Periódico Eletrônico "Fórum Ambiental da Alta Paulista"
Electronic Journal "Environmental Forum of Alta Paulista"

ISSN 1980-0827 – Volume 19, Number 5, Year 2023

Analysis of a degraded area used as a dumping ground in the municipality of Nossa Senhora das Graças - PR

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ISSN 1980-0827 – Volume 19, Number 5, Year 2023

ABSTRACT
The proper disposal of urban solid waste is a critical issue for Brazilian municipal authorities. Despite regulatory initiatives to reduce environmental and public health impacts, the practice of disposing of waste in open-air dumps is still a reality in many cities across the country. In this context, the present study aims to evaluate the environmental impacts generated by the use of the dump in the municipality of Nossa Senhora das Graças-PR as a waste disposal area for almost two decades. The methodology consisted of collecting samples of soil, groundwater, and surface water near the old dump. The results obtained indicate the dimension of environmental damage resulting from the inadequate disposal of urban solid waste, reinforcing the need for technical and regulatory actions to monitor and recover areas used as dumps. The social and environmental implications of this study are significant, as they contribute to the identification and implementation of more sustainable practices for the management of urban solid waste throughout the country.

KEYWORDS: Waste management. Environmental impacts. Environmental restoration.

1 INTRODUCTION

The environmentally appropriate final disposal of municipal solid waste (MSW) is one of the biggest challenges facing municipalities. It requires the implementation of appropriate management of disposal areas to prevent, reduce and/or mitigate possible negative impacts on the environment and public health.

However, it is still common to find open dumps, known as *vazadouros*, in Portuguese, which receive a variety of waste without any structure or prior preparation, causing various environmental impacts. When these areas lose their usefulness, environmental recovery measures are needed to mitigate the situation.

According to Romani and Segala (2014), integrated MSW management is no longer seen as strictly operational and static, but as an organic approach to management and processes. In this sense, the integrated MSW management must be understood as a dynamic process. This involves not only the final disposal of waste but also prevention, reduction, and reuse actions, in order to minimize environmental impacts and promote sustainability.

The concept of environmental degradation is defined by Decree 97.632, Brasil (1989). It is defined as the set of processes that occur as a result of damage to the environment, which leads to the loss or reduction of some of its properties, such as the quality or productive capacity of environmental resources.

Degradation can be remedied through environmental restoration. The concept of environmental recovery is often related to interventions that aim to restore the conditions of a natural environment that has been degraded or modified, to bring it closer to its original state, either partially or completely (IBAMA, 2022). This concept was initially established as one of the principles of the Brazilian National Environmental Policy and is still present in various regulations. Among these is Decree 8972/17, which defines environmental recovery as the restitution of native vegetation cover through practices such as the implementation of agroforestry systems, reforestation, natural regeneration of vegetation, ecological rehabilitation, and ecological restoration. The decree also defines other modalities related to the recovery or recomposition of native vegetation, with recovery being considered the main concept and the others as ways of conducting the process (BRASIL, 2017).

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Sustainable Development Goal (SDG) 12, which refers to responsible consumption and production, set the target of environmentally appropriate management of chemicals and waste throughout their life cycle, in accordance with agreed international standards. In addition, the release of these products into the air, water, and soil is significantly reduced to minimize their adverse effects on human health and the environment. Furthermore, by 2030, the goal is to substantially curb waste generation through prevention, reduction, recycling, and reusing (UNITED NATIONS ORGANIZATION, 2015).

According to ABNT (2004), in NBR 10.004, solid waste is defined as all waste resulting from industrial activities, which can be found in solid, semi-solid (pasty), and liquid states. In the case of liquids, solid waste is considered to be waste whose particularities make it unfeasible to discharge it into the public sewage system or bodies of water. Or when the technical and economic solutions for doing so are unfeasible in relation to the best available technology.

Law No. 12.305/2010, which instituted the National Solid Waste Policy (NSWP), establishes guidelines for the integrated management of solid waste in Brazil. According to the legislation, the environmentally appropriate final disposal of solid waste must follow the technical and environmental standards established by the competent bodies. The law also encourages the implementation of selective collection programs and the recovery of recyclable waste.

In addition to the NSWP, other legislation is relevant to urban solid waste management. Decree 7.404/2010, which regulates the NSWP, establishes criteria and procedures for the final disposal of solid waste and defines the responsibilities of the different agents involved in waste management. CONAMA Resolution 307/2002 establishes guidelines, criteria, and procedures for the management of construction waste.

