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DYNAMICS OF SURFACE SETTLEMENTS IN LANDFILLS IN THE MUNICIPALITY OF JABOATÃO DOS GUARARAPES, PERNAMBUCO, BRAZIL

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ABSTRACT

A source of social and environmental problems, the disposal of waste is a global difficulty and has attracted looks that aim to mitigate these evils. The study of the structure that receives this waste is of fundamental importance, aiming at the stability of these lands. Thus, the research deals with a comparative analysis in solid landfills on a large scale, being an old dump and a landfill, monitoring surface settlements. Considered the first year after the deactivation of the cells, the behavior of the discarded mass was known, through the implantation of superficial reference points, located on the shoulders during the operation period. These landfills are borderline and in the same physiographic conditions as Jaboatão dos Guararapes. The results revealed the elevation behavior of the structure and its direct relationship with climatic variations, also observing the influence of clay mineralogy in relation to the settlements.

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INTRODUCTION

In September 2018, the World Bank issued a report on the volume of waste generated worldwide, warning that, without urgent action, a 70% increase in this volume by 2050. Rapid urbanization and increased population or volume increase of waste to 3.4 billion tons, from 2.1 billion tons estimated in 2016. The report still warns about the management of chemical waste and is critical for health and a sustainable environment, but it is almost always ignored, especially in developing countries (World Bank, 2018). Harmful effects on health and the environment have been known since antiquity and periods over time have used different methods to contain or increase the volume. A method that lasted through the centuries and was extremely popular in the early 20th century was incinerated.

Many residential buildings in the United States, for example, were built with garbage incinerators, with entrance to the building. In the 1920s, it was common for garbage and ashes to be used to burn waste and other areas of the city that would cause groundwater contamination (Barles, 2012). For safety reasons, residential incinerators were disappearing, and the first landfills were designed by digging a hole or trench, filling it with trash and covering it with earth. In most cases, garbage and residues were placed directly on the ground without a barrier or containment layer that prevented the water that passed through the waste from catching contaminants (bleach), leaving the landfill and contaminating groundwater (Hickman, 2016). In 1955, the American Society of Civil Engineers published the first rules for a "landfill" that suggested compacting the waste and covering it with a layer of soil every day to reduce odors and control rats.

Modern landfills are specifically designed to protect human health and the environment, and although a large amount of waste is reused, recycled, or energetically recovered, landfills still play an important role in the waste management strategy (Conde *et al*. 2014). The practice of monitoring urban solid waste (MSW) has become a requirement of government environmental agencies and the Public Ministry, and is an excellent instrument for scientific research, as it allows to know the adopted system, its performance, its evolution, its effectiveness maintenance, its potential, limitations and deficiencies. This work aimed, therefore, to evaluate the dynamics and the evolution in the superficial settlements in cells closed in two solid waste landfills, monitoring their stability and knowing the behavior of the disposed mass, through the implantation of landmarks located parallel to the beginning of the operations of each landfill, the results being discussed from the perspective of the time and soil mineralogy.

MATERIALS AND METHODS

The study was divided into three stages: in the first stage secondary data from the landfill, called A, were collected and analyzed, where cell 8 was chosen, which had the highest number of points with data available during the period from January to December 2017 being analyzed, 9 points. In the second stage, secondary data from the landfill, called B, were collected and analyzed, where cell 1 was chosen, which was selected because it had the same number of points in the cell, 8 from landfill A, during the period from January to December 2017. Dates corresponding to the first year of cell deactivation. In the third stage, an improved study of landfills and a comparison between the analyzes carried out in landfills "A" and "B" during the period from September 2017 to July 2019 was carried out.

