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## Preliminary selection of area to implementation of a landfill at the city of Oliveira, Minas Gerais, Brazil

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### ABSTRACT

With the current population growth of cities, one of its major problems is the solid waste disposal. A landfill is the best solution to final disposal of solid waste; however, the selection of areas to implement the project is a difficult work. This paper presents the results of a preliminary selection of areas for the construction of a landfill at the city of Oliveira, Minas Gerais, Brazil. Three areas were evaluated through the area size, nearest population center's distance, urban center's distance, watercourse's distance, federal or state road's distance, vegetation type and land situation, analyzing advantages and disadvantages of each area for the implementation of a landfill. According to the evaluated criteria and the observed advantages and disadvantages during the preliminary selection, it was verified that the area 03 was the most suitable to receive the landfill, among selected areas.

**Keywords:** urban solid waste, environmental impacts, legislation

### INTRODUCTION

Humanity lives a time marked by consumption, where technology and information are becoming ever more advanced. This society based on rampant consumption of products that are discarded quickly and, in most cases, inappropriately, creates a major environmental problem: the disposal of urban solid waste (BORTOLATTO; AHLERT, 2012). Due to resources lack, administrative shortcomings, environmental awareness absence, among other reasons, waste is placed in inappropriate places,

causing soil degradation and contamination of rivers and groundwater, as well as atmosphere pollution (ELK, 2007).

Insufficient areas for urban solid waste disposal, conflicts of land use between rural and urban employment, the need for creation of integrated municipal solid waste management systems and shared between municipalities, etc., are some limiting aspects for adequate practice of urban solid waste disposal (BRUSCHI, 2011).

The concern about environmental preservation led to the regulations of the National Solid Waste Policy (PNRS) by Law No. 12,305 / 2010, which provides important tools to solve problems related to inadequate management of solid waste. Among these tools, Law No. 12,305 / 2010 aims to close all the dumps and deploy landfills which are appropriate constructions for urban solid waste disposal.

For the landfill implementation, it is important to study the physical environment characteristics aiming create tools for contamination's prevention of topsoil, subsoil and surface and groundwater, as well as establish geotechnical and geo-environmental criteria for planning of use and occupation of soil (ROCHA et al., 2015). An appropriate choice of areas means less risk to environment and public health, and ensures a smaller spent with preparation, operation and closure of the landfill (TECHNOLOGICAL RESEARCH INSTITUTE - IPT, 1995).

The area selection for landfills implementation for urban solid waste disposal is a serious trouble to Brazilian public administrations, not only by restrictions for choosing environmentally appropriate areas, but by the lack of specialized persons to develop and implement programs and projects that meet current environmental standards (TEIXEIRA et al., 2006).

The area selection for landfill implementation, when it is done improperly, can seriously compromise the presence of animal and plant species in the region, or become more expensive the landfill operating costs because of inadequate location could hinder transport and search for inert material for waterproofing and coverage of solid waste. Thus, the landfill area selection can provide

problems of gigantic proportions, since that this stage of the project planning interferes in the use and occupation of soil and in society as a whole (NETWORK OF TRAINING AND TECHNOLOGICAL EXTENSION ON SANITATION - ReCESA, 2008).

For characterization of the landfill place, the Brazilian Norm - NBR 8419 establishes some basic criteria that should be considered for the selection and justification of the area selected: environmental zoning, urban zoning, access, neighborhood, transportation economy, economic operating of landfill, urban infrastructure, basin and sub-basin where landfill will be located (BRAZILIAN ASSOCIATION OF TECHNICAL STANDARDS - ABNT, 1992).

The evaluation of suitability of an area for the landfill implementation, according to NBR 13896 (ABNT, 1997), should be made in order to cause minimal environmental impact in its implementation and operation. Thus, the landfill installation should be made based on local zoning, providing its use for a long period of time and be acceptable by the neighboring population.

