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WASTE SOLID MANAGEMENT FROM BALBINA VILLAGE, PRESIDENTE FIGUEIREDO, AMAZONAS STATE - BRAZIL

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ABSTRACT

Brazil is an example of countries in development that has facing several environmental problems due increasing of population together with rise of residue production. It happens because of a great volume of households wastes deposited into the garbage dumps and no adequate waste management. In some Brazilian cities initiatives for an efficient management could be observed. The Amazon State, in focus, has not enough evolution in this way. Over there is not available data about residues management in this State, except in its capital - Manaus. This work was developed in a small village located in the President Figueiredo City. Balbina Village was selected in order to determinate the physical characterization of the household waste class II and III, as well the feasibility study to recycle part of the generated waste. From May to September, eight household waste samples were carried out to demonstrate the physical characteristics of the residues. The results indicated differences in the humidity and weight of dry residue following the local weather seasons. The final result of 0.270 kg/hab/day was considered under Brazilian's cities household waste generation average. The household solid waste management is feasible mainly for organic matter, plastic, paper and cardboard. This work comes out to suggest one household waste management model based on selective collection, including a solution for organic material, that starts in the waste generation source separation going through recycling process and sanitary landfill construction.

Key-words: waste management, selective collection, household waste, recycling.

GERENCIAMENTO DE RESÍDUOS SÓLIDOS DA VILA DE BALBINA, PRESIDENTE FIGUEIREDO, AMAZONAS - BRASIL

RESUMO

O Brasil é um exemplo de país em desenvolvimento que tem enfrentado uma série de problemas ambientais com o crescimento da população e o aumento na produção de resíduos sólidos. Isto acontece porque um grande volume de resíduos domésticos são depositados em lixões e não há gerenciamento adequado para os mesmos. Em alguns lugares do Brasil foram observadas iniciativas de gerenciamento eficaz. Não obstante, no estado do Amazonas nota-se que não há dados disponíveis referentes ao gerenciamento de resíduos sólidos, exceto em Manaus sua capital. Este estudo foi desenvolvido na Vila de Balbina, localizada no município de Presidente Figueiredo-AM, de forma a determinar a caracterização física dos resíduos domésticos de classes II e III, bem como a viabilidade econômica de suas reciclagens. Os resultados indicam diferenças na umidade e no peso seco dos resíduos de acordo com a estação climática. A produção final de resíduos domiciliares foi de apenas 0,270 kg/hab/dia, considerada baixa quando comparada com a de outros municípios brasileiros. O gerenciamento de resíduos sólidos urbanos (RSU) revelou-se viável, principalmente para resíduos orgânicos, plásticos, papel e papelão. Os dados obtidos neste estudo contribuíram para a formulação de proposta de um novo modelo de gerenciamento de RSU, baseado em coleta seletiva, com separação na fonte geradora e construção de um aterro sanitário.

Palavras-chave: Gerenciamento de lixo, coleta seletiva, resíduos domiciliares e reciclagem.

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INTRODUCTION

Brazil produces about 125,000 tons of domestic solid wastes per day in which 68.5 % coming from larger cities were disposed of in garbage dumps (PNSB 2002). Among the 5,507 Brazilian townships, only 451 of them keep selective collection programs, 63.6% have open-air garbage dumps, 32.2% disposed of appropriately in landfills (13.8% sanitary landfills, 18.4% controlled landfills) and 5% gave no answer about how their urban solid wastes (USW) were disposed (IBGE, 2002; CEMPRE, 2002).

The North region of Brazil, with a production of more than 11,000 metric tons of USW per day, deposits about 50% of its waste in garbage dumps (IBGE, 2002). Most townships in this region have no suitable USW management. Manaus is the only township provided by a controlled landfill in the Amazonas State. However, it does not meet the NBR 8849 Brazilian standard.

In Amazonas, due to the lack of adequate waste collection management and basic sanitation, all wastes being produced gets thrown directly into water streams or along their banks (Dos-Santos et al., 2002). Besides chemical, physical, and biological pollution this practice causes obstruction of these water bodies (Valente e Grossi 1999).

