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Negative environmental impacts generated by cemetery: Case study

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Abstract
When cemeteries do not follow the implementation and operation rules established, they can be sources of potential environmental impacts, causing damage to public health and the environment. In the process of decay the corpses are generated cadaverous, gaseous and liquid effluents, which can cause potential impacts on the soil, surface and underground water. The effluent produced from the decomposition of bodies is leachate, which has a high pathogen load, mineral salts and degradable organic substances. The possible negative environmental impacts generated by the cemetery were analyzed in this work. The investigation was carried out in cemetery, which is located in the state of Pernambuco, Brazil. The methodology used for data collection and analysis were on-site visits, questionnaire, photographic recordings, and Leopold matrix. In the cemetery activity impacts of contamination and pollution will always exist, but these impacts can be reduced by following the rules of implementation and management for cemeteries.

Keywords: deposits, leachate, gas, impacts, health, environment

1. Introduction
In the construction of most cemeteries in Brazil there are practically no environmental impact studies carried out since many originated even before the creation of the National Environment Council. Considering that quality of life and environmental problems are interrelated, any change in the environment has consequences in the urban environment, causing impacts that affect the population's quality of life [1, 2]. Prove that cemeteries can be a source of environmental impacts, presenting high potential for pollution and contamination, and can be increased depending on location and management.
In Brazil, cemeteries are in need of environmental planning and monitoring, with no control in the construction of cemeteries, much less in the supervision of existing ones [1]. Public cemeteries are more susceptible to negative impacts as they are implemented and neglected [3].
Regarding the implementation and management of cemeteries, especially those located in urban areas, it is essential to know the environmental impacts caused. Toxic substances produced by rotting bodies, leachate, gases, heavy metals, can pollute air, soil and water, causing a major environmental impact [1].
After death the corpses produce and release large quantities of substances from the rotting process such as: hydrogen sulfide (H_2S), carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3), cadaverine and putrescine, responsible for the smell. of rotten meat in addition to Phosphine (PH_3). Most of these substances have a high degree of contamination and environmental pollution. When the human body stops its vital activities, it becomes an ecosystem inhabited by microorganism, insects and other beings that feed on dead matter). In addition to these substances, the rotting leachate contains high amounts of different bacteria such as tetanus (Clostridium tetani), gas gangrene (Clostridium perfringes), typhoid (Salmonella typhi), parasitoid fever (Salmonella paratyphi), dysentery (Shigella dysenteriae) and viruses such as hepatitis. Heavy metals, formaldehyde and methanol used in embalming are also present and may contain hospital chemical treatment residues [4].
This work aimed to perform an analysis of the negative environmental impacts generated by a public cemetery in the municipality of Escada, located in the Zona da Mata Sul of Pernambuco, through on-site inspections and using the Leopold matrix.

2. Materials and methods
2.1. Study Area
The municipality of Escada, with an estimated population of 68,281 inhabitants [5], is located in the Mesorregião da Mata and the Southern Microregion of the State of Pernambuco, being limited to the north by Cabo de Santo Agostinho and Vitória de Santo Antão, south with Sirinhaém and Ribeirão, east with Ipojuca and west with Primavera. It occupies an area of 348.8 km^2, representing 0.35% of the state of Pernambuco. The seat of the municipality has an approximate altitude of 109.0 meters, Latitude 8º 21 '33' ', Longitude 35º 13' 25 ".

2.2. Methodology
The study began with a literature review and relevant legislation on the subject, which supported the development of the study. The subsidies used to analyze the situation of the area were collected through five technical field visits with photographic records, informal interviews with the administrators and employees of the cemetery analyzed. A visit was also made to the Municipal Secretariat of Infrastructure, the body responsible for the administration of the cemetery in the municipality. As the study area is fully

inserted in an urban environment, there was also a need to analyze the problems faced by residents in the surrounding areas of the cemetery.

For a more detailed analysis and visual representation of the data obtained, we used the Microsoft Office Excel program to create the graphs and tabulation of the questionnaires. Due to the complexity involved in the diagnosis of environmental impacts, it is necessary to have a holistic view in the data analysis, so the Leopold Matrix was applied to identify and analyze the negative impacts generated and their consequences for the environment.

The environmental impact rating was defined by the relationship between degree of importance versus severity, providing the final category. The environmental factors evaluated refer to soil, water and living things. An adaptation was made regarding the degree of importance score, considering points ranging from 1 to 5, where number 1 corresponds to the least important condition and number 5 corresponds to the maximum values of these attributes.

