Evaluation of Surface Water Quality of The Area of Influence of The Landfill of The City of Manaus/Am

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ABSTRACT

This work aimed to evaluate the quality of surface water around the Manaus Solid Waste Landfill (ARSM), in which it is located near important waterways in a growing urban expansion area. During the collection period, the parameters pH, T, fecal coliforms, OD, DBO5, nitrate, phosphate, turbidity and total solids were monitored, where these are the main parameters for performing water quality index calculations. The results analyzed indicate contamination in the streams near the perimeter of the Landfill, where the possible origins for non-conformities can be problems in draining the leached and waterproofing system of the landfill ponds. The recovery of the quality of these water resources is essential, since it is an area with flora and fauna that are heritage, not only of the residents who occupy their surroundings, but also the population of Manaus who in the past enjoyed bathing and fishing areas in the streams currently affected by the slurry produced in the landfill.

Keywords: Water quality; Surface waters; Landfill

INTRODUCTION

With the expansion of cities and population growth have generated many problems related to the disposal of solid waste. Today one of the world's biggest concerns has been the issue of excessive generation of solid waste and its final disposal, to which it poses risks to human health, biodiversity and water resources. For modern society it remains to face the great challenge of properly managing waste while there is a lack of areas of final environmentally appropriate disposition for these.

This fact has often led to the emergence of sites with inadequate management, and there is mostly the appropriate treatment for slurry thus causing contamination of soil and underground water sources through toxic waste. There are several places where waste is not adequately arranged, covering extensive areas, not observing legal limitations and disobeying the standards and techniques of proper management.

For Monteiro et al, (2001) the lack of support tools and professionals trained in the municipalities are factors that make decisions difficult to make about the sustainability of the waste management system of most municipalities in Brazil. According to Brollo e Silva (2001) what the issue of public health, urban waste, from a sanitary point of view, constitutes a means of transmission of diseases by the action of vectors that are attracted to the places where garbage is disposed, feed and proliferate -if, indirectly being the cause of epidemiological diseases.

The term solid residue presents different definitions, made by several authors. For Hamada (2006), waste refers to things without utility or value, and can also be defined as remnants of human activity which physically contains the same materials that are found in their original products, which had value and Utility. Economic, social, geographic, educational, cultural, technological and legal factors affect the process of generating solid waste, both in relation to the quantity generated and its qualitative composition (ZANTA *et al.*, 2006).

Detailed knowledge of the damage that can be caused in water resources around areas of deposition of municipal solid waste (dumps or landfills) is fundamental for planning preventive and corrective actions. In view of the growth of the urban area towards the area of the Solid Waste Landfill of Manaus (ARSM) and the importance of surface waters (BRASIL 2002), especially in communities and neighborhoods present in the vicinity and do not enjoy public supply (BARRONCAS 1999), CPRM (Mineral Resources Research Company – Geological Survey of Brazil) has been monitoring the contamination of water resources around ARSM since 2006.

According to NBR 8419/92 of the Brazilian Association of Technical Standards (ABNT), landfill is the technique of disposal of municipal solid waste in the soil without causing damage to public health and its safety, minimizing environmental impacts, a method that uses engineering principles to confine solid waste in the smallest possible area and reduce them to the lowest permissible volume, covering them with a layer of land at the conclusion of each working day or at shorter intervals if necessary.

Landfill is recommended as the best way to make up the final layout of urban waste. This technique basically consists of the compaction of waste in the soil, with them in layers that are periodically covered with land or other inert material, forming cells in order to have an alternation between waste and cover material.

Until 2005, the city of Manaus presented as a form of final destination of municipal solid waste a controlled landfill, where the deposited waste was scattered, compacted and arranged in layers, interspersed with clay soil removed from the near the site forming cells. Solid waste from households, hospitals, industries, fairs, markets and complementary services were received on site (weeding, sweeping, gardening and cleaning of streams) were received. As well as, remains of tree pruning and waste from fairs and markets that were moving towards composting (OLIVEIRA, 2007).