Study area: Landfill "A" is in the rural area of the municipality of Jaboatão dos Guararapes, in the town of Muribeca dos Guararapes, close to the Integration Hub in Prazeres - Jaboatão, about 16 km from the center of Recife. The disposition limit is between the following UTM coordinates: 280,952 m to 281,894 m - East and 9,096,694 m to 9,097,472 m - North, SIRGAS 2000, meridian 33, spindle 25, occupying an area of approximately 60 hectares. Landfill B was successor to landfill A, allowing it to close in 2010. It was the first large-sized landfill licensed in the State of Pernambuco, and which allowed the closure of Landfill A. Serves the capital, neighboring cities and the Suape Industrial Pole , with the capacity to receive around 5,000 tons of waste per day. The current disposition limit is between the coordinates: 281,288 m to 282,324 m - East and 9,096,079 m to 9,096,796 m - North, with an area of approximately 60 hectares. It is also located in the rural area of the Municipality of Jaboatão dos Guararapes, in the locality of Muribeca dos Guararapes, close to the Integration Hub in Prazeres - Jaboatão, about 16 km from the center of Recife, next to the Closed Landfill of Muribeca (Figure 1). About the climate, it is a tropical coastal region of monsoon rains almost all year round, with an "Ams" climate in the Köppen-Geiger classification. The municipality is in a tropical climate region, with average temperatures between 32°C of maximum and 18°C of minimum. The relative humidity is high, reaching an average value of 79.2%, with a maximum of 83% in May and a minimum of 74% in December (Nóbrega *et al*. 2016). According to Lins (2003), it presents precipitation throughout the year with the highest peaks observed, on average, in June and July, at approximately 400 and 370 mm of rain, respectively. The rainy season takes place between March and July, with precipitation between 230 and 400 mm monthly. The lowest levels of precipitation were observed from October to December, with values ranging from 62 to 68 millimeters per month. The historical average of evaporation between 1971 and 2008 leads to the conclusion that the landfill region presents greater evaporations between the months of October and December, with values ranging from 169 to 176 mm, in agreement with the dry season, where the lowest precipitation occurs.

Figure 1. Spatial characterization of landfills A and B located in the municipality of Jaboatão dos Guararapes by aerial survey. Source: The Authors (2020)

As far as geology is concerned, the Municipality of Jaboatão dos Guararapes comprises three large lithological clusters, formed in different periods, in the time span of 2,500 million years ago to the present. The lithology comprises lithotypes of the Pernambuco-Alagoas Massif, lithotypes of the Pernambuco Group and tertiary and quaternary cover sediments, distributed along the coastal strip, according to a study by the Geological Survey of Brazil (RIGEO, 1997). It is still possible to observe rocks that sometimes appear on the surface of the land, sometimes covered by their respective soils or by the sediments of the plain. Granitic rocks with different aspects (textures and structures) were identified, classified as granite. These rocks emerge at various points in the area and are generally not very fractured. In some points, mainly in the northern part, these fractures appear sealed by quartz veins, forming protruding ribs in relation to the rock surface, this condition being an important factor for making it difficult for water to infiltrate rock fractures, making them completely impermeable. , which is positive about serving as a base for landfills. When analyzing the geological stratigraphy of soils with Qa description, which are soils from the quaternary period, being sedimentable, the behavior of this sandy-clay material is obtained, according to a study by Amorim (2004) in Table 1.

Tabela 1. Metodologia de classificação da suscetibilidade à expansão

Susceptibility	Crystalline rocks	Sedimentary rocks	Sediments
High	Mafic rocks; mica schists; carbonate rocks	Claystone; leaflets; marine limestones	Clays
Average	Intermediate rocks	Arcósios; siltites and calcareous sandstones	Clays Sand-clay sediments
Low	Rocks rich in quartz; quartzites	Artisan sandstones	Quyartzosas sands; organic matter; peat

Source: Amorim (2004).

Data collection: The data were obtained through a set of superficial landmarks, called repression plates, consisting of a concrete structure with a trapezoidal shape measuring 60 cm in height, 40 x 40 cm at its largest base and 20 x 20 cm at its top, with a center marked by a steel pin, a reference for topographic measurements, being installed semi-buried in the perimeter of each cell. The readings were performed with a total station, brand TOPCON, angular precision 5” and linear 2mm / ± 2ppm, aiming a stick with a vertical prism, on the repression plate. The trigonometric leveling method was used to obtain the vertical displacements taking the average sea level (NMM) as the reference datum and supplied by the concessionaires of each landfill. This method consists of the identification of vertical distances by trigonometric principles. The plates were distributed in order to characterize study lines, with expected displacement directions, to allow monitoring the evolution and movement of the landfill and, therefore, to guide the preventive and mitigating actions that are necessary to maintain control of the massif's stability. To carry out this monitoring, fixed, irremovable landmarks, of reference level and absolute position, were implanted outside the landfill area, where vertical displacements were observed by monthly topographic survey according to this reference. To establish a comparative study between the two landfills, 18 plates were analyzed: 9 in cell 8 of Landfill A (or Dump A), named A1, A2, A3, A4, A5, A6, A7, A8 and A9, and 9 in cell 1 of Landfill B , called B1, B2, B3, B4, B5, B6, B7, B8 and B9 (Figure 2).

