eVitroKhem. 2022; 1:27
doi: 10.56294/evk202227

SHORT COMMUNICATION

Environmental and health risks due to inadequate waste disposal in San Pablo, Peru

Riesgos ambientales y de salud por disposición inadecuada de residuos 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.

Cite as: Díaz-Fonseca BW, Lozano-Carranza CM, Lozano-Chung A. Environmental and health risks due to inadequate waste disposal in San Pablo, Peru. eVitroKhem. 2022; 1:27. https://doi.org/10.56294/evk202227

Submitted: 01-09-2021 **Revised:** 21-12-2021 **Accepted:** 05-03-2022 **Published:** 06-03-2022

Editor: Prof. Dr. Javier Gonzalez-Argote

Corresponding author: Benny Walker Díaz-Fonseca

ABSTRACT

Solid waste generation was one of the most persistent environmental and municipal management problems, affecting both urban and rural areas. In the district of San Pablo, the lack of a formal landfill forced waste to be disposed of in an open dump, producing toxic leachates containing heavy metals such as lead, cadmium and chromium. These contaminants infiltrated the soil and nearby water bodies, putting human health and the quality of natural resources at risk, especially in agricultural areas. National and international research showed that this phenomenon physically, chemically, and biologically degraded the soil, reducing its fertility and affecting food chains. The proximity of the dump to productive areas increased the risk of bioaccumulation of contaminants in crops and livestock. High BOD, COD, and bacteriological values above permissible limits were also observed. Social, cultural and political factors, such as excessive consumption, lack of environmental education and political will, intensified the problem. International experience showed that the solution required planning, adequate infrastructure, technical control, community participation and environmental education. For San Pablo, it was proposed to implement a sanitary landfill with waterproofing, leachate treatment, recycling programmes and continuous environmental monitoring. Without a comprehensive strategy, the negative impact of leachates would continue to degrade the soil, water and public health, compromising food security and the socio-economic well-being of the community.

Keywords: Solid Waste; Leachates; Pollution; Public Health; Environmental Risk.

RESUMEN

La generación de residuos sólidos representó uno de los problemas ambientales y de gestión municipal más persistentes, afectando a zonas urbanas y rurales. En el distrito de San Pablo, la carencia de un relleno sanitario formal obligó a disponer los residuos en un botadero a cielo abierto, lo que produjo lixiviados tóxicos con metales pesados como plomo, cadmio y cromo. Estos contaminantes se infiltraron en el suelo y en cuerpos de agua cercanos, poniendo en riesgo la salud humana y la calidad de los recursos naturales, especialmente en áreas agrícolas. Investigaciones nacionales e internacionales evidenciaron que este fenómeno deterioró física, química y biológicamente el suelo, reduciendo su fertilidad y afectando cadenas tróficas. La proximidad del botadero a zonas productivas incrementó el riesgo de bioacumulación de contaminantes en cultivos y ganado. Asimismo, se observaron altos valores de DBO, DQO y presencia bacteriológica por encima de los límites permisibles. Factores sociales, culturales y políticos, como el consumo desmedido, la ausencia de educación ambiental y la falta de voluntad política, intensificaron el problema. La experiencia internacional demostró que la solución requería planificación, infraestructura adecuada, control técnico, participación comunitaria y educación ambiental. Para San Pablo, se propuso implementar un relleno sanitario con

impermeabilización, tratamiento de lixiviados, programas de reciclaje y monitoreo ambiental continuo. Sin una estrategia integral, el impacto negativo de los lixiviados continuaría degradando el suelo, el agua y la salud pública, comprometiendo la seguridad alimentaria y el bienestar socioeconómico de la comunidad.

Palabras clave: Residuos Sólidos; Lixiviados; Contaminación; Salud Pública; Riesgo Ambiental.

BACKGROUND

Solid waste generation is one of the most persistent and complex environmental and municipal management problems of recent decades, affecting both urban and rural areas. Its inadequate management not only poses a logistical challenge, but also has direct consequences for public health, ecological balance, and the sustainability of natural resources. Although the causes and possible solutions have been identified for some time, in many countries, especially in developing regions, the actions implemented have been partial and fragmented, leaving vast sectors of the population unattended. In this context, municipalities, as the entities responsible for the collection, transport, and final disposal of waste, face a burden that grows year after year, aggravated by population growth and the lack of adequate infrastructure for the treatment and disposal of this waste. This problem is particularly evident in the District of San Pablo, where there is no formally established landfill, forcing final disposal to take place in an open dump. This practice generates highly toxic leachates, derived from the microbial decomposition of organic matter and the release of chemical components present in the waste, which end up infiltrating the soil, contaminating it and putting human health and the quality of natural resources at risk, especially in nearby agricultural areas.[1,2]