The Municipal landfill of Manaus was designed to hold an average daily production of up to 980 tons/day, which would allow a useful life of about 20 years (BARRONCAS, 1999). Exceptionally until 2005, the landfill received more than double the maximum waste capacity provided for in its initial project (SEMULSP, 2006).

The landfill studied in this work has its solid waste collection and transport services executed, in almost its entirety, by two concessionaires and are subdivided, according to concession contract, in five modalities: Home Collection, Mechanical Removal, Manual Removal, Pruning Collection and Selective Collection. A smaller portion of the garbage collected in Manaus comes from third parties, that is, companies providing services, such as disk debris, construction companies, industries, among others, which request authorization to dispose of waste in landfill.

The Solid Waste Landfill of Manaus is the main final destination complex of the city's municipal solid waste. It is located at km 19 of the AM-010 highway, spatially positioned through the geographical coordinates S02°57'23.86" and W60°00'47.62. The complex has an environmental license of operation provided by the Environmental Protection Institute of the State of Amazonas - IPAAM. The estimated area is 66 hectares.

This work aims to analyze possible contamination surface and groundwater around the landfill. The water quality was monitored in wells and streams in the area of influence of the Manaus landfill. The parameters of water quality measured were dissolved oxygen, fecal coliforms, pH, biochemical oxygen demand, nitrate, phosphate, temperature, turbidity and total solids.

MATERIAL AND METHOD

Characterization of Study

The Solid Waste Landfill of Manaus (ARSM), is located at km 19 of the am-010 state highway, at the expansion limits of the urban area, and currently occupies an approximate area of 66 hectares (Figure 1). It is inserted in the Matrinxã creek basin, a tributary of the Acará creek, which joins with the creek of Santa Etelvina to form the creek of Bolivia. Arsm is bordered to the east and north by the Matrinxã creek valley; to the south by a small tributary of this same creek, and to the west by the AM-010 highway. A small portion of the land, closer to the highway, is drained by an arm of the Aracu creek, a tributary of Bolivia's creek.

Figure 1: Satellite image indicating the location around the red line, the landfill of solid waste in the city of Manaus/Am (Google Earth Pro -2019).

Sample Collection

Technical visits were made to the Manaus landfill during the month of May when it was possible to obtain information from the study area. Preceding the in-situ data collection activities, the landfill area was recognized and around it. The aim of the recognition was to analyze the aspects related to the following stops such as: facilities for access to data collection sites (roads and extensions); details of the distribution of the surface drainage network; existing localities (communities, villages, farms, sites, changing rooms, etc.); water supply systems for human consumption; location of the slurry extravasation points and landfill operating conditions. For a more detailed analysis of the site, a topographic map of the Manaus Landfill was elaborated, in order to verify the hydrodynamic behavior around the ARSM (Figure 2).