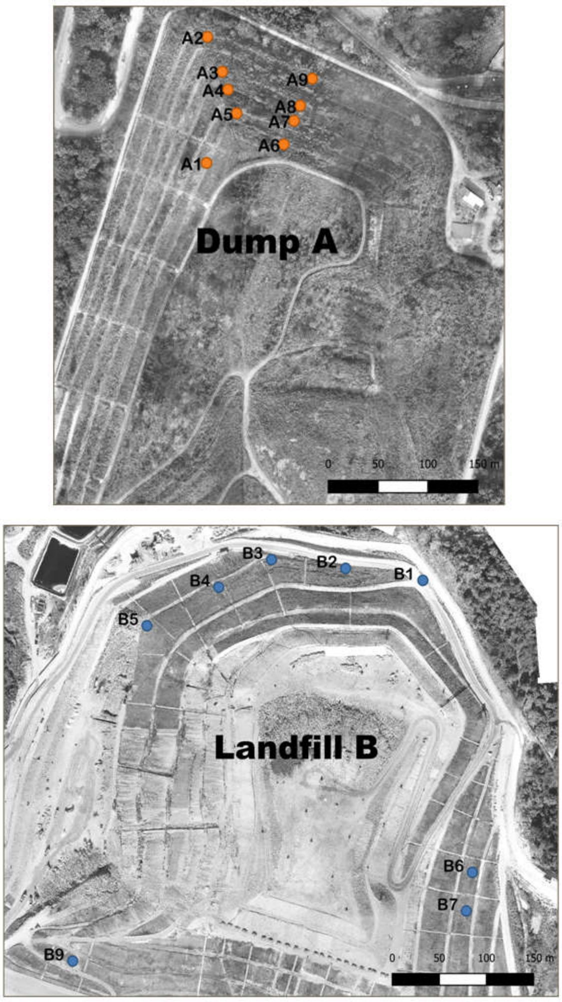

Figure 2. Distribution of surface landmarks within the cell studied at each landfill. Source: The Authors (2020).

The criterion for choosing the plates was given by the volume of data offered within the analyzed period, since, during that time, some plates initially implanted were lost. Regarding the location of surface landmarks, where they were located equidistantly, preferably on the projected slopes. Thus, defined as these are the places most vulnerable to instability, providing vertical and horizontal displacement data. For the analyzes, only the vertical settlement data were addressed because the data were available in the period for the two landfills, thus allowing comparisons.

Analysis of the soil in the cover layer: The granulometric analysis was carried out, according to NBR 7181/2017, to recognize the soil grain size in two parts: sieving and sedimentation. Sieving was used to separate particles that vary in size above 0.074 mm. This separation is due to the use of sieves of different sizes, where it is possible to analyze different types of soil. Sedimentation was used for grains smaller than 0.074 mm. The coarse material that is retained in the sieve 10 was washed (on top of the same sieve) by water jet to remove all the soil present in these grains. The rest of the sieve was taken to the greenhouse for 24 hours. After drying, it was necessary to weigh the dry sample. A weight P of a dry soil sample is taken and sieved. For sedimentation, an amount of soil was taken and passed through the sieve 10 and dispersed in water, which adds, for better dispersion of the elements, a deflocculant (sodium hexametaphosphate). The soil was left to rest, where the solution acted in 24 hours. Then, the entire solution was placed in a 1000 cm^3 beaker and supplemented with distilled water. The cylinder was placed in a constant temperature and environment. The mixture was stirred inside the cylinder for 1 minute and a hydrometer, previously tared, was introduced, reading the gradation of its progressive sinking from 30s, 1min, 2min, 4min, 8min, 15min, 30min, 1h, 2h, 4h, 8h, 25h, from the moment the test tube was immobilized. At the end of this process, all the material that was in the beaker was washed with a water jet, in the number 200 sieve. The washed material goes to the oven, where it was dried for 24 hours. Then, the same screening procedure was used for coarse soils, with a difference only in the sieve openings. Only granulometry was not enough to classify soils with a texture rich in fine particles, since their plastic properties depend on the moisture content, with which the different soil states are defined.