According to Romani and Segala (2014), the National Solid Waste Policy (NSWP) stipulates that public authorities, civil society, and the business sector are jointly responsible for the correct management of solid waste. The public authorities are responsible for drawing up management plans, while the business sector must take charge of collecting waste after use. In turn, civil society has the role of participating in selective collection programs, storing and separating waste properly, as well as seeking to reduce consumerism, contributing to the reduction of waste generation. In this way, we can see that the involvement of all players is essential for the proper management of solid waste throughout the production chain.

In view of the complexity and urgency of urban solid waste management, it is essential that municipalities adopt measures to guarantee the environmentally appropriate final disposal of MSW. With this in mind, the aim of this article is to assess the environmental impacts generated by the use of the dump in the municipality of Nossa Senhora das Graças-PR. The dump has been used as an urban solid waste disposal area for almost two decades. To this end, samples of soil, groundwater, and surface water will be collected in the vicinity of the old dump.

In addition, the aim is to reinforce the need for technical and regulatory actions to monitor and recover areas used as dumps, in view of the environmental damage caused by the improper disposal of municipal solid waste. Finally, the aim is to contribute to the identification

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and implementation of more sustainable practices for the management of solid urban waste throughout the country, considering the social and environmental implications of this study.

2 METHODOLOGICAL PROCEDURES

The study was carried out in the area that used to be a dumping ground in the municipality of Nossa Senhora das Graças, in the northwestern region of Paraná, located 489 meters above sea level. The municipality of Nossa Senhora das Graças belongs to the Mesoregion of North Central Paraná, specifically to the Microregion of Astorga, with a territorial area of 185.176 km² and is located 380 km from the capital.

This study can be classified as exploratory field research, as samples were collected and analyzed. To carry out the study, groundwater, and surface water samples were collected at two points (upstream and downstream of the dump site), as well as 5 soil samples. The soil samples were mixed, thus characterizing a composite sample in order to obtain a value closer to reality, given that the disposal of solid waste in the area of the dump occurred randomly.

The analyses described in Table 1 were carried out by the LABSAM - Environmental Laboratory, which holds the IAPCCL 035A Laboratory Registration Certificate.

Table 1- Groundwater, surface water, and soil parameters analyzed

Analysis	Parameters sampled
Basic Analysis - Groundwater	Chloride, turbidity, sulfide, ambient temperature, fluoride, liquid temperature, sodium, pH, sulfate (expressed as SO4), total dissolved solids, nitrite (expressed as N).
Complete analysis - Groundwater	Aluminum, nickel, antimony, nitrate (expressed in N), arsenic, barium, selenium, zinc, benzene, lead, copper, chromium, ethylbenzene, iron, manganese, carbon tetrachloride, mercury, toluene, xylene.
Analysis of surface water upstream and downstream	BOD, COD, DO (Dissolved Oxygen), pH, Toxicity (Daphnia Magna), Total Phosphorus, Temperature (°C), Suspended Solids
Soil analysis	Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Lead, Cobalt, Total Copper, Total Chromium, Total Iron, Manganese, Mercury, Molybdenum, Nickel, Nitrate (as N), Selenium, Vanadium, Zinc

Source: Adapted from LABSAM - Environmental Laboratory (2021)

The analyses carried out were basic and complete groundwater analysis, as well as surface water analysis at two points. The methodology followed the norms and standards established by current environmental legislation in order to guarantee the quality and reliability of the results obtained.

3 RESULTS

Between 2000 and 2019, the municipal waste dump area received solid waste from households and public cleaning, including sweeping and tree pruning waste. During this period, the disposal cells were not waterproofed with geomembrane and there was no cover for the waste deposited. The situation of the dump in 2011 can be seen in Figure 1.

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Figure 1 - Nossa Senhora das Graças dump in 2011

Source: Nossa Senhora das Graças City Hall archives, 2011.

To evaluate the results, the values recommended by Ministry of Health Ordinance No. 888 of May 4, 2021, which provides for procedures to control and monitor the quality of water for human consumption and its standard of potability, were adopted. The groundwater sample was collected from an artesian well located about 538 meters from the dump monitoring site. Table 1 shows the results of the basic groundwater analysis.

