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Application of the Waste Landfill Quality Index (IQR): Study in an area in southern Brazil

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A B S T R A C T

The population growth is responsible for the production of large quantities of solid waste. The right final disposal of this waste occurs in sanitary landfills. This study aimed to analyze the methodology proposed by the Environmental Company of the State of São Paulo, which determines the landfill quality index in the northwest of Rio Grande do Sul. The first visit revealed a value of 8.4, adequate conditions and some inconsistencies were the inefficiency in the slurry drainage, the absence of geotechnical monitoring and the presence of birds and flies. In the second visit, the Landfill Quality Index was 9.2, where there was an adequacy in the slurry drainage system and the lack of outcropping of this material, however, the remaining problems are still present in the project. Thus, we note the importance of these studies for a good management, mitigating the negative environmental impacts.

Keywords: Landfill, CETESB, Environmental management, IQR, Leachate.

Aplicação do Índice de Qualidade de Aterros de Resíduos (IQR): Estudo em área no sul do Brasil

R E S U M O

O aumento populacional é o responsável pela produção de grande quantidade de resíduos sólidos. A disposição final correta destes resíduos ocorre em aterros sanitários. Este estudo tem por objetivo analisar a metodologia proposta pela Companhia Ambiental do Estado de São Paulo que determina o índice de qualidade de aterros de resíduos em aterro sanitário no noroeste do Rio Grande do Sul. Na primeira visita constatou-se um valor de 8,4, condições adequadas e as inconsistências foram, ineficiência na drenagem de chorume, ausência de monitoramento geotécnico e a presença de aves e moscas. Na segunda visita, o índice de qualidade de aterros de resíduos encontrado foi de 9,2, onde, houve adequação no sistema de drenagem de chorume e a inexistência de afloramento deste material, contudo, as demais problemáticas continuam presentes no empreendimento. Assim, nota-se a importância desses estudos para uma boa gestão, mitigando impactos ambientais negativos.

Palavras-Chaves: Aterro sanitário, CETESB, Gestão ambiental, IQR, Lixiviado.

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1. Introduction

Urban Solid Waste (USW) is a severe problem in developing countries. In this sense, sanitary landfills are the most suitable technique for the environmentally adequate final disposal of waste. According to the Brazilian Association of Technical Standards - ABNT (1997), its definition states that sanitary landfill is a technique for the disposal of USW in the soil, mitigating the negative impacts on the environment, public health, and safety.

The Diagnostic of Urban Solid Waste Management assessment for the year 2018 (Brazil, 2019) revealed that 24.40% of Urban Solid Waste is in controlled landfills and dumps and 75.60% in sanitary landfills. The research involving this theme aims to assist the gaps related to proper management. In the State of Rio Grande do Sul, according to data from the State Plan for Solid Waste (Government of the State of Rio Grande do Sul, 2014), 80% of the municipalities' Urban Solid Waste disposes of its waste in landfills. Thus, it observes the importance of landfills in the process of USW management in the state.

Thus, methodologies that aim to assist the waste management process or determine the quality of landfills are essential. Among these methodologies, the Index of Quality of Waste Landfills (IQR - Portuguese abbreviation), proposed by CETESB (2007), is traditional. Through a checklist, it is possible to evaluate and identify possible operational inconsistencies in waste disposal areas.