Thus, the main characteristic that allowed the identification of clay soils was plasticity, defined as the property of a soil, in a humid state, which will undergo great deformations without suffering rupture (Barba *et al*. 1997). The liquidity limit was determined by the Casagrande device, which consists of a brass plate, in the shape of a shell, on an ebonite support by means of an eccentric, printing to the plate, repeatedly, falls from a height of 1 cm and intensity constant (NBR 6459/2017). The Plasticity Limit (LP), on the other hand, was determined by calculating the percentage of moisture by which the soil started to fracture when it was attempted to mold it into a cylinder shape of 3 mm in diameter and about 10 cm in length. After the test, the sample was weighed on a sensitive precision analytical balance and taken to the oven for 24h to have a constant weight (established humidity) (NBR 7180/2016). For the analysis of soil expansiveness, the criteria established by Carvalho *et al*. (2015) were used, as shown in Table 2. For the determination of the geotechnical studies, 4 (four) soil samples were collected in triplicate, 50% of the samples from the deposit of Landfill “A” and another 50% of the deposit of Landfill "B" in order to determine the physical indexes of each type of soil.

Analysis of Gravimetric Composition: Obtaining and evaluating these data proved to be extremely important for understanding the variation of future settlements according to the levels of local organic matter. To characterize the waste quantitatively, the collection truck weighed over a period of 6 consecutive days from Monday to Saturday, in which the approximate average demand for waste generated was obtained. To characterize the waste qualitatively, we used Waste Sampling according to NBR 10007/2004. It is noteworthy that even obtaining the data in a secondary way, the standard was properly executed and monitored by professionals who developed theses (Mariano *et al*. 2007; Teixeira, 2015).

RESULTS AND DISCUSSION

Landfills are dynamic structures with varying life spans, where even after they are closed, their mass remains active through the decomposition of organic matter inside. From this perspective, knowing the anatomy of the landfill, its form of waste disposal, its composition, surface settlements and the study of the soil become of fundamental importance to direct the comparative approach object of this study.

Anatomy and layout of the MSW: Landfill A, closed together with cell 8 object of this research, had its useful life defined by two distinct moments of its anatomy. First and most of the time, it was classified as a dump, that is, an open waste discharge, where, according to Lopez (2017), urban solid waste (MSW) is simply disposed of without any protection or control measure. In the second moment, and the last year in operation, the landfill went through a transition period, assuming procedures that would lead it to a new classification: controlled landfill, defined by the Brazilian Association of Technical Standards, NBR 8419/1992 as a disposal of solid waste on the ground in order to minimize environmental impacts and without causing damage or risks to public health or the environment. Despite this attempt to adapt, Dump A had its closure requested in the same year by the government in view of the pressure exerted by the current guidelines and subsequent sanctioning of Brasil (2010) that instituted the National Waste Policy Solids (PNRS), containing indicators for integrated management and waste management, acting as a beacon for the construction of sanitary landfills and the adequacy of the dumps of the 5,570 municipalities and the Federal District (Ardenghi, 2013).

Even so, even if it remained in operation, the controlled landfill would not be considered an adequate form of waste disposal because it would not avoid the problems of environmental contamination since all the engineering and sanitation resources that would prevent contamination of the environment are not used. The second place analyzed was landfill B, which received a different classification from the two mentioned above and is classified as a landfill. In this anatomy, the disposal of solid urban waste does not cause damage to public health, reducing environmental impacts. This method uses the engineering principles to confine solid waste in a reduced area and in a reduced permissible volume, being covered by soil at each working day NBR 8419/1992. Considered environmentally correct, it is an accepted method and indicated by environmental agencies because it makes the project, operation, and environmental requirements compatible with local potentialities, minimizing the impacts on the environment and public health (Vilhena, 2017). After the start of operations and as the landfills were receiving the MSW and their cells were being filled, both started to mold the existing relief, thus filling the voids on the slopes and adopting mamelonar characteristics, with flattened tops due to the traffic of trucks, depositors of materials (Figure 3).

Composition of the MSW: No destination for the type of waste collected, Landfills A and B (Dump A and Landfill B) receive class II waste, that is, they are not hazardous NBR 10007/2004. It should be noted that a large portion of the return is associated with the degradation of these residues, being formed by natural or artificial materials of different categories, shapes and sizes, which may exhibit significant variations in their transformation and degradability characteristics, according to the conditions of Alcântara (2007). However, in addition to knowing the type of waste, it was important to survey the percentages of each material contained in the mass, where different decomposition rates were verified, directly influencing the results of water studies. The data of this composition were obtained from substantial research in authors (Mariano *et al*. 2007; Teixeira, 2015) whose object of study was a delimited area, resulting in the following classification (Figure 4). As predicted, in landfills that receive domestic waste, an amount of organic matter is higher when compared to other materials. As you can see, or the organic matter content in soil A shows higher than the minimum required amount of air B. The amount of plastic in the two humidity levels shows similar numbers, followed by paper / paper also with less variation. Metals, wood, textile materials, rubber, leather, glass, and coconut were found in lesser quantities in both landfills. Considering only the composition of the waste as a fundamental variable for surface settlements and the high levels of organic matter, it is suggested that Dump A may tend to have greater settlements when compared to landfill B.