The areas selection for landfills implementation should consider a set of technical, legal, economic and social factors, often conflicting and interdependent. The usual methodology consists of the preliminary selection of available areas, identification of criteria to be assessed, defining priorities, assessing the fulfillment of the criteria and identification of the most suitable area (ReCESA, 2008).

Population in the city of Oliveira, Minas Gerais, Brazil, is growing and hence the waste generation. And to present date, final disposal of waste

generated by the population has been done incorrectly, in a dump.

Law No. 12,305 / 2010 specifies that final disposal of wastes in landfills becomes mandatory in all municipalities. So, the municipality of Oliveira has to adapt for proper solid waste disposal. And area selection for landfill implementation, performed properly, accurately and based on technical and relevant normative criteria, it is certainly the key to the success of the project to be implemented.

In this context, this study aimed to carry out the preliminary selection of possible areas for a landfill implementation in municipality of Oliveira, Minas Gerais, Brazil, that meets current and future needs of the municipality relative on urban solid waste final disposal.

## MATERIALS AND METHODS

The municipality of Oliveira has an estimated population for 2015 equal to 41,562 inhabitants (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS – IBGE, 2015). The municipality of Oliveira is located in the Brazilian state of Minas Gerais under geographical coordinates 20° 41' 50 "south latitude and 44° 49' 40" west longitude (DB-CITY, 2016).

For area selection for landfills implementation, it is necessary to determine a minimum area that meets current and future needs of the municipality in question. To estimate this minimum area, it was necessary to estimate waste generation over the landfill useful life as well as the useful volume of waste deposition cells, according to the methodology proposed by ReCESA (2008). It was established, for this study, an useful life for the landfill equal to 20 years.

From data collected by Andrade (2015), it was possible to reach a total waste generation in 20 years equal to 362,960 tons, resulting in a total useful volume of waste deposition cells equal to 695,673 cubic meters.

Setting a value for the depth of waste disposal cells, it is possible to estimate the cells coverage area (volume = area x height). According to ReCESA (2008), it is not recommended that cells depth is greater than 5 m to don't difficult entrance and exit of deposition vehicles and waste compacting.

Adopting the value of 5 m for depth of landfill cells, it's obtained an area for construction of cells deposition equal to 139,135 m<sup>2</sup>.

However, a landfill is not composed only by waste deposition cells. There are several other structures and systems that compose the landfill as leachate treatment system, legal reserve, administrative area, access roads, borrow areas, among others.

The area of 13.9135 ha previously calculated refers to required area only for constructing waste deposition cells. To ensure that the chosen area supports also the other systems inherent at a landfill, it will be considered that the selected area must present at least surface equal to twice the area used for waste deposition.

Thus, the possible areas to be diagnosed for the landfill implementation of the municipality of Oliveira should have at least 28 ha of surface.

After estimating minimum size of landfill implementation area, it was proceeded to preliminary selection of suitable areas for the landfill installation in the municipality.

It was selected initially three areas available for landfill implementation. Selection was made by

observing relevant legal aspects related to location in environmental protection and conservation units, proximity airfields and areas with identified environmental risks. It's valid to remember that the area should present at least 28 ha.

For area selection, it was used the Google Earth software and, after selected the three areas to be studied, it was established the parameters that would be evaluated. Selected areas were evaluated through the following parameters: area size, distance from the nearest population center, distance from urban centers, distance from watercourses, distance from federal or state roads, vegetation type and land situation.

After identifying the parameters to be evaluated, it was defined priorities and weights of each parameter to be measured, as it is shown in Table 1 adapted from ReCESA (2008). Later, scores were assigned for each parameter analyzed in each pre-selected area. The final score for each area was obtained by the sum of the product of the weight parameter with its score.

Advantages and disadvantages of each area in relation to its suitability for landfill implementation were also analyzed.