According to Souza Vaz et al. (2003), the USW heterogeneity and quantity draw to the need of creating a specific management plans in the townships. Each city should have its suitable waste management model.

An USW integrated management plan is a hard assignment, but necessary to in development countries because of the following factors: a) population growth; b) ever increasing trash volume; c) lack of education in sanitary practices; d) absence of citizen participation; e) reduced government investment, those results in decreasing waste management budgets (Jaramillo 1999). Society and government cooperation is needed to Manager the USW in an integrated way (Monteiro et al., 2001).

According to Gidarakos et al. (2005), in order to have efficient management we should: a) calculate the amount of potentially recyclable materials; b) identify the sources of recyclable and non-recyclable components; c) acquire waste processing equipments; d) evaluate thermal, chemical, and physical waste properties; and e) accomplish to waste disposal regulation and policies.

Therefore, before beginning a waste management program is important to define which approach is most effective for the particular wastes being produced, that is, diagnose the situation. In the case of wastes destined for recycling is necessary to evaluate these different aspects: recycling technological processes; the population education and cultural characteristics; as well as the recyclable local market (Vilhena, 1998).

Reducing the maximum waste quantity disposed into landfills is considered to be modern management philosophy in the international consensus. Fehr et al. (2000) proposed a new management model to Brazil, aiming to selectively collect and dispose of wastes at their source by taking advantage of any available, local biodegradable materials. However, most townships that have developed any kind of selective collecting program still do so according to the traditional model, only some of the potentially recyclable material is being separated right at its source. It took no advantage of nearly 50% that could be used for composting.

Therefore, the present study suggests a USW management model based on a) the physical characterization of USW and b) marketing survey for recyclable material viability to improve the solid waste collection and disposal at Balbina Hydroelectric Plant Residential Village, located at Presidente Figueiredo (Amazonas, Brazil).

Study Area

Balbina Residential Village is situated 86 km from Presidente Figueiredo – tourist city with more than 100 water falls and water streams - and 200 km from Manaus – capital of Amazon State - at the following geographic coordinates: 59°28' longitude west and 01°55' latitude south. It contains 518 residences, distributed in 2 neighborhoods: *Atroari* with 295 residences destined for lower level employees and *Waimiri* with 223 residences, destined for upper level employees. The whole Balbina Village population was 2,955 habitants in 2005.

As Balbina is a closed village, the work process results could be replicated in other similar cities in the Amazon region.

All households produce 5 m³/day of trash. It was collected by a dump truck load used by the City-Hall garbage collection service. The solid wastes produced in the Balbina Village are collected daily from: households, commercial areas, hotels, factories, the hospital, and other businesses. The wastes are packed into plastic bags without any separation, and placed in drums on the sidewalk or hung on gratings or poles, or even into trash baskets randomly scattered throughout the Village of Balbina.

These wastes are hauled to garbage dump located approximately 500 m from Balbina downtown and deposited in trenches. When the trench is filled up it is covered up with earth and a new one is dug. Infectious wastes, such as syringes, needles, dressings and biological materials deriving from the hospital and the public health clinic making up nearly 25 kg/week are separated and delivered to the incinerator, located next to the hospital inside Balbina Village. The incinerator is turned on once per week, usually on Fridays.

METHODOLOGY

Physical characterization

Eight solid waste samples originated from hotels, tourist areas, households and commercial areas were collected from the Village of Balbina. These wastes were removed daily by a dump truck that was also used to remove public wastes such as rubbish, tree prunings, and grass cuttings.

For the physical characterization of the wastes, samples were randomly collected during rainy (winter), and dry season (summer) in May, June, and September 2005. In October (dry season) two simultaneous sample collections were carried out at Atroari and Waimiri neighborhoods, for the purpose of comparing the wastes produced at both sampling area. Each sample consisted of 200 liter container filled up with waste, from each container the following physical variables according to D'Almeida (2000) recommendation were obtained: i) Net weight of waste (kg); ii) Specific weight or apparent density (kg/m^3); iii) Humidity index; and iv) Dry material index.