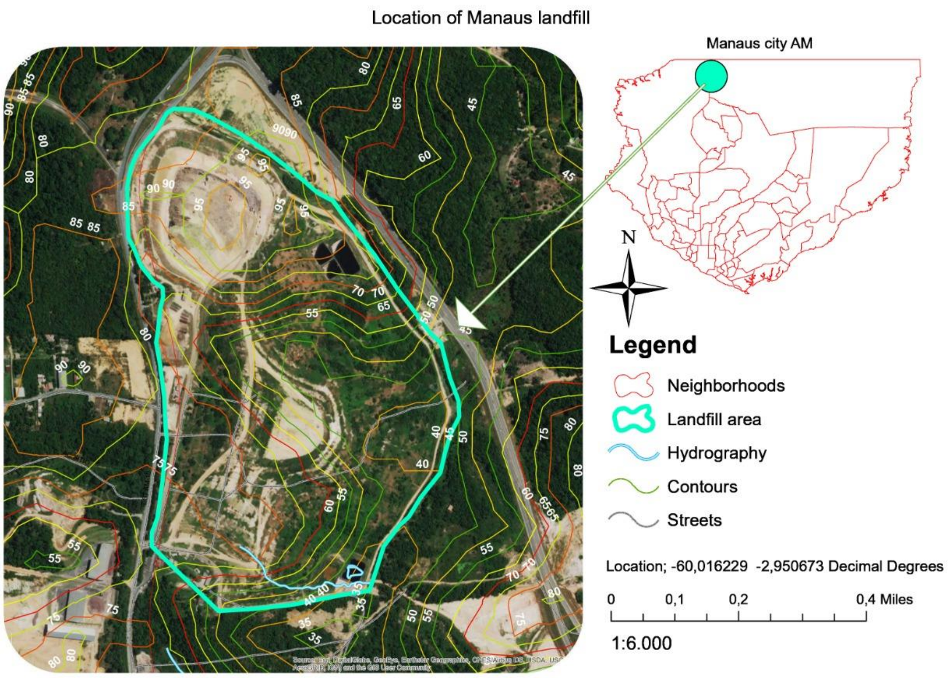

Figure 2: ASRM topographic map.

Surface water monitoring

For the development of the work, three sampling points located in the Matrinxâ igarapé hydrographic basin, near ARSM, were selected. Surface water samples were collected and analyzed during September 2019 to assess the quality of the basin. The first sampling point is situated 1,300 feet from the landfill. The second point is in the same tributary, but there is a kilometer from the first, in the extension of Avenida Governador José Lindoso. And finally, the third point which was approximately 750 meters from the second point.

The results of bacteriological and physicochemical examinations of surface waters in the area of influence of the landfill were compared with maximum values recommended by CONAMA Resolution No. 5/357, Art. 15 – from the sweet waters. The resolution presents the classification of water bodies and environmental guidelines for their framework, in addition to establishing the conditions and patterns of effluent launches.

The collection and analysis of surface water samples were based on the conditions proposed by Rodger (2017). Furthermore, the samples of surface water for physicochemical analyses were performed using one liter vials. On the other hand, bacteriological collection of sterilized 250 mL bottles and laboratory preparations were used. To perform the analyses of BOD5, total solids, pH, turbidity and nitrate nitrogen, 1L sample analyses were collected.

Figure 3: Collection and monitoring of surface water temperature.

Preceding the surface water sampling activities, on-site measurements of three physicochemical parameters were performed: pH, dissolved oxygen (OD) and temperature, made through a digital device kit. These parameters serve to reveal, in preliminary, evidence of possible chemical contamination in the water bodies sampled.

2.4 Characterization of the Water Quality Index

In the characterization of the Water Quality Index, he used some parameters that represent its physicochemical and biological characteristics. These parameters were established by the National Sanitation Foundation (NSF) in the United States, through opinion research with various environmental experts, for the development of an index that indicated water quality.

Thus, nine parameters were considered more representative: dissolved oxygen, fecal coliforms, pH, biochemical oxygen demand, nitrate, total phosphate, water temperature, turbidity and total solids. Each parameter was assigned a weight, listed in Table 1, according to its relative importance in the calculation of the WQI/NSF.

Table 1 - Weight of WQI parameters.

Parameter	Peso (wi) NSF-WQI
Dissolved Oxygen	0,17
Fecal Coliforms (NMP/100 mL)	0,15
PH	0,12
DBO5 (mg/L)	0,10
Nitrates (mg/L NO3)	0,10
Phosphates (mg/L PO4)	0,10
Temperature (°C)	0,10
Turbidity (UNT)	0,08

Total Solids (mg/L)	0,08
TOTAL	**1,00**

Then the WQI is calculated by the weighted production of water qualities corresponding to the parameters according to equation:

$$WQI = \prod_{i=o}^{9} q_i^{wi}$$

Where: WQI, water quality index, a number from 0 to 100; qi= quality of parameter i obtained through the average quality; wi= weight attributed to the parameter, depending on its importance in quality, between 0 and 1. Index values range from 0 to 100, as specified in Table 2, as follows:

Table 2 - WQI Quality Level.