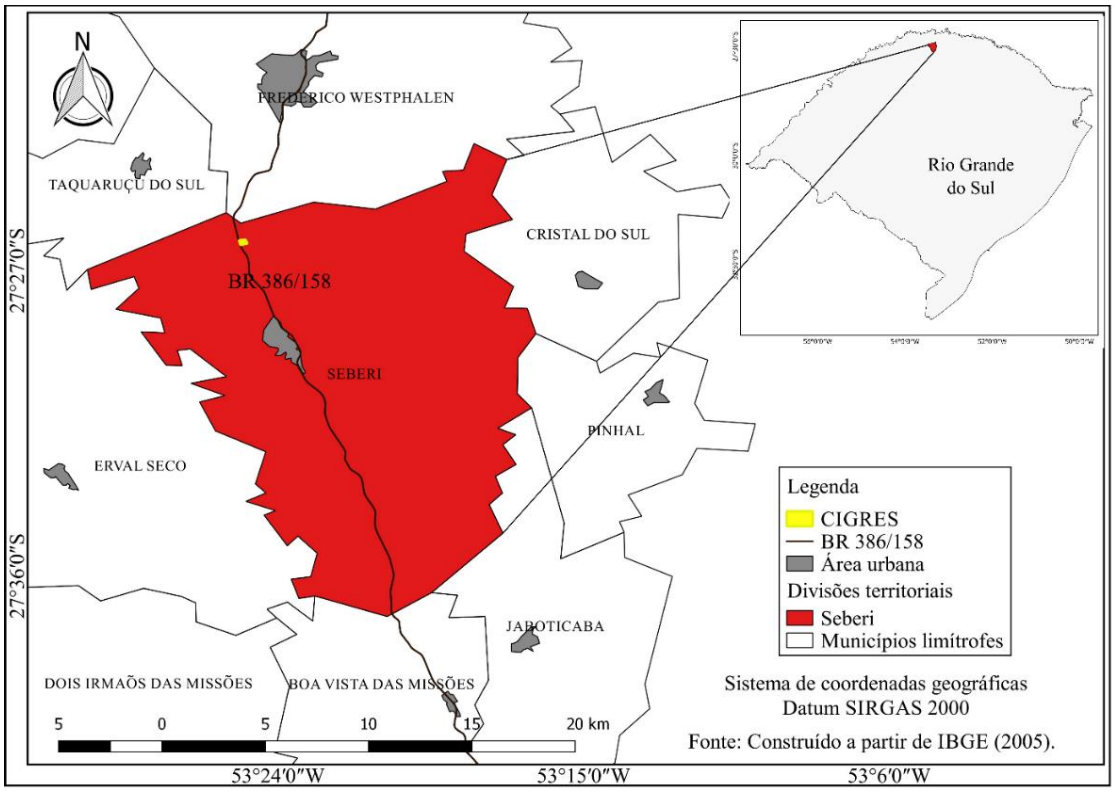
It is essential to conduct research involving the theme in this context, either in the Brazilian or international context (Díaz-Villavicencio; Didonet; Dodd, 2017; Guibrunet; Calvet; Broto, 2017; Silva; Prietto; Korf, 2019; Tirkolaee et al., 2020). Thus, this study aims to apply the IQR (CETESB, 2007) in a landfill located in the northwest region of the State of Rio Grande do Sul (Brazil).

2. Material & Methods

2.1. Characterization of the study area

The landfill under research is on the right side (south-north direction) of the BR 386/158 highway, in the municipality of Seberi/RS (Figure 1). The facility receives Urban Solid Waste from a population of approximately 180,000 inhabitants (IBGE, 2010). The average monthly reception is 1,900 tons, with sorting, composting, and environmentally appropriate waste disposal. The average sorting and recycling of materials is 15%, and the rest (85%) is in landfill cells.

Figure 1 - Landfill location.



Source: Borba (2019).

Regarding the soil parameters, according to Embrapa (2017), its classification is Red Latosol, with an average clay content of 86% (Borba, 2016). Regarding the local geology, there is the Serra Geral Formation, Paranapanema facies (CPRM, 2006), consisting of basaltic rocks and their weathering products. In hydrogeology, the area inserts in the Serra Geral Aquifer System, according to Machado & Freitas (2005). Thus, this aquifer system is of the fissural type, where its recharge occurs by fracturing the rocks (Freitas et al., 2012).

2.2. IQR Determination (CETESB, 2007)

The classification of the Index of Quality of Waste Landfills - IQR (CETESB, 2007) is through the points (Table 1). Two visits were made in the year 2018 (four months difference from visitation) in the study area to survey the information.

Table 1 - Parameters required to obtain the IQR (CETESB, 2007).