Table 1 - Basic Groundwater Analysis Results

Parameter	Results	Limits
Turbidity	<0.50 uT	5 uT
Ambient temperature	34 °C	n/a
Liquid temperature	27,0 °C	n/a
pH	5,41	From 6.0 to 9.0
Total dissolved solids	88.0 mg/L	500 mg/L
Chloride	< 5.0 mg/L	250 mg/L
Sulphide	< 0.01 mg/L	0.05 mg/L
Fluoride	< 0.10 mg/L	1.5 mg/L
Sodium	1.5 mg/L	200 mg/L
Sulfate (expressed as SO4)	< 8.0 mg/L	250 mg/L
Nitrite (expressed in N)	0.09 mg/L	1 mg/L

Source: Adapted from LABSAM - Environmental Laboratory (2021)

With regard to parameters available in Table 1, it is important to note that only the pH parameter differed from what is stipulated in Ministry of Health Ordinance No. 888. The Ministry of Health recommends that the pH of water in the distribution system be kept within the range of 6.0 to 8.0. However, it is worth noting that the results of the other parameters are within the limits acceptable under current legislation.

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Electronic Journal "Environmental Forum of Alta Paulista"
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Table 2 shows the results of the complete groundwater analysis, which are in line with the guidelines contained in Ministry of Health Ordinance No. 888 of May 4, 2021. It is important to note that a complete analysis is essential to ensure water quality and guarantee public health.

Table 2 - Results of the Complete Groundwater Analysis

Parameter	Results	Limits
Aluminum	< 0.01 mg/L	0.2 mg/L
Antimony	< 0.005 mg/L	0.006 mg/L
Arsenic	< 0.01 mg/L	0.01 mg/L
Barium	0.16 mg/L	0.7 mg/L
Lead	< 0.005 mg/L	0.01 mg/L
Copper	< 0.02 mg/L	2 mg/L
Chrome	< 0.01 mg/L	0.05 mg/L
Iron	< 0.01 mg/L	0.3 mg/L
Manganese	0.011 mg/L	0.1 mg/L
Mercury	< 0.001 mg/L	0.001 mg/L
Nickel	< 0.01 mg/L	0.07 mg/L
Nitrate (expressed in N)	2.88 mg/L	10 mg/L
Selenium	< 0.01 mg/L	0.04 mg/L
Zinc	0.021 mg/L	5 mg/L
Benzene	< 0.005 mg/L	0.005 mg/L
Ethylbenzene	< 0.005 mg/L	0.3 mg/L
Carbon tetrachloride	< 0.001 mg/L	0.004 mg/L
Toluene	< 0.005 mg/L	0.03 mg/L
Xylene	< 0.015 mg/L	0.5 mg/L

Source: Adapted from LABSAM - Environmental Laboratory (2021)

Surface water analyses were carried out upstream and downstream of the Água Limpa stream, as shown in Table 3. Using Art. 15 of CONAMA Resolution 357/2005 as a reference, the dissolved oxygen, and total phosphorus parameters were found to be above the maximum permitted values.

Table 3 - Upstream and downstream surface water analysis results

Parameter	Results		Limits
	Amount	Downstream	
BOD	< 2.0 mg/L	< 2.0 mg/L	5 days at 20 °C up to 5 mg/L O2
COD	< 15 mg/L	< 15 mg/L	
DO (Dissolved Oxygen)	4.10 mg/L	4.80 mg/L	Not less than 5 mg/L O2
pH	5,70	5,99	From 6.0 to 9.0
Toxicity (Daphnia Magna)	2	2	
Total Phosphorus	0.14 mg/L	0.20 mg/L	up to 0.050 mg/L
Temperature (°C)	27 °C	27 °C	n/a
Suspended Solids	30 mg/L	16 mg/L	

Source: Adapted from LABSAM - Environmental Laboratory (2021)

The main cause of the increase in phosphorus is the use of chemical products on the plantations surrounding the stream. These products are rich in phosphorus, potassium, nitrogen, and other components, in addition to their periodic application to crops (monoculture

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soy or corn) that leads to a significant accumulation of these components in the soil. With precipitation, rainwater flows to the lowest point of the land, where the receiving body is located, thus increasing the concentration of these components in the water. This problem can be mitigated by adopting more sustainable agricultural practices, such as crop rotation and reducing the use of chemical products, which would contribute to preserving water quality in the Água Limpa stream. In addition, with the increase of these components in the receiving body, aerobic microorganisms proliferate by consuming organic matter, which reduces the concentration of dissolved oxygen in the water, worsening the situation.

