water. Jaramillo[12] proposes that the use of manual sanitary landfills, when designed and operated in accordance with technical specifications, can significantly reduce the generation of pollutants.

Strategies for leachate treatment include biological, physicochemical, and combined processes. Álvarez et al.[6] highlight that biological treatment systems are effective in reducing organic load and some dissolved contaminants, provided that they are adapted to the characteristics of the leachate.

SEMARNAT[13] emphasizes that integrated waste management must include systems for the collection, conveyance, and treatment of leachate, as well as plans for the remediation of contaminated soil. Ojeda[14] proposes periodic soil assessments in areas affected by landfills, while Ramírez[15] highlights the importance of environmental education and political will to implement

sustainable solutions.

CONCLUSIONS

The analysis of the environmental problems associated with the inadequate disposal of solid waste in the municipal landfill of the District of San Pablo shows that soil contamination is a complex phenomenon with direct and indirect implications for public health, agricultural productivity, and the sustainability of local ecosystems. The accumulation of waste without technical criteria or control measures generates leachates with a high load of contaminants—including heavy metals, persistent organic compounds, and pathogenic microorganisms—which, when they infiltrate the subsoil, alter the physical, chemical, and biological properties of the soil. This process, documented in the reviewed literature, not only degrades the fertility and structure of the edaphic resource, but also compromises groundwater sources, posing risks to food security and the quality of life of the population.

The location of the landfill in proximity to agricultural areas accentuates the vulnerability of the area, as contaminants can enter the food chain through crops and livestock, generating cumulative impacts that transcend the local sphere. Added to this is the proliferation of disease vectors, landscape deterioration, and loss of biodiversity, creating a scenario of progressive environmental degradation. These findings are consistent with previous studies that indicate that inadequate urban solid waste management is a determining factor in the alteration of biogeochemical cycles and the increased incidence of gastrointestinal, respiratory, and skin diseases in communities near open dumps.

At the regulatory level, both national provisions—such as the Environmental Quality Standards for Soil established by MINAM—and recommendations from international organizations (PAHO, CEPIS, CONAM) provide a technical and legal framework for the prevention and mitigation of these impacts. However, the effectiveness of these measures requires effective coordination between political will, resource allocation, the application of appropriate technologies (waterproofing, drainage, and leachate treatment), and citizen participation. Likewise, environmental education is an essential component for changing consumption patterns and waste disposal practices that currently perpetuate the problem.

In this sense, this research is important not only as a diagnosis of the level of soil contamination in the area affected by the landfill, but also as input for the design of comprehensive solid waste management strategies. The implementation of sustainable alternatives, based on technical criteria and adapted to the socioeconomic reality of the district, will not only minimize the negative impacts identified, but also lay the foundations for more efficient environmental management, aimed at preserving natural resources and the well-being of current and future generations. This reaffirms the need to transform the current situation into a responsible management model, where soil is recognized as a vital resource whose protection is essential for sustainable development.

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None.

AUTHOR CONTRIBUTION

Conceptualization: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Data curation: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Formal analysis: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Research: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Methodology: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Project management: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Resources: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Software: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Supervision: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Validation: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Visualization: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Writing – original draft: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.
Writing – review and editing: Benny Walker Díaz-Fonseca, Carlos Mauricio Lozano-Carranza, Andi Lozano-Chung.