Item	Subitem	Rating	Weight	Scores
Supporting Structure	1 Reception, weighing and surveillance services	Yes / Sufficient	2	
		No / Insufficient	0	
	2 Physic isolation	Yes / Sufficient	2	
		No / Insufficient	0	
	3 Visual Isolation	Yes / Sufficient	2	

		No / Insufficient	0	
	4 Unloading front access	Adequate	3	
		Inadequate	0	
Working Front	5 Workfront Dimensions	Adequate	5	
		Inadequate	0	
	6 Compaction of the waste	Adequate	5	
		Inadequate	0	
	7 Covering the waste	Adequate	5	
		Inadequate	0	
Slope Contention	8 Dimensions and inclinations	Adequate	4	
		Inadequate	0	
	9 Vegetation cover	Adequate	4	
		Inadequate	0	
	10 Vegetal protections	Adequate	3	
		Inadequate	0	
	11 Presence of leachate	No / Rare	4	
		Yes / numerous	0	
Upper surface	12 Leveling of surface	Adequate	5	
		Inadequate	0	
	13 Coverage Homogeneity	Yes	5	
		No	0	
Environmental Protection Structure	14 Ground waterproofing	Yes / adequate (Do not fill item 15)	10	
		No / inadequate (Fill in item 15)	0	
	15 Water table depth (P) x Soil permeability	P > 3 m, k < 10^{-6} cm/s	4	
		P <=1 m, k < 10^{-5} cm/s	2	
		Inadequate condition	0	
	16 Leachate Drainage	Yes / Sufficient	4	
		No / Insufficient	0	
	17 Leachate treatment	Yes / adequate	4	
		No / inadequate	0	
	18 Temporary rainwater drainage	Sufficient / Unnecessary	3	
		No / Insufficient	0	
	19 Definitive rainwater drainage	Sufficient / Unnecessary	4	
		No / Insufficient	0	
	20 Drainage of gases	Sufficient / Unnecessary	4	
		No / Insufficient	0	
	21 Groundwater Monitoring	Adequate	4	
		Inadequate / Unnecessary	1	
		Non-existent	0	
	22 Geotechnical monitoring	Adequate	4	
		Inadequate / Unnecessary	1	
		Non-existent	0	
SUBTOTAL 1			86	
Item	**Subitem**	**Rating**	**Weight**	**Scores**
Other information	23 Presence of waste pickers	No	2	
		Yes	0	
	24 Waste Burning	No	2	
		Yes	0	
	25 Occurrence of flies and odors	No	2	

		Yes	0	
	26 Bird and animal presence	No	2	
		Yes	0	
	27 Receiving unauthorized waste	No	2	
		Yes	0	
	28 Receiving industrial waste	Yes (Fill item 29)		
		No (Fill item 30)		
	29 Structures and procedures	Adequate	10	
		Insufficient / Unnecessary	0	
SUBTOTAL 2.1			**10**	
SUBTOTAL 2.2			**20**	
Item	**Subitem**	**Rating**	**Weight**	**Scores**
Area characterization	30 Proximity to population centers	> = 500 meters	2	
		< 500 meters	0	
	31 Proximity to waterbodies	> = 200 meters	2	
		< 200 meters	0	
	32 Area lifetime	< = 2 years		
		2 < x < = 5 years		
		> 5 years		
	33 Legal restrictions on land use	Yes		
		No		
SUBTOTAL 3			**4**	

Source: CETESB (2007).

The IQR (CETESB, 2007) is from the equation: IQR = Sum (subtotal 1 + 2.1 + 3)/10. If the IQR values are between 0 and 7, the conditions are inadequate; if the values are between 7.1 and 10, the conditions are adequate.

3. Results and Discussion

The application of the IQR (CETESB, 2007) on the first visit to the study area showed a value of 8.4, indicating that the structural conditions are adequate (Table 2) (CETESB, 2007). It observes the leachate and, consequently, inefficiency in the drainage system of this material as inconsistencies of the first visit (Figure 2).