Analysis of surface settlements: Although many variables act in this process of biodegradation, an auxiliary parameter has been showing satisfactory results with regard to the evaluation of the speed and the decomposition stage of this matter: the monitoring of repression is also a useful tool to assess the potential of increasing life landfill and its use after closure. It is noteworthy that landfill settlements occur in 3 distinct stages, defined by Teixeira & Pinheiro (2018) as: a) initial compression, when an external load is applied and, consequently, the reduction in the void index, occurring due to the weight itself waste and the dissipation of interstitial pressures, within 30 days; b) primary compression, as caused by the dissipation of capillary water and gas from empty spaces. This stage can happen right after the placement of the waste, that is, in a few months; c) secondary compression, caused by mechanical interactions and long-term slippage through the late compression of some constituents of the waste. At this point, once the deposition activities cease, changes begin to occur causing deformations in the form of repression, which can have negative effects on the integrity of the structure. Considering this behavior, the study focused on this last stage of compression, where the repressions start to offer guiding elements for more conclusive behavior and stability analyzes. The monitoring of settlements aims, at first, to verify that the measured deformations are within an acceptable range, so that the integrity and the proper

Table 2. Criteria for the classification of expansive soils based on free expansion and expansion stress

Criterion by Seed et al. (1962)	Criterion of Vijayvergiya and Ghazzaly (1973)		Degree of expansiveness
Free expansion (%) for overload voltage 7 kPa	Free expansion (%) for overload voltage 10kPa	Expansion voltage (kPa)	
0-1	<1	<30	Low
01/may	01/apr	<30 – 120	Average
may/25	04/oct	120-300	High
>25	>10	>300	Very High

Source: Carvalho et al. (2015).

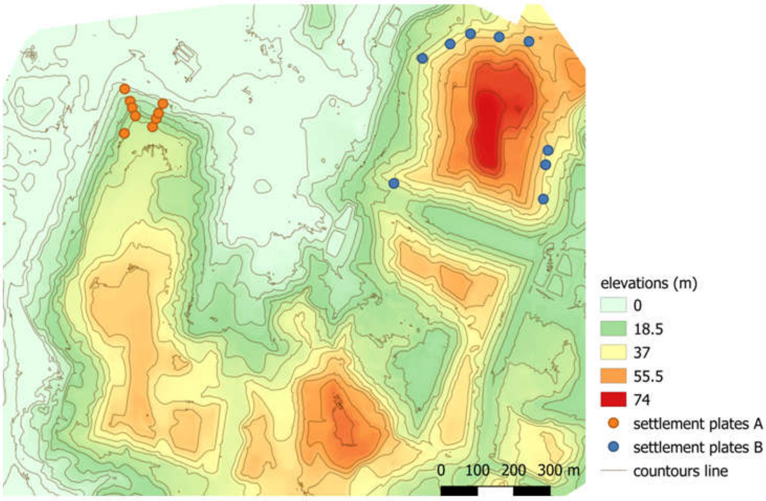

Figure 3. Plan altimetric survey with hypsometric map revealing dimensions Source: The Authors (2020)