3. Results & Discussion

The cemetery is located in the center of the municipality of Escada, state of Pernambuco, where there are several residential and commercial establishments. Today, the cemetery is overcrowded, with no vacancies to build new deposits. The type of burial offered by the Cemetery is by burial, which are constructions of concrete boxes or masonry in horizontal and vertical form. The type of burial can also contribute to increase, control or decrease pollution. Comparing the swelling with the swelling, the swelling is the most recommended technique, but the construction of the deposits needs to be well executed to avoid the leakage of leachate and gases [4]. Figure 1 shows the types of deposits found in the cemetery by horizontal and vertical accumulation.

Fig 1: Types of burials - Escada Cemetery - PE. Source: The authors.

The cemetery has approximately 1200 graves, many are considered centenarians, and some are in total abandonment. Families can reuse them after a minimum of three years for adults and two years for children. According to the information gathered on the site, the construction of the tombs does not involve any special material, they are made of sand, cement and bricks without any waterproofing. However, Article 6 states that the construction of tombs must obey technologies that prevent the passage of gases and the leakage of liquids from colliquation [6]. It was also noted that not only older deposits have structural problems, but also newer ones, including retired ones (Figure 2). It is noteworthy that these tomb construction problems can cause leakage of leachate and emission of gases into the environment [3]. classifies this type of impact as secondary physical, which are directly linked to the poor preparation and maintenance of deposits.

Fig 2: Structural conditions of the graves in Escada cemetery. Source: The authors.

[7] Pointed out that in burial burials, depending on the waterproofing conditions of the deposits, the leachate naturally polymerizes, reduces to dust and does not pass into the surrounding soil. However, if the deposits are poorly structured, it can make the environment quite unhealthy by infiltrating the walls, emitting odor and attracting insects.

Another problem diagnosed was the lack of management of solid waste generated from exhumation, visits and renovation of deposits. These types of waste if not properly managed can cause significant impacts on health and the environment [8]. In Article 9, there is a determination that solid, non-human waste resulting from body exhumation should be disposed of environmentally and healthily, following the same treatment given to solid waste from wastewater services health, such as incineration [6]. Several types of waste were improperly disposed in the cemetery, such as construction waste, body exhumation, crown remains, flowers, candles and others [3]. points out that it must be considered that these residues can serve as foci for fungi and bacteria, especially if they are residues from human bodies derived from contagious diseases, as well as the exhumation remains of cadavers undergoing cancer treatments.

The human body of a 70 kg adult male contains approximately: 16 000 g carbon, 1800 g nitrogen, 1100 g calcium, 500 g phosphorous, 140 g sulfur, 140 g potassium, 100 g sodium, 95 g chlorine, 19 g magnesium, 4.2 g iron, and water 70–74% by weight. The elemental composition of females is between two thirds and three quarters of that for males [9].

In the on-site technical visit, it was found that the city does not follow the norms for the conditioning, treatment and final disposal of this type of waste. The management of the waste generated in the cemetery is inadequate because they are exposed to the environment and the local community without any sanitary and environmental care.

Waste is placed in front of the cemetery, waiting to be collected by the city, which gives the final disposal in the private landfill, or thrown into a vacant lot near the cemetery (Figure 3). The management of solid waste from cemeteries must comply with technical standards to

minimize risks to public health and environmental quality [10]. classifies wastes of this type into two groups: group A, wastes that pose a potential risk to public health and the environment due to the presence of pathogenic biological agents such as urns, clothing, gloves , plastics, etc., generated by the exhumation of bodies, and group D are the common waste, with characteristics of municipal waste, such as crowns, flowers and candles, office waste, toilet paper, waste kitchen and dining hall, remnants of tree pruning and mowing, etc.

Fig 3: Inadequate disposal of solid waste generated in the cemetery. Source: The authors.

After the deadline for the exhumation of the bodies has elapsed, and if the family does not attend, the exhumation and human remains are burned in the cemetery itself, being a criminal act that infringes the Arts. 208 to 212 [11] that deals with crimes against religious sentiment and respect for the dead, as well as the release of pollutant gases into the atmosphere (Figure 4). The justification given by the local administration is due to the lack of ossuary in the cemetery.

The violation of technical norms in the operation and adequacy of cemeteries, lack of supervision, lack of planning and environmental management, serve as characteristics of the pressures exerted by anthropic activity, factors that can lead to contamination and pollution of the areas where the cemetery is located. The state of the environment that results from pressures are release of liquid and gaseous cadaveric effluents, solid waste production without proper management, burning of bones due to lack of ossuary, lack of rainwater drainage.

Fig 4: Burnt bones in the cemetery and surrounding areas. Source: The authors.