Moreover, the absence of a geotechnical monitoring system and birds and flies in the landfill area are other inconsistencies of the first visit. These factors can cause, in addition to possible soil contamination, the transmission of vectors through zoonoses.

Table 2 - Parameters collected for the application of the IQR (CETESB, 2007).

Item	**Subitem**	**Rating**	**Weight**	**Scores** *	**Scores** **
Supporting Structure	1 Reception, weighing and surveillance services	Yes / Sufficient	2	2	2
		No / Insufficient	0		
	2 Physic isolation	Yes / Sufficient	2	2	2
		No / Insufficient	0		
	3 Visual Isolation	Yes / Sufficient	2	2	2
		No / Insufficient	0		

	4 Unloading front access	Adequate	3	3	3
		Inadequate	0		
Working Front	5 Workfront Dimensions	Adequate	5	5	5
		Inadequate	0		
	6 Compaction of the waste	Adequate	5	5	5
		Inadequate	0		
	7 Covering the waste	Adequate	5	5	5
		Inadequate	0		
Slope Contention	8 Dimensions and inclinations	Adequate	4	4	4
		Inadequate	0		
	9 Vegetation cover	Adequate	4	4	4
		Inadequate	0		
	10 Vegetal protections	Adequate	3	3	3
		Inadequate	0		
	11 Presence of leachate	No / Rare	4		4
		Yes / numerous	0	0	
Upper surface	12 Leveling of surface	Adequate	5	5	5
		Inadequate	0		
	13 Coverage Homogeneity	Yes	5	5	5
		No	0		
Environmental Protection Structure	14 Ground waterproofing	Yes / adequate (Do not fill item 15)	10	10	10
		No / inadequate (Fill in item 15)	0		
	15 Water table depth (P) x Soil permeability	P > 3 m, k < 10^{-6} cm/s	4	4	4
		P <=1 m, k < 10^{-5} cm/s	2		
		Inadequate condition	0		
	16 Leachate Drainage	Yes / Sufficient	4		4
		No / Insufficient	0	0	
	17 Leachate treatment	Yes / adequate	4	4	4
		No / inadequate	0		
	18 Temporary rainwater drainage	Sufficient / Unnecessary	3	3	3
		No / Insufficient	0		
	19 Definitive rainwater drainage	Sufficient / Unnecessary	4	4	4
		No / Insufficient	0		

	20 Drainage of gases	Sufficient / Unnecessary	4	4	4
		No / Insufficient	0		
	21 Groundwater Monitoring	Adequate	4	4	4
		Inadequate / Unnecessary	1		
		Non-existent	0		
	22 Geotechnical monitoring	Adequate	4		4
		Inadequate / Unnecessary	1		
		Non-existent	0	0	0
SUBITEM 1					
Item	**Subitem**	**Rating**	**Weight**	**Scores ***	**Scores ****
Other information	23 Presence of waste pickers	No	2	2	2
		Yes	0		
	24 Waste Burning	No	2	2	2
		Yes	0		
	25 Occurrence of flies and odors	No	2		
		Yes	0	0	0
	26 Bird and animal presence	No	2		
		Yes	0	0	0
	27 Receiving unauthorized waste	No	2	2	2
		Yes	0		
	28 Receiving industrial waste	Yes (Fill item 29)			
		No (Fill item 30)			
	29 Structures and procedures	Adequate	10		10
		Insufficient / Unnecessary	0		
SUBTOTAL 2.1					
SUBTOTAL 2.2					
Item	**Subitem**	**Rating**	**Weight**	**Scores ***	**Scores ****
Area characterization	30 Proximity to population centers	> = 500 meters	2	2	2
		< 500 meters	0		
	31 Proximity to waterbodies	> = 200 meters	2	2	2
		< 200 meters	0		
	32 Area lifetime	< = 2 years			
		2 < x < = 5 years			

		> 5 years	x		x
	33 Legal restrictions on land use	Yes			
		No	x		x
SUBTOTAL 3			**4**		

Source: CETESB (2007). *Visit 1 and Visit 2.