Description (NSF)	FAIXA	Description (CETESB)	TRACK
Poor quality	0 – 25	Poor quality	0 - 19
Bad quality	20 – 36	Bad	20- 36
Medium quality	37 – 51	Regular	37-51
Good quality	52 – 79	Good	52-79
Excellent quality	91 – 100	Excellent	80-100

Source: CETESB (2007)

Thus defined, the WQI/NSF reflects the interference by leaching and other organic materials, nutrients and solids in the quality of water resources.

RESULTS AND DISCUSSIONS

The evaluation of the results of the physicochemical parameters of the surface waters of the Matrinxã-Acará Basin was performed comparing the values obtained in each stage, as well as using reference values existing in RESOLUTION CONAMA No. 357/2005. The results obtained are presented in the following tables:

Table 3: Results of The Dot samples P – 01.

Parameters	Unit	Sample result	VMP
Fecal coliforms	NMP/100mL	$17x10^3$	1.000
DBO_5	mg O_2/L	24,0	5
Phosphate	mg PO_4/L	5,8	NA
Nitrate	mg N/L	1,9	10,0
Dissolved Oxygen	mg O_2/L	6,4	Não inferior a 5
pH	-	7,80	6,0 a 9,0
Total Solids	mg /L	76,0	NA

Temperature	°C	21,5	Inferior a 40°
Turbidity	UNT	12,5	100

VMP: Maximum values allowed by Resolution CONAMA nº. 357/05.

NA: Not applicable

The results obtained through the analyzed sample presented values above the maximum value established by CONAMA Resolution No. 357/05, for fecal coliforms and DBO_5 parameters. The point analyzed is far about 400 m from the perimeter of the landfill and downstream of the release of the treated effluent that does not present a good efficiency in the removal of pathogenic bacteria and organic load, not meeting environmental standards (LATORRACA, 2007).

The launch of this effluent directly reflects on the quality of the Matrinxâ igarapé, where the signs of pollution are visible in the color and odor of water, confirmed in the results of the parameters of DBO_5 and fecal coliforms. These results agree with those obtained in the Cleto (2003) study, where the author verified that the studied area presents variations in the parameters analyzed in different rainfall periods, which at a certain time of year cause dilutions of their water bodies. Thus, natural changes in the physical and chemical properties of the waters of the landfill region are quite common.

Table 4: Results of The Dot samples P – 02.

Parameters	Unit	Sample result	VMP
Coliforms	NMP/100mL	$22x10^3$	1.000
DBO_5	mg O_2/L	26,0	5
Phosphate	mg PO_4/L	6,0	NA
Nitrate	mg N/L	1,5	10,0
Dissolved Oxygen	mg O_2/L	6,3	Not less than 5
pH	-	6,9	6,0 a 9,0
Total solids	mg /L	79	NA
Temperature	°C	22	Less than 40°
Turbidity	UNT	14	100

VMP: Maximum values allowed by Resolution CONAMA nº. 357/05.

NA: Not applicable

Point P-02 is 100 m from the perimeter of the landfill, the values of DBO5 and fecal coliforms presented values above the maximum limits recommended by CONAMA no. 357/05. Probably these results are due to the inefficiency of waste cover and rainwater drainage system, rainwater washes and percolate waste increasing leaching production and flows towards the analyzed point. In a similar study, Jordan and Pessoa (2005) showed that during the rainy season domestic wastewater, presented dark coloration and odor.

It is verified that in point P- 02 the results presented a contamination greater than point P-01, however both points suggest that it is linked to the release of the effluent treated by the sewage treatment system of the landfill. It is observed that the concentrations of organic matter (DBO5) coliforms and turbidity in point P- 01 decreases towards downstream P-02. This decrease may be due to the phenomenon of self-purification or dilution in the spring, since there is a distance between the points of approximately 750 m. However, both points show indicative of contamination.