Globally, inadequate solid waste management causes soil, air, and water pollution. The soil, as the final recipient of much of the waste, suffers physical, chemical, and biological deterioration that alters its structure and composition. The leachates generated by water percolating through the waste mass carry heavy metals and other contaminants that not only affect the soil profile but also move through runoff or infiltration into surface and groundwater bodies. This phenomenon has been documented in multiple international and national studies, such as in Mexico,[3] where dangerous concentrations of lead and other metals above the limits established by the EPA have been detected, or in Colombia, where old landfills closed decades ago still have high levels of heavy metal contamination. In Peru, the situation is not encouraging either: it is estimated that some 23 000 tons of municipal solid waste are generated daily, of which only 15 % is recycled, while around 90 % ends up in more than 1 200 illegal dumps, without any technical or environmental control.[4]

In San Pablo, the location of the municipal landfill—just two kilometers from the Huingoyacu-Consuelo highway—poses a clear risk, as it is close to agricultural areas where crops and livestock products that are part of the local food chain are grown. The exposure of the soil to leachates containing lead, cadmium, and chromium, among other metals, not only degrades the land, reducing its fertility, but can also cause the bioaccumulation of these elements in plants and animals, with potentially serious consequences for human health. The experience of other Peruvian municipalities shows that, in similar contexts, leachates have high BOD and COD values, as well as high bacteriological concentrations, including fecal and total coliforms above the Maximum Permissible Limits, confirming their role as a vector of both chemical and biological contamination.

The problem of solid waste, however, cannot be analyzed solely from a technical perspective; it also involves social, cultural, and political factors. The “use and throw away” culture, hyper-consumption, and lack of environmental awareness exacerbate the problem. In communities where there are no sustained environmental education campaigns or consistent public policies, the population often perceives landfills as inevitable solutions, without recognizing the invisible damage that accumulates over time. The absence of planning for final disposal and the lack of adequate infrastructure reflect not only budgetary constraints but also deficiencies in political will and environmental governance.

Soil, as a fundamental resource for life, performs essential ecological and productive functions: it acts as a filter and regulator of aquifers, sustains biogeochemical cycles, preserves biodiversity, and forms the basis for food production. When this resource is contaminated with leachates, it loses its ability to sustain life and becomes a source of risk. Leaching causes the loss of essential nutrients such as nitrogen, phosphorus, and potassium, while introducing persistent toxic substances. In humid climates, this process is intensified, and if vegetation cover is insufficient or non-existent, erosion and the transport of contaminants increase exponentially. Studies of leachate composition show that this liquid contains high levels of organic matter, heavy metals, nitrogen compounds, salts, and pathogenic microorganisms.[5] In new landfills, BOD and COD values are particularly high, while in older landfills they tend to stabilize, although the presence of metals and persistent pollutants remains for long periods.[6]

The environmental impact of leachates is multidimensional. In surface water, they can cause eutrophication and loss of aquatic biodiversity; in groundwater, they pose a direct risk to human supplies; in the air, although

to a lesser extent, they generate offensive odors and toxic gas emissions during anaerobic decomposition.[2] Landscape deterioration and loss of value of land near dumps also affect the socioeconomic dimension of communities, reducing opportunities for development and tourism and increasing the marginalization of adjacent sectors. In fauna and flora, prolonged exposure to pollutants alters food chains, increases the mortality of sensitive species, and favors the proliferation of pests such as rodents and disease-carrying insects.[3]

Although the problem has been clearly diagnosed, the solution requires a comprehensive strategy that combines adequate infrastructure, effective public policies, and citizen education.[7] The case of San Pablo, like others in the region, could benefit from the implementation of a sanitary landfill with base waterproofing systems, leachate collection and treatment, gas emission control, and daily waste coverage to minimize environmental exposure. The development of a mitigation plan would not only reduce soil contamination, but could also include recycling and composting programs that would decrease the amount of waste disposed of in the landfill, extending the useful life of the facilities and generating economic benefits for the community.[8] In addition, regular monitoring of soil and water quality in the area of direct influence is essential to evaluate the effectiveness of the measures implemented and to detect possible sources of contamination in a timely manner.[9,10,11]

International experience offers valuable examples: in countries that have significantly reduced the impact of their landfills, the keys have been long-term planning, the allocation of financial and technical resources, community participation, and strict enforcement of environmental regulations.[12] However, replicating these models in contexts such as Peru requires adaptations that take into account local economic, social, and cultural realities. It is not just a matter of installing advanced technology, but of ensuring its operation and maintenance over time, something that has often failed in previous initiatives.

Environmental education is an essential pillar of any strategy. Raising public awareness of the risks of improper waste disposal, promoting separation at source, and encouraging responsible consumption habits are actions that, while not replacing the need for infrastructure, significantly reduce pressure on final disposal systems.[13] At the same time, strengthening municipalities by providing them with the resources and capacities to properly manage waste is essential to breaking the vicious cycle of uncontrolled landfills, pollution, and environmental degradation.