Gravimetric composition was determined for the eight samples collected from Atroari and Waimiri neighborhoods. These samples had to be collected by hand. Solide residues were separate in paper/cardboard; plastic film; PET; hard plastic; cloth and fabrics; organic materials (food wastes); ferrous metal; non-ferrous metal; glass and scrap to determined each weight percentage.

Per capita waste production (kg/inhabitant/day) was calculated according to the average weight of the waste collected daily by a 5 m^3 capacity dump truck (Total Daily Waste – TDW);

The following equation is used to obtain the per capita average weight daily wastes:

Equation

$$Waste = \frac{TDW}{Number\ of\ inhabi\tan ts}$$

Separate solid waste marketing viability

In Manaus, a survey was carried out on recycling material trade companies. The local City-Hall selective garbage collection professionals were inquired about recyclable materials sold by the group of garbage collector assisted by them. Beside the sales values for recyclable material the costs to transport the material from Balbina Village to Manaus city was considered in the feasibility study.

RESULTS AND DISCUSSION

Physical characterization

Table 1 shows the highest rainfall index (305.5 mm) and lowest humidity index (96.4 mm) occurring in the rainy (May) and dry seasons (September), respectively. The variation between low and high humidity levels is within the mean value found in Manaus (59.3% - Stroscki, 2002) and Brazil (ranging from 30% to 60% - Monteiro et al., 2001). Actually, the mean dry waste moisture index was nearly 40% higher in the dry than rainy season. The apparent, solid waste density was 159.5 kg/m³. This finding points it out to be lower in the Village of Balbina than Manaus (194 kg/m³ - Stroski, 2002).

Table 1

Humidity index and dry waste, of the samples of solid wastes collected in two seasons.

Season	Humidity (%)		Dry Wastes (%)	
	Average	Min./max.	Average	Min./max.
Rainy[1]	52.5	37.8- 69.2	47.4	30.7 – 62.1
Dry[2]	40.0	36.8 – 43.2	79.9	56.7 – 63.1

[1]average of four samples collected in May and June
[2]average of two samples collected in September 2005

Generation of wastes by the residents in the Village of Balbina

The total urban solid waste produced (USW) by the Village of Balbina showed to be 2,097 kg/day, of which is 1,300 kg/day plant debris and 797.5 kg/day domestic wastes. Keeping in mind the number of 2,955 residents (in 2000), a value of 0.700 kg/resident/day was estimated for the USW production. When only the domestic wastes are considered, the estimated production per resident was 0.270 kg. This finding corroborates that found in Brazil for towns up to 200,000 inhabitants (Table 2). The solid waste at the Village of Balbina is not as much as in Manaus, which was the only existing reference regarding USW production for the Amazonas State. Barros et al. (1991) a*pud* Guimarães (2000) report that, in Brazil, each person produces about 0.4 to 0.7 kg/res/day that, depending on the region of the country, could increase up to 1.2 kg/res/day, highlighting that more than half of it corresponding to the production of organic solid waste. Therefore, the data obtained for the Village of Balbina is within the limits reported by them.

Table 2

Number of residents and daily quantity of USW generated by residents in various towns

Town	Number of residents	kg/res/day
Balbina	2,955	0.700
Manaus	1,644,690	1.320
Town[1]	≤200,000	0.700
Town[2]	≤15,000	0.570
Brazil[4]		0.800

Source: [1]Semulsp-Prefeitura Manaus (2005), [2]IBGE- PNSB (2000), [3]IBGE – PNSB (2000), [4]CEMPRE, 2006

Table 3 expresses solid waste quantities obtained in the eight collections carried out in Balbina Village, represented basically by organic matter. Organic material concentration values are within the limits found in other Brazilian townships (Table 4), the mean production of which is around 52% (D'ALMEIDA, 2000). Ferrous and non-ferrous metal quantities show no significant differences from those in other Brazilian townships (CEMPRE, 2004).