Table 5: Results of The Dot samples P–03:

Parameters	Unit	Sample result	VMP
Coliforms	NMP/100mL	$40x10^3$	1.000
DBO_5	mg O_2/L	4,5	5
Phosphate	mg PO_4/L	0,09	NA
Nitrate	mg N/L	0,05	10,0
Dissolved Oxygen	mg O_2/L	5,9	Not less than 5
pH	-	7,20	6,0 a 9,0
Total solids	mg /L	51	NA
Temperature	°C	21,50	Less than 40°
Turbidity	UNT	7,00	100

VMP: Maximum values allowed by Resolution CONAMA nº. 357/05.

NA: Not applicable

Point P-03 showed no evidence of slurry contamination, being the only sampling point that presented BOD5 with a result lower than the maximum value allowed by CONAMA Resolution No. 357/05. This result may be due to the distance from the perimeter point of the ARSM, as the sampling point is located approximately 1 km away from the landfill. However, the results of coliforms presented values higher than the standards established by CONAMA Resolution No. 5/357, possibly related to the anthropic occupation on the banks of this stretch of the creek. Water resources may present contamination related to anthropic occupations devoid of sewage system, a fact that contributes greatly to the degradation of this resource (BARRONCAS, 1999).

For the dissolved oxygen parameter, it was observed that at all monitoring points the concentrations remained within the minimum limit of 5mg/L established for class 2 rivers, as recommended by CONAMA Resolution No. 357/05. With regard to samples for microbiological analyses all samples, they are at odds with the bacteriological standards for class 2 waters of CONAMA Resolution 357/2005, with values above 1,000/100 mL of thermotolerant coliforms (fecals).

With regard to the results of the samples for pH, it is necessary to make a caveat with respect to the value range (6.0 – 9.0), used as a reference in CONAMA 357/2005, since in it no specificity of the Amazon Region was taken into account , that is, the natural acidity of black waters, caused by excess humic acids dissolved.

With regard to the results of the samples for pH, it is necessary to make a caveat with respect to the value range (6.0 – 9.0), used as a reference in CONAMA 357/2005, since in it no specificity of the Amazon Region was taken into account , namely, the natural acidity of black waters, caused by excess dissolved humic acids. Santos (2001) found in this course of water, just downstream of ARSM, at different times of the year, pH values ranging from 5.8 to 6.1 and dissolved oxygen from 1.5 to 4.0 mg/L. Such data, compared with those obtained for this study, suggest that contamination intensified sharply.

Thus, it is important to emphasize that the results based on a single sampling campaign, such as that carried out for this study, cannot be considered as a definitive reference, requiring a program to monitor water quality affected by ARSM, so that a picture of variations in diagnostic parameters is obtained throughout hydrological cycles.

Surface water quality index (WQI)

The Figure 4 shows the location of collection points and surface water quality index according to WQI/NSF ranges.