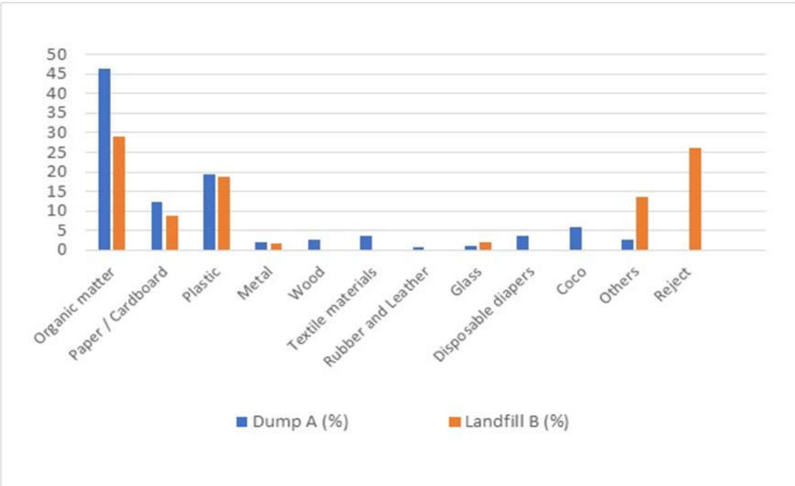

Figure 4. Gravimetric composition of landfills A and B. In blue gravimetric composition of Landfill, A in % and in orange gravimetric composition of Landfill B in %. Source: Adapted of Mariano et al. (2007) and Teixeira (2015)

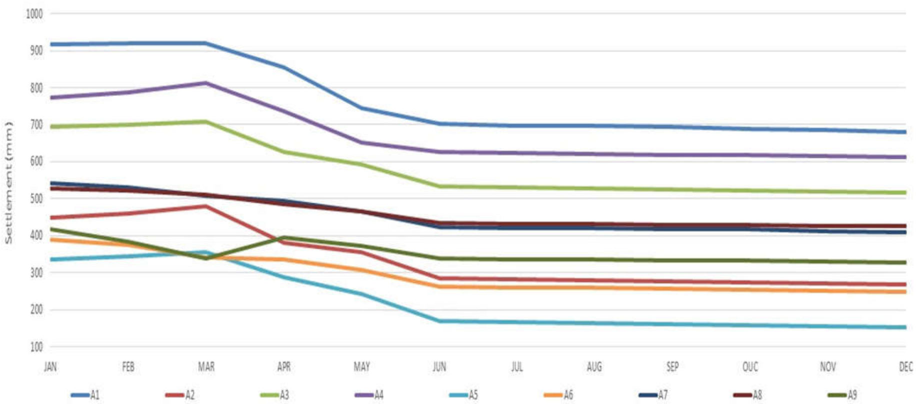

Figure 5. Analysis of settlement for the period of one year at the Landfill "A" Source: The Authors (2020).

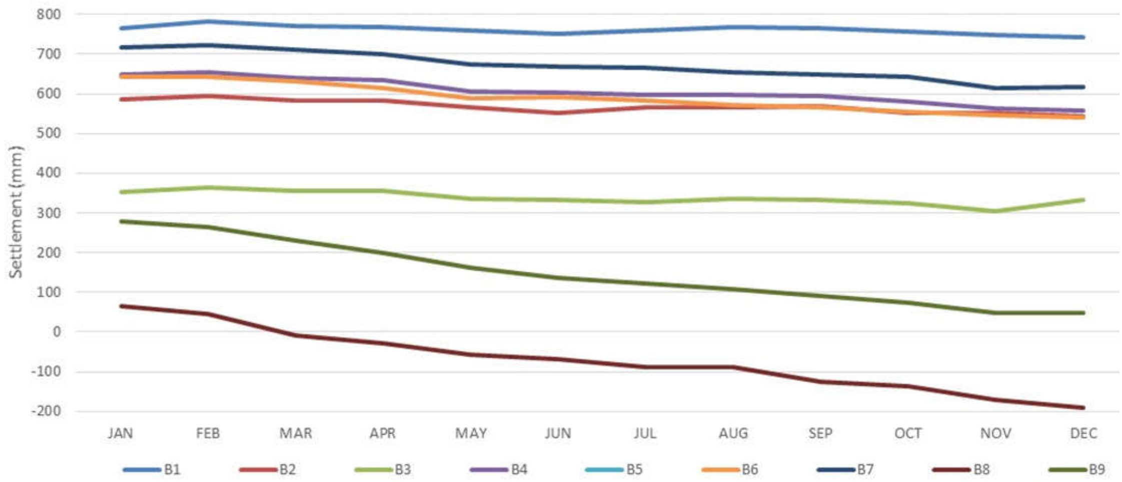

Figure 6. Analysis of settlement for the period of one year at the Landfill "B" Source: The Authors (2020)