Aluminum, due to have a high aggregate value, was practically non existent in solid waste material. Recycling in Brazil, principally of aluminum and paper, approaches that found in developed countries (CEMPRE, 2005). Plastic film, rigid plastic and PET bottles were the second most found solid waste material of the Village of Balbina corresponding to 14.1% of the whole amount studied. It was similar to that produced in Brazil (15% - CEMPRE, 2000).

Paper and cardboard represented the third largest (11.2%) amount of solid waste component found in the Balbina Village. It was similar to values e found in every big Brazilian metropolis, such as São Paulo, Rio de Janeiro, etc (CEMPRE, 2004).

Due to the socioeconomic difference between Waimiri (greater income) and Atroari (lower income), solid wastes were collected simultaneously at each community, for ascertaining whether they were any different as to their composition (Figure 1). There were practically no differences among industrialized products, such as plastic and others, conversely organic material and scraps were the

wastes most found in Atroari and Waimiri. The production of organic material was lower in Atroari, in contrast the scrap production was higher in Atroari than Waimiri.

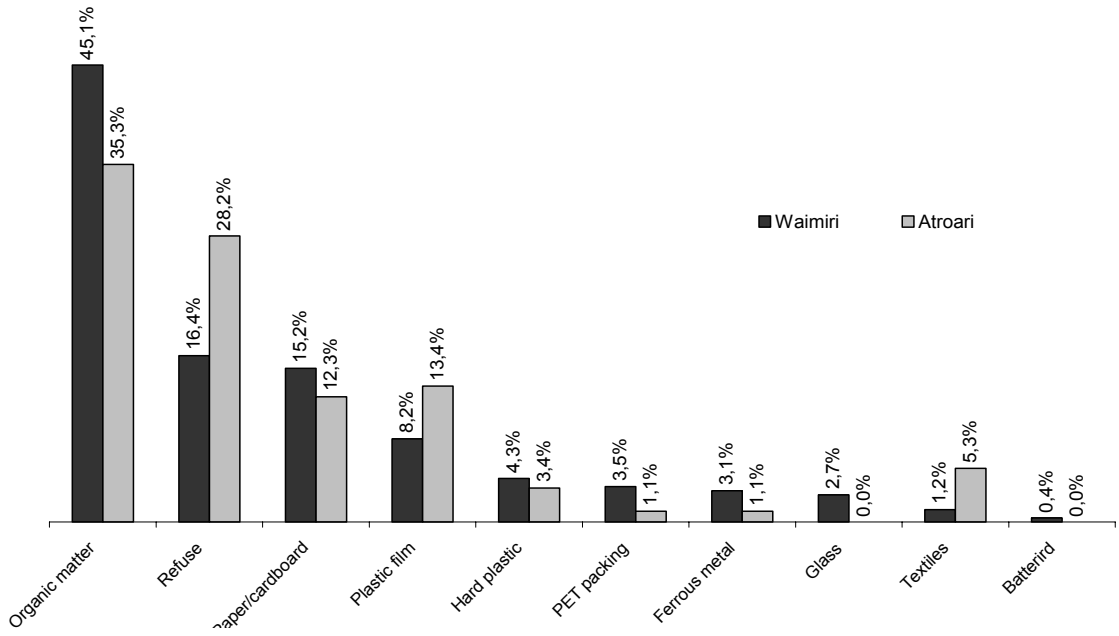

Figure 1: Solid waste produced by Atroari and Waimiri neighborhoods, 2005.

Feasibility Study

The recyclable material market in Amazonas State is in its initial stage. In Manaus, only few companies are trading this recyclable material on account of its high price fluctuations due to demand and dollar rates of exchange. The recyclable material, such as plastic, ferrous and non-ferrous metals, is separated according to category and sold to recycling enterprises located in São Paulo, Rio de Janeiro, etc. This business is feasible only after 30 days of storage. The amount of storied material could justify the transport cost between the source and the companies. In this way paper/cardboard, plastic, glass and metals could be storied to transport once a month to Manaus.