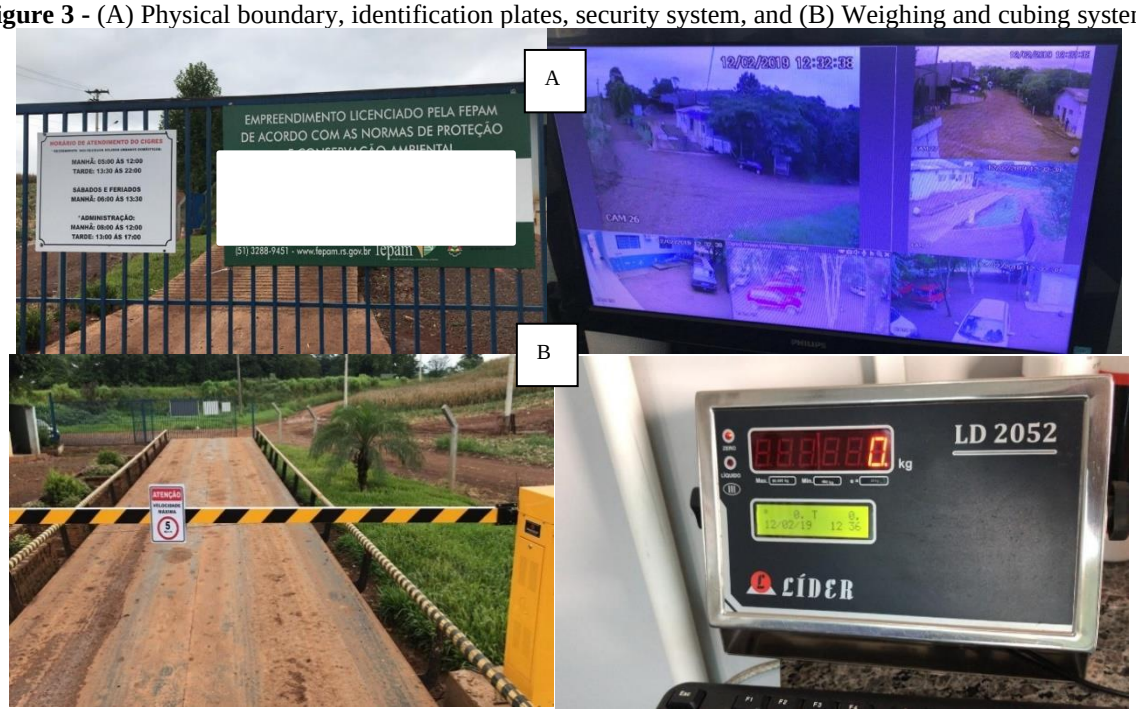
Figure 2 - (A) Presence of leachate and (B) birds at the site on the first visit.

The IQR value (CETESB, 2007) was 9.2 (adequate condition) in the second visit. Note the changes due to the non-existence of leachate outcropping and adequacy of the drainage system. The other inconsistencies seen on the first visit continue the second (presence of birds, absence of geotechnical monitoring system, presence of flies).

The operational parameters in USW disposal areas represent an essential tool for preserving the environment. Among the main ones, the reception of materials, which avoids inappropriate waste, such as those from the health service or industrial, is an example. However, these residues disposed of incorrectly can lead to the transmission of pathogens or the contamination of soil and groundwater by components present in these materials. Therefore, an efficient monitoring system is essential, with NBR 13.896/1997 (ABNT, 1997) commenting that it is necessary to implement a careful waste sampling system.

The operation was in good condition in both surveys. In general aspects, there is fencing around the entire bordering area and an efficient security system (Figure 3A). This system consists of a gate with electronic closure and an internal security monitoring network, which aims to identify the presence or circulation of unauthorized persons in the interior area. In addition, the enterprise understudy has a weighing and cubing system (Figure 3B), facilitating controlling the input and output of waste and assisting in demands that refer to the management of the landfill.

Figure 3 - (A) Physical boundary, identification plates, security system, and (B) Weighing and cubing system.