**Table 1** - Criteria for defining the landfill area. Source: Adapted from ReCESA, 2008.

Criteria	Definition/Justification/Observations	Evaluation range	Note	Weight
Distance from watercourses. (A)		< 200 meters	0	
	Relative to distance from watercourses, the Ordinance No. 124 of 08.20.1980 (Ministry of Interior of Brazil)	200 a 499 meters	3	3
	standardizes as minimum distance the value of 200 meters	500 a 1000 meters	4	
		> 1000 meters	5	

Distance from roads (B)	Intensity of certain environmental impacts such as noise, odors and landscape changes, depends directly on the distance from the pollution source relative to the receiver.	< 100 meters	0	1
		100 a 499 meters	3	
		500 a 1000 meters	4	
		> 1000 meters	5	
Distance from urban centers (C)	If landfill is located so far away from urban area, the shuttle service is more expensive. It is recommended a maximum distance of 15 km. Additionally, population is not interested in owning a landfill near the homes. These two factors resulted in the score beside.	100 a 250 meters	1	1
		250 a 500 meters	2	
		500 a 1000 meters	3	
		1000 a 2000 meters	4	
		> 2000 meters	5	

The area that had the highest final score and the highest number of benefits was considered, in the context of the preliminary selection, as the most suitable for the implementation of the landfill.

**RESULTS AND DISCUSSION**

It's shown below the characterization of pre-selected areas for landfill implementation of the municipality of Oliveira.

Area 01 (Figure 1) has 41.6085 ha, with following characteristics:

- Geographic location: between latitudes 20° 39' 52.46" S and 20° 40' 14.98" S and between longitudes 44° 48' 17.61" W and 44° 47' 59.13" W;

- 4 km away from the nearest population center;
- 771 m away from the watercourse;
- 1,645 m away from the state road;
- Undergrowth vegetation;
- 8 km away from aerodrome;
- 6.28 km away from the center of Oliveira;
- Area belongs to a private owner.

Area 02 (Figure 2) has 52.1621 ha, with following characteristics:

- Geographic location: between latitudes 20° 41' 27.02" S and 20°37'19.17"S and between longitudes 44° 48' 44.04" W and 44° 48' 02.04"W;
- 430 m away from the nearest population center;
- 6.54 km away from the center of Oliveira;
- 1,523 m away from the watercourse;
- 37 m away from the state road;
- Undergrowth vegetation;
- 6.04 km away from aerodrome;
- Area belongs to a private owner

**Figure 1** - Area 01. Source: Google Earth, 2013.



**Figure 2** - Area 02. Source: Google Earth, 2013.



Area 03 (Figure 3), has 28.0958 ha, with following characteristics:

- Geographic location: between latitudes 20° 37' 01.72" S and 20° 37' 19.17" S and between longitudes 44° 44' 27.39" W and 44° 44' 12.59" W;
- 22 km away from the center of Oliveira;
- 12 km away from the nearest population center;
- There isn't watercourse near to the place;
- 240 m away from the federal road;
- Undergrowth vegetation for animals pasture, however unused;
- 16.5 km away from aerodrome;
- Area belongs to a private owner.

**Figure 3** - Area 03. Source: Google Earth, 2013.



The criteria for each area were evaluated according to the parameters in Table 1. The notes awarded for each criterion and the final scores are presented in Table 2.

It was verified that area that had best score was area 03, indicating it as the most suitable area for landfill implementation at municipality of Oliveira.

It was also analyzed other parameters complementary of those listed in Table 1. And according to the rules and the parameters analyzed, each area has the following advantages and disadvantages:

**Table 2** – Punctuation of each area.

Criteria	(A)	(B)	(C)	
<b>Weight</b>	3	1	1	
Area 01	4	5	5	<b>TOTAL</b>
<b>Notes</b>				
Area 02	5	0	5	
Area 03	5	3	5	
Area 01	12	5	5	22
<b>Punctuation</b>				
Area 02	15	0	5	20
Area 03	15	3	5	23

Area 01:

Advantages:

- Area size is suitable for landfill construction, being greater than minimum value calculated, and propitiating future enlargement, if necessary;
- The distance from the city of Oliveira is adequate, just 6.28 km, making that the spending with fuel is lower;
- The distance from road is equal to 1,926 m, which is a good value according to Table 1;
- This is an area with grass, with little arboreal vegetation to be removed.