functioning of the landfill are ensured (Alcântara & Jucá, 2010). According to Figures 5 and 6, it was observed that at Landfill A, the largest gap was found at point A1, being -237 mm, while at Landfill B, the highest value found was -254 mm at point B8, being very close to B9, with -230mm. In spite of the points mentioned with the highest difference in landfill B, Dump A is the one that shows a more accentuated repression behavior in most points, with unevenness always above 100mm, with the exception of point A9, with 88 mm. At Landfill B, the behavior shown refers to a variation of unevenness, much less evident, with most of the points indicating values below 100mm, especially points A1, A2 and A3, below 50mm. It was verified in this comparison that the quotas in Dump A referred to a more significant annual difference than in Landfill B, reaching an average difference of 111.35% greater in dump, within the same period. After this general analysis, where only the first and last reading on each plate were considered, weighting Tables 1 and 2 mentioned above, it was necessary to observe some factors mentioned in the literature as more active in this process, with the introduction of liquids what receives greater prominence, followed by the composition and disposal of solid waste. Benson *et al*. (2007) also affirm that these liquids can influence through a series of mechanisms, causing additional settlement increasing the specific mass and biodegradation

In order to establish this correlation with the presented settlements, monthly data of pluviometric precipitation in the proposed years were collected (Table 5) and later plotted in a comparative way with the accumulated settlements also on a monthly basis, since the climatic conditions and the composition of the residues present themselves as relevant factors and, therefore, they should also influence the evolution and magnitude of the repression observed as a function of the grounding time (Alcântara & Jucá, 2010). Analyzing the monthly variation, the first quarter in both landfills was marked by a behavior that refers to positive settlements, that is, the quota collected in the month is higher than the quota collected in the previous month, causing the land to rise in level. This phenomenon was again more noticeable at Landfill ‘A’, being seen at points A1, A2, A3, A4 and A5 and less markedly at Landfill B, being found on all plates, except for point B9. In relation to the subsequent quarters, the two landfills offered a similar behavior with regard to the type of settlement and different in the way this settlement occurred between the months, that is, in landfill “A”, all points started to present negative settlements, where the superficial landmarks indicated ever decreasing quotas, this difference being more accentuated in the months of April and June, punctually the months with the greatest accumulated rainfall in the year. From July onwards, the elevation variations were smoothed, consonant with a slope more uniform, remaining so until the end of the analyzed period. At landfill “B”, performance in the second quarter is similar to landfill “A” in terms of the type of settlement, with a downward trend in its quotas, but in a more uniform way without sudden drops between months, being more apparent until the middle of the year. third quarter, remaining mostly negative and with no major changes during the year studied.

Coverage soil analysis: With the results of the behavior of the structure where some points showed “positive settlements”, in the first quarter of the two landfills, it was suspected that there was an active presence of an expansive material in the covering soil. The term "expansive material" is used to refer to those materials that preferably contain potentially unstable clay minerals with laminar structures, such as montmorillonite, vermiculite, chlorite, and interstate. They are materials that have high liquidity limits and high plasticity. When dry they are hard, but easily lose their resistance when they absorb water (Presa, 1984). In order to understand this behavior, there was then a need to geotechnically explore the area in question, where for this purpose, granulometric and expansive soil analyzes were performed, according to NBR 7181/2017 at the Geotechnics Laboratory of the Federal University of Pernambuco (UFPE) in July 2019. For the determination of geotechnical studies, 4 (four) soil samples were taken, 2 from the landfill A deposit and 2 from the landfill B deposit to determine the physical indices of each soil typology. The granulometry and sedimentation tests allowed to obtain the percentages of each type of particle present, from the largest diameters to the smallest diameters. The granulometric curve of the soil samples shows the presence of a well-graded soil by drawing the graph, as also observed in the studies by Freitas & Neves (2017). Table 6 shows the percentages of the particle size fractions of the analyzed samples, from a test performed at the Geotechnical Laboratory at Federal University of Pernambuco, Recife, Brazil. The samples indicated a SC (Sand-Clay) soil, according to the classification of the Unified Soil System.

Table 6. Consistency Indices and Unified Soil Classification System

Sample	Soil Consistency Limits (%)			Moisture (%)	Unified Soil Classification System
	LL	LP	IP		SUCS
1	46,07	29,47	16,6	21,03	SC (sand with clay)
2	46,43	29,46	16,97	16,89	SC (sand with clay)
3	50,32	30,02	20,3	17,61	SC (sand with clay)
4	46,88	30,06	16,82	15,16	SC (sand with clay)

Fonte: The Authors (2020).