Establishing criteria for preventing and maintaining soil quality is essential for environmental preservation and for guaranteeing human health. CONAMA Resolution 420/2009, instituted in 2009, was an important regulatory milestone in this regard. It established criteria and guideline values for soil quality in relation to the presence of chemical substances and provided guidelines for the environmental management of areas contaminated by these substances.

Table 4 - Soil analysis results

Parameter	Result obtained (mg.kg^{-1} dry weight)	SBC
Antimony	< 2,00	2
Arsenic	< 0,20	15
Barium	8,58	150
Cadmium	< 0,20	1,3
Lead	< 2,00	72
Cobalt	< 0,40	25
Total Copper	4,27	60
Total Chromium	1,74	75
Mercury	< 0,02	0,5
Molybdenum	< 10,00	30
Nickel	1,48	30
Selenium	< 0,20	5
Zinc	7,13	300

Source: Adapted from LABSAM - Environmental Laboratory (2021)

The results of the analyses carried out on the soil are shown in Table 4, and indicate that the parameters are within the safe bearing capacities by legislation. It should be noted that these values were established on the basis of the strictest standard in Annex II of CONAMA Resolution 420/2009, which guarantees that environmental conditions are in line with nature protection and conservation standards.

However, it is crucial to highlight the importance of periodically analyzing soil quality in order to detect possible contamination that could affect public health and the environment. In addition, constant monitoring of soil quality can guarantee the preservation of biodiversity and the maintenance of local ecosystems, as well as avoiding long-term negative impacts.

After carrying out the analyses and verifying that the impact caused by the waste in the former municipal dump area is low, it can be stated that the measures taken by the municipality of Nossa Senhora das Graças have been effective in minimizing environmental

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impacts. The disposal of solid urban waste in the licensed landfill of the company Serrana Engenharia LTDA, located in the municipality of Maringá, is an important action to prevent soil and groundwater contamination. In addition, decommissioning the area of the old dump is a measure that contributes to environmental preservation and improves the quality of life of the local population.

With regard to solid waste management, it is essential to note that actions such as selective collection and recycling should be encouraged and implemented in all spheres of society. These measures not only reduce the amount of waste going to landfills but also help to reduce the extraction of raw materials, greenhouse gas emissions, and energy and water consumption.

In addition, it is significant to note that the improper disposal of solid waste is a global problem and the adoption of public policies and sustainable practices should be encouraged at all levels, from the government to the individual. Each individual can do their part by adopting conscious practices of consumption, disposal, and recycling of materials.

It is important that human activities are carried out in a conscious and sustainable manner, respecting the limits of the environment and always seeking to preserve natural resources for future generations.

Finally, it is necessary for governments and companies to adopt effective measures for solid waste management, always seeking to reduce environmental impact and promote sustainable development. Implementing public policies that encourage sustainable solid waste management is a shared responsibility, and only in this way can we guarantee a more sustainable future for generations to come.

4 CONCLUSION

Based on the results presented in this work, it can be concluded that the proposed aims were achieved. The integrated management of solid urban waste is a dynamic and organic process that must involve actions of prevention, reduction, reuse, and environmentally appropriate final disposal, in order to minimize environmental impacts and promote sustainability. However, critical points have been identified, such as the existence of open dumps and the lack of infrastructure in small municipalities to carry out proper waste management. These points need to be addressed if integrated waste management is to be effective.

It is intended that this study will contribute to the identification and implementation of more sustainable practices for the management of solid urban waste, considering the social and environmental implications. In addition, it has demonstrated the importance of environmental monitoring and recovery actions in final waste disposal areas to mitigate the negative impacts caused by environmental degradation.

During the study, difficulties were encountered in relation to the lack of accurate and up-to-date data on urban solid waste management. Therefore, new studies should be carried out to obtain more detailed information on the situation of urban solid waste management, as

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well as the creation of incentive programs to promote actions to prevent, reduce, reuse and properly dispose of waste.

5 ACKNOWLEDGEMENTS

The authors would like to thank the Academic Writing Center (Centro de Escrita Acadêmica, CEA) of the State University of Maringá (UEM) for assistance with the English language and developmental editing.

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