As for the leachate drainage (Figure 4A), the effluent recirculates from the lagoons to the cells after its preliminary treatment (Figure 4B). The reinjection of percolated liquid into the mass of waste already landfilled facilitates the decrease of constituents by biological activity and physical-chemical reactions inside the landfill (Pires, 2002). According to Pires (2002), the recirculation of leachate reduces its volume due to loss through evaporation. Observes the leachate treatment occurs in three natural lagoons: two anaerobic and one facultative.

Figure 4 - (A) Leachate drainage system and (B) effluent treatment ponds.

Regarding environmental monitoring, in the study area, there are six monitoring environments (four are in operation) (Figure 5). These build environments (wells) are following the technical standards established by NBR 15.495-1/2007 (ABNT, 2007) and 15.495-2/2008 (ABNT, 2008). It performs quarterly collection for qualitative groundwater monitoring of a series of physical, chemical, and biological water quality parameters.

This monitoring aims to identify possible changes in water quality, facilitating the decision-making process in remediation. The item soil sealing (14) was "adequate" because the environmental agency licenses the existing cells.

The NBR 15.849/2010 (ABNT, 2010) indicates that it is necessary to have a groundwater monitoring network composed of at least three wells downstream and upstream of the activity in landfill areas. In this sense, the site presents the minimum condition, indicating the drilling of more monitoring wells, especially in the underground flow direction.

Figure 5 - Groundwater monitoring wells.

The gas drainage system shows in Figure 6, where the gas in the collection is released directly into the atmosphere (Figure 5), not the burning, for operational and financial reasons. According to Brito Filho (2005), the gas generation capacity depends on several factors: waste composition, humidity, particle size, age of the waste, pH, temperature, and others.

Figure 6 - Drainage of the gas present inside the landfill.

The existing rainwater drainage system aims to avoid directing the water to the leachate treatment ponds and its accumulation in the area. Instead, it collects the rainwater in the covered areas to be used later in washing floors or irrigation. Moreover, in the other regions, drainage is performed utilizing sub-surface drains and subsequent forwarding to the external area, as shown in Figure 7.

Figure 7 - Storm drainage system.

The covering of the waste is weekly or more frequently. It uses the soil from a side area, and a hydraulic excavator performs the compaction and accommodation of the garbage in conjunction with a tracked tractor (Figure 8).

Figure 8 - Accommodation, compaction, and overlay of the waste.

Several types of research apply the IQR (CETESB, 2007) in the national territory. Santos et al. (2012), when applying the IQR in the municipality of Anápolis - GO, attributed weight 8.0, analyzing several inconsistencies, being them, presence of scavengers and birds, problems in the leachate drainage system, and lack of surveillance. Duarte and Silva (2019), applying the IQR (CETESB, 2007) in São Paulo Municipalities, obtained sufficient conditions. Cunha and Silva (2007), in six landfills located in the metropolitan region of Campinas - SP research, observe adequate conditions. In the Municipality of Goianésia - PA, and Goiânia - GO, Lacerda et al. (2020) and Barros et al. (2020) classified the analyzed areas as inadequate, obtaining a value of 1.2 and 2.2, respectively.

Studies involving the management and monitoring of USW disposal areas are essential since they represent a tool in the process of risk assessment and environmental protection, especially related to soil and groundwater protection. In addition, the application of this method allows identifying specific conditions of operational inconsistencies in landfills, facilitating the process of the adequacy of these points in a timely and effective.

4. Conclusion

From the use of IQR, the study area presents adequate conditions in the two visits performed. In addition, some inconsistencies from the first visit were corrected in the second visit, indicating the applicability of the method. On the other hand, it identified some inadequate points that need corrections, mainly birds, flies, and the non-existence of geotechnical monitoring.

Applying these methodologies is essential, which allows the identification of problematic points in the Solid Urban Waste management process. In the study area, this condition was critical because it allowed between visits to perform the correction of issues related to the outcropping and drainage of leachate, minimizing environmental impacts, and contributing to the processes of proper management of USW. Thus, managers use the studies in this sense as a subsidy in decision-making.

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