In the specific case of the District of San Pablo, the approach to the problem must include a detailed technical diagnosis of the composition and concentration of heavy metals in the soil, comparing the results with current Environmental Quality Standards. This assessment will allow for the prioritization of remediation actions and determine whether it is necessary to remove contaminated soil, apply phytoremediation techniques using plant species capable of absorbing metals, or chemically stabilize contaminants to reduce their mobility. The implementation of physical or hydraulic barriers to contain the spread of leachates, together with the channeling and treatment of rainwater, can help mitigate the spread of contamination.[14,15]

The challenge is enormous because waste accumulation will not stop unless structural changes are made in the way the community produces, consumes, and disposes of waste. Land-use planning, taking into account the strategic location of disposal sites, is crucial to prevent agricultural areas and water sources from being affected. Likewise, the incorporation of circular economy models, in which waste is recognized as a resource and reintegrated into the production cycle, opens up the possibility of transforming a problem into an opportunity for sustainable development.

Ultimately, the case of São Paulo is not an isolated incident, but rather a reflection of a widespread reality in many localities in Latin America and the Caribbean. The lack of adequate landfills, indiscriminate waste disposal, the generation of toxic leachates, and soil contamination are symptoms of a waste management system that needs to be rethought from the ground up. Scientific evidence, from both local and international research, confirms that without decisive and sustained intervention, the negative impacts will continue to accumulate, compromising not only the health of the environment, but also food security, public health, and the economic well-being of communities.

This analysis is that the problem of solid waste and leachate contamination requires an interdisciplinary response that combines science, engineering, public policy, and education. In the case of the District of San Pablo, the hypothesis that leachates cause soil contamination is supported by previous experience in similar contexts and by available theoretical and empirical evidence. Overcoming this challenge involves not only the construction of technically adequate final disposal infrastructure, but also the transformation of the social and consumption practices that fuel the problem. Partial and short-term solutions have already proven insufficient; a sustained commitment from local, regional, and national authorities, with technical and financial support, is essential to move toward a comprehensive solid waste management model that guarantees the protection of soil, water, and human health in the present and for future generations.

BIBLIOGRAPHICAL REFERENCES

1. Champi V, Villalba Balsa M. Evaluación de la contaminación por disposición final de residuos sólidos en

los centros poblados de Pisac, Coya, Lama y Calca- Región Cusco [tesis de pregrado]. Cusco (Perú): Universidad Nacional de San Antonio Abad del Cusco; 2014. 181 p.

2. Vivanco V. Evaluación de la contaminación del suelo producida por el botadero municipal de Abancay y sus impactos negativos en el entorno y la salud humana [tesis de pregrado]. Abancay (Perú): Universidad Alas Peruanas, filial Abancay; 2012. 80 p.

3. Márquez L. Evaluación de la contaminación de suelos agrícolas por lixiviados de un botadero municipal en la parte central de México [tesis de pregrado]. México: Universidad del Valle de Toluca; 2010. 45 p.

4. Vásquez F. Evaluación del índice de calidad del agua en el área de influencia del botadero municipal de Tarapoto, sector Yacucatina-San Martín [tesis de posgrado]. Tarapoto (Perú): Universidad Nacional de San Martín; 2010. 127 p.

5. Fernández A. Contaminación por lixiviados. 2006 oct 13. Disponible en: http://www.consumer.es/web/es/medio_ambiente/urbano/2006/10/13/156373.php

6. Ministerio del Ambiente (MINAM). Guía para muestreo de suelos (En el marco del Decreto Supremo N° 002-2013-MINAM, Estándares de Calidad Ambiental para Suelo). Perú; 2014. 39 p.

7. Tchobanoglous G, Theisen H, Vigil A. Gestión integral de residuos sólidos. Madrid: McGraw-Hill Interamericana de España SA; 1998. 1120 p. ISBN: 9788448118303.

8. Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). Programa Nacional de Remediación de Sitios Contaminados. México; 2010. 152 p. ISBN: 978-607-7908-27-2.

9. Salazar J. Guía para la evaluación de la calidad y salud del suelo. Argentina; 2000. 88 p.

10. Martínez F. Edafología y fertilidad de suelos. Loja (Ecuador): Instituto Tecnológico Superior Juan Montalvo; 2016. 92 p.

11. Ramírez HJ. Determinación de los niveles de contaminación del agua por la disposición final de residuos sólidos generados en la ciudad de Moyobamba-2014 [tesis de pregrado]. Moyobamba (Perú): Universidad Nacional de San Martín; 2014. 92 p.

12. Hernández C. Evaluación del índice de lixiviados de vertederos de residuos sólidos urbanos a cielo abierto en la ciudad de La Habana [tesis de pregrado]. La Habana (Cuba): Universidad Tecnológica de La Habana José Antonio Echeverría; 2009. 68 p.

13. Rodríguez J. Hacia un uso sostenible de los recursos naturales. Sevilla (España): Junta de Andalucía; 2008. 99 p. ISBN: 978-84-7993-048-6.

14. CONAM, CEPIS, OPS. Guía técnica para la clausura y conversión de botaderos de residuos sólidos. Lima (Perú); 2004. 98 p.

15. Jaramillo J. Guía para el diseño, construcción y operación de rellenos sanitarios manuales. Antioquia (Colombia); 2002. 303 p.

FINANCING

None.

CONFLICT OF INTEREST

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.