Table 7. Colloidal activity of soil samples

Sample	Plasticity Index (IP)	Fraction percentage of particles < 2 μ
1	16,6	0,59
2	16,97	0,57
3	20,3	0,62
4	16,82	0,58

Source: The Author (2020).

Table 8. Results of the expansion edometric tests

Sample	Free expansion (%)	Expansion pressure at constant volume (kPa)
1	2,9	10,00
2	6,65	12,50
3	10,95	32,50
4	8,7	20,83

Source: The Author (2020).

Tests were carried out to determine the consistency indexes (Atterberg Limits) (Table 6), and it is advisable to check the soil moisture levels to determine the Liquidity Limit (LL), the Plasticity Limit (LP) and the Plasticity Index (IP) being the numerical difference between the Liquidity Limit and the Plasticity Limit (IP = LL-LP). IP is used as one of the parameters for soil classification; the higher the IP value, the more plastic the soil appears. As for the colloidal activity (Ab) data presented in Table 7, the samples revealed themselves as low activity clays based on indexes established by Skempton (1953), with particle fraction percentages less than 0.75. However, the most common clay in the analyzed soils was Ilita, since the variation of the samples showed results between 0.57 to 0.62. In order to understand the degree of expandability of the soil, obtaining parameters to relate it to the behavior of the studied settlements, it was necessary to use the direct quantitative method with free expansion edometric tests, revealing the behavior of the 4 samples collected in a simulated to natural environment, that is, saturated (Table 8).

According to Ataíde & Ferreira (2016), economic development in conjunction with the country's environmental policies is increasingly expanding studies on expansive soils, since they have a direct relationship with engineering projects, especially about maintenance and service life of the structures. The results of the expansion can be seen, varying, in percentage terms, to the lower limits of 2.9 and the upper limit to 8.7. With the free tension test, an overload of 10 Kpa was applied, characterizing the behavior of the soil as having medium expansiveness in sample 1, high in samples 2 and 3 and extremely high in sample 4. The compilation of these results indicates that the covering material in both landfills has in its composition the presence of expansive clays. This material has the property of "positively" deforming the soil, presenting a direct relationship with climatic variations, where the introduction of water from rainfall can lead to several expansion cycles. Forouzan (2016) was one of the investigators of the behavior of these cycles and noted that while some authors found that when the sample of fine soils repeatedly experiences retraction and/ or expansion, the sample will exhibit a phenomenon of fatigue and, consequently, less expansion occurs later. And yet, other authors have expressed that, in case the sample is exposed to a water content below the respective retraction limit, the respective expansion potential increases with the number of wetting and drying cycles, reaching equilibrium after a certain period. number of cycles. The presence of the expansive material may become an agent in the phenomenon of positive settlements, where the terrain shows higher levels in subsequent months. This fact did not necessarily happen in periods with greater saturation, where it has already been observed that the absence of water can also act in this expansion, being an indication of the positive quotas, especially in the first quarter of the two landfills, not being a conclusive statement, due to the many variables acting in the massif.

Conclusion

From the perspective of a comparison between landfills with different forms of disposal, it was possible to establish a correlation between the main mechanisms operating in this type of structure, confirming the importance of the study of settlements as the main guiding tool in the stabilization process of these lands. The study offers as a first finding the presence of a similar behavior with respect to changes in the altimetric profile of the mass during the analyzed period, with its disagreements being observed only in the different intensity with which they occur. In the landfill that had its useful life marked by the absence of regulatory instruments, in this case a landfill in the process of being transformed into a landfill, the settlements were more aggressive, in contrast to a much smaller elevation variation when observed inside a landfill, designed in compliance with the main regulations in force, from PNRS (Brasil, 2010). In this case, the composition of the MSW, without having an effective control of what determines this gravimetry, may be acting significantly in the intensity variations.

It is important to affirm the occurrence of positive settlements in the first quarter of deactivation of the two landfills, where the characteristics of the covering material, in this case the expansive clay, may be acting as a mechanism of action in this type of settlement, considering the tests geotechnical control of surface layers when subjected to the use of materials with expansive possibility. In view of the above, it is important to highlight that although the studied variables are shown to be significantly active in the dynamics of surface repression, this type of structure involves a series of mechanisms with very varied characteristics, being difficult to manipulate, especially when working with cells on a full scale , which confirms the relevance of the theme, in order to present themselves as another tool in the comparison with models in simulated environments, thus facilitating stabilization forecasts for new uses, not conclusive considering only the first year of deactivation.

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