With all the information, it was possible to assemble the Leopold matrix to analyze the possible negative environmental impacts generated by the cemetery (Chart 1). Seeking to understand the cause and effect of anthropogenic actions on the environment is critical to decision making that will help guide environmental diagnosis and what can be done to prevent and mitigate current and future negative impacts.

			Natural and Human Elements																	
			Physical and Chemical Characteristics							Biological Conditions				Cultural Factors					Ecological Relations	
			Earth		Water			Atmosphere		Flora		Fauna		Human and Aesthetic Interests		Culture				
			Soil Quality	Relief	Surface Water Quality	Runoff Rainwater Quality	Groundwater Quality	Particulate Material	Gases	Trees	Bushes	Birds	Land Animals	Padrão da Paisagem	Urbanização	Health and safety	Job	Income Generation	Food chain	Soil Excavation
Project Actions	Regime Modifications	Habitat Modification	-2	-2	-2	-5	-5	-2	-2	-3	-3	-4	-4	-4	-4	-2	1	1	-2	-3
		Ground Cover Change	-4	-5	-3	-2	-2	-2	-1	-4	-5	-5	-5	-5	-5	-1	1	1	-2	-3
		Drainage Change	-2	-2	-2	-1	-2	-2	0	-1	-1	-1	-1	-2	-2	-1	1	1	-2	-5
	Space Transformation	Ditches	-5	-5	-4	-2	-2	-3	0	-4	-4	-3	-3	-5	-2	-3	1	1	-2	-5
		swelling	-1	-3	-1	-1	-1	-1	-4	-1	-1	-1	-1	-3	-3	-1	1	1	-1	-1
		Human Bodies	-5	-5	-5	-3	-5	-1	-5	-1	-1	-1	-1	-5	-5	-5	1	1	-5	-5
	Operation	Cleanliness and conservation	-2	-1	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	2	1	-2	-2

Chart 1: Leopold Matrix for the São Luís Cemetery - Escada - PE.

Ways to mitigate the responses presented by the Leopold matrix would be through the Environmental Risk Prevention Program (PPRA) or Immediate Tomb Recovery to prevent leakage of liquids from colliquing and also treatment of any gaseous effluents, using, for example, activated carbon.

There are some products that can neutralize or retain leachate, serving as methods to mitigate the environmental impacts caused by cemeteries. The absorbent blanket, used to prevent the leakage of leachate, is also an efficient resource, consisting of a resistant plastic, which has a cellulose layer and a powder that in contact with the effluent turns into a gel [12]. [13] suggest the use of tablets containing a huge amount of selective bacteria that have a high capacity to digest organic matter also serve as resources to minimize environmental impacts. These naturally occurring products, also called bioenzymes, contain select strains of bacteria that are highly digestive of organic matter, gradually activated as they come into contact with leachate, transforming the organic compound complexes into carbon dioxide and water. These bacteria come in spore form and are gradually activated. The pellets are placed inside the funeral urn, and as the body releases the leachate they are activated and digest these substances. [14] suggests the use of oxidizing substances in burials, such as anhydrous calcium oxide (lime) or calcium peroxide, an oxidizing substance that maximizes decomposition due to its acidity and minimizes leakage of leachate to the soil.

There are numerous solutions to the environmental problems generated by cemeteries, where studies by [12, 13, 14] for example, prove the efficiency. However, the existence of a solid waste management plan for proper sanitary disposal of the generated waste and vector control is essential for the reduction of environmental risks. The construction of an ossuary and the implementation of an adequate rainwater drainage system to safely capture and route rainwater runoff are essential for proper management.

8. Conclusions

With this study it was observed that the main negative environmental impacts generated by the cemeteries are linked to the non-compliance with current norms, lack of supervision, environmental management and a multidisciplinary team of trained professionals. Considering these areas as potential source of environmental impacts, it is necessary to rigorously license, supervise, monitor and monitor cemetery activity;

In the cemetery studied is notable the lack of health and environmental care, which can generate significant environmental impacts for the environment and public health. Liquid and gaseous effluents generated by the rotting process can contaminate the soil, surface and underground water bodies;

Given the emphasized problems, it is possible to consider the areas of study suspected of contamination and environmental pollution, but it is necessary to carry out a deeper environmental analysis of geological and hydrogeological characteristics;

The application of the Leopold matrix tried to show the operation of the Escada - PE cemetery, demonstrating the links between the environmental elements, social and political agents. Several data were selected for the application of the matrix, but the difficulty to access information that should be public, the lack of others and even the non-authorization for data transfer, hampered the analysis.

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