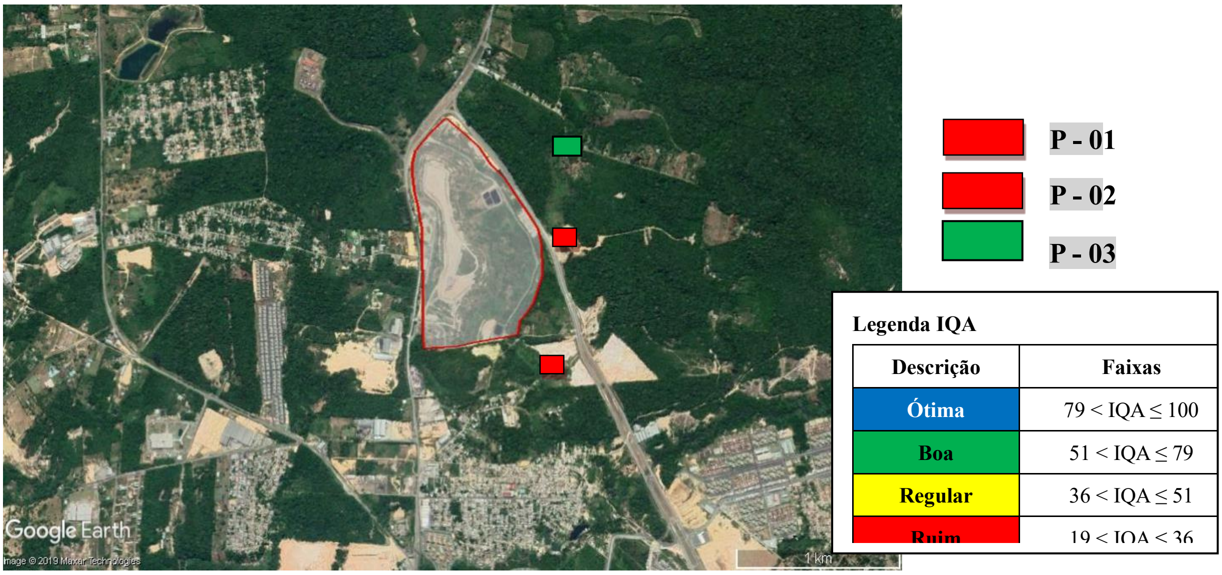

Figure 4: Classification of surface WQI in the area of influence of the ASRM.

The Iq of surface water of point P-03 presented a value of 70, considered good. The results for sampling points P-01 and P-02 presented A Poor Surface Water Quality Index with values of 33 and 31, respectively, probably influenced by the landfill. Points P-01 and P-02 are located on the east bank of the landfill area, where there are indications of slurry contamination, because it presents anomalous values of the main physicochemical parameters, such as pH and DBO5, and the considerable increase in nitrate concentrations, when compared to the sample results of the farthest point and with less influence of ARSM.

Thus, the values of these parameters were very high in relation to the reference values for class 2 waters of CONAMA Resolution 357/2005. It is important to mention that both points are very close to slurry launch sites and during the monitoring stages, the launch of slurry was observed directly on the bed of the Matrinxã creek, coming from the underground drainage pipes of the Landfill.

CONCLUSION

The data produced from the analyzed samples show that slurry from ARSM compromises the quality of the waters of the Matrinxã stream, as can be observed by the comparison between the results obtained for point P-03 (upstream of the landfill), free of contamination, and points P-1 to P-02 (downstream of landfill), with contamination statements.

The slurry produced by the Manaus Municipal Landfill is considered the main source of water pollution identified in this region. Several activities carried out near the Landfill can also contribute to changes in water quality, such as: areas occupied by waste tanks from septic tanks and leisure properties such as clubs, changing rooms and Ranches. As observed in the samples for microbiological analyses all samples, they are at odds with the bacteriological standards for class 2 waters of CONAMA Resolution 357/2005, with values above 1,000/100 ml of thermotolerant coliforms (fecals), even if one of the points is not directly connected to the landfill area of influence. However, the consequences caused by the activities carried out in the Landfill are more aggravating, mainly due to the constant fractures in the layers of waste cover, leaving them exposed.

The AQI of surface water in the area of influence of the landfill for points P- 01 and P - 02presented values of 33 and 31, therefore considered, poor, and is probably directly associated with the poor efficiency of the effluent treatment system of the landfill, highlighting the large amount of coliform organic matter analyzed in the samples. The surface water from the farthest point of landfill P–03 presented the value of 70, considered good, thus does not directly suffer influence of the landfill due to topography and distance.

Therefore, to mitigate the reported situation, it is recommended that the interruption of the slurry to the bed of the Matrinxã stream is carried out as soon as possible, diverting all the slurry generated to the stabilization ponds already existing in ARSM. This measure is essential to initiate the process of environmental recovery of the Matrinxã Stream and, without it, there is no way to think about mitigating the degradation observed a long time ago. There should be greater control in the waterproofing and closure of cells, as well as in the construction and maintenance of the drainage system so that all leached produced is in fact referred to the treatment ponds.

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