Disadvantages:

- There is a watercourse near the place, which will require an improved soil sealing in landfill construction and frequent monitoring analysis;
- The area does not conform to the Resolution of the National Environment Council - CONAMA No. 04 of 1995 concerning the minimum allowable distance from aerodrome, which is 13 km radius, and the related area is 8 km from an aerodrome;
- The area belongs to a private owner, so, it will be necessary to expropriate, rent or buy the area.

Area 02:

Advantages:

- Area size is suitable for landfill construction, being greater than minimum value calculated, and propitiating future enlargement, if necessary;
- The distance from the city of Oliveira is adequate, just 6.54 km, making that the spending with fuel is lower;
- The distance from road is only equal to 37 m;
- This is an area with grass, with little arboreal vegetation to be removed.

Disadvantages:

- There is a watercourse near the place, which will require an improved soil sealing in landfill construction and frequent monitoring analysis;
- The area does not conform to the Resolution of the National Environment Council - CONAMA No. 04 of 1995 concerning the minimum allowable distance from aerodrome, which is 13 km radius, and the related area is 6 km from an aerodrome;
- The area belongs to a private owner, so, it will be necessary to expropriate, rent or buy the area.

Area 03:

Advantages:

- Area size is suitable for landfill construction, being slightly higher than minimum value calculated;
- There isn't a watercourse near the site, reducing the surface water contamination probability;
- The distance from road is equal to 240 m, which is a reasonable value, according Table 1;
- The area is occupied by pasture for animals that is disabled, with little vegetation to be removed.
- The area is 16.5 km away from aerodrome, complying with Resolution of the National Environment Council - CONAMA No. 04 of 1995.

Disadvantages:

- The area is 22 km away from the center of Oliveira and, according to ReCESA (2008), it's recommended a maximum distance of 15 km. However, the distance of 22 km is the same distance between the current dump and the urban center, which will not alter the current fuel spent of the municipality if deployed the landfill in this area;
- The area belongs to a private owner, so, it will be necessary to expropriate, rent or buy the area.

Analyzing the advantages and disadvantages of pre-selected areas, it is observed that area 03 showed the highest number of advantages (with consequent fewer disadvantages), reinforcing the conclusion that this is the best area for the landfill implementation at municipality of Oliveira in the preliminary analysis performed in this work.

In preliminary selection of area for landfill construction performed in this work were considered physical environment parameters with topographic and hydrological character (size of the area and distance from watercourse), a parameter of biotic environment (type vegetation), predominating parameters related to anthropic environment and legal aspects (distance from the urban center, distance from the nearest population center, distances from roads, land situation and distance from aerodromes).

However, the final selection of an area to landfill implementation involves a careful analysis of above parameters and of other important aspects such as location of environmental protection units and proximity from conservation areas with environment risks identified. It is noteworthy also that areas that do not meet defined criteria legally on any aspect can not be used.

Thus, for area selection to landfill implementation it's necessary considering various important parameters, such as:

- Water table depth, obtained by probing; if the water table is deep, the contamination risk by leachate generated in waste decomposition is lower;
- Soil hydraulic conductivity, which describes the facility with which a liquid percolates through the porous, indicating the greater or lesser susceptibility of contamination of groundwater by leaching;
- Physical and mechanical characteristics of soil, such as texture, plasticity, compressibility and resistance are important to assess the need of borrow areas if the soil of the area is not suitable for its use and exploitation in the implementation, operation and closure of landfill activities;
- Soil thickness is important in implementation and especially the operation of the landfill in order to avoid borrow areas;
- Local fauna and flora should be quantified, because may exist animals endangered and rare that need to be taken to other areas of environmental preservation;
- Average slope, because it can limit the transport of solid waste to the place, among other parameters.

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