Table 3 prospected the weekly, monthly and yearly potential amount to generate recyclable material and the associated value for each kind of material in Manaus.

Table 3

Average gravimetric composition of wastes in weight and percentage, according to material type, Village of Balbina (Waimiri and Atroari neighborhoods)

Material	Vila Balbina1			Waimiri²		Atroari²	
	(kg)		%	(kg)	%	(kg)	%
Organic matter	17.74	± 4.17	55.60	11	45.10	10	35.30
Refuse	3.54	± 1.36	11.10	4	16.40	8	28.20
PET packing	0.40	± 0.35	1.30	3.7	15.20	3.5	12.30
Ferrous metal	0.78	± 0.55	2.40	2	8.20	3.8	13.40
Paper/Cardboard	3.58	± 1.15	11.20	1.05	4.30	0.95	3.40
Batterird	0.03	± 0.05	0.10	0.85	3.50	0.3	1.10
Hard plastic	1.21	± 0.44	3.80	0.75	3.10	0.3	1.10
Plastic film	2.87	± 0.63	9.00	0.65	2.70	0	0.00
Fabrics	1.08	± 0.89	3.40	0.3	1.20	1.5	5.30
Glass	0.68	± 0.57	2.10	0.1	0.40	0	0.00
Total	31.91	± 5.1	100	24.4	100.00	28.35	100.00

[1]Average value related to the eight collections,
[2]Value relative to one collection

Paper, cardboard, plastic, ferrous and non-ferrous metals are more profitable. The shipment of glass to other states is impractical due to their weight, volume and fragility. Organic wastes may be used to produce organic compost.In the economic point of view the return on sales is lower, but the social and environmental return is intangible.

Balbina Village could avoid 85 ton/year coming direct into the garbage dump. It means 30% of USW recycled.The utilization of 160 ton/year of organic material to prepare fertilizer make the final USW to the dump landfill reduced to 14,5% of the initial volume. The useful time for the dump landfill and for the future sanitary landfill will be extended.

Table 4

Comparison of the gravimetric composition of the solid wastes from the Village of Balbina with those of some Brazilian capitals

Material	**Balbina** **%**	**Manaus[1]** **%**	**Rio de Janeiro[2]** **%**	**São Paulo[3]** **%**
Aluminum	0.0	0.0	0.0	0.69
Organic material	55.6	45.2	42.4	58.07
Ferrous metals	2.4	3.6	2.6	1.44
Paper/Cardboard	11.2	18.0	23.6	10.52
Plastics	14.1	18.5	23.7	16.45
Batteries	0.1	0.0	0.0	0.12
Fabrics	3.4	2.6	0.0	4.06
Glass	2.1	2.0	3.5	1.65
Other	11.1	10.1	4.2	7.00
Total	**100.0**	**100.0**	**100.0**	**100.00**

Source: [1]Storski, (2002), [2]Silveira (2004), [3]Limpurb, Prefeitura de São Paulo (2003)

Table 5

Estimated value for recycled materials

Recycled Materials	Value/kg US$[1]	Weekly value		Monthly value		Annual value	
		kg	US$	kg	US$	kg	US$
Paper and cardboard	0.05	627	31.35	2.685	134.25	32,220	1,611.00
Scrap iron	0.03	136	4.08	585	17.55	7,020	210.60
Plastics	0.14	784	109.76	3.360	470.40	40,320	5,644.00
Glass	0.03	119	3.57	510	15.30	6,120	183.60
Total		1,666	148.76	7,140	637.50	85,680	7,649.20

[1] exchange of the dollar – 1 US$ = R$ 2.101. Source: Bank of Brazil-2006

CONCLUSIONS

The data obtained prove that there was not knowledge about waste production information, the potential for waste recycling and composting of organic wastes in the Balbina Village. Despite the small amount collected daily, a correct treatment or utilization of the solid wastes is not taking place. The final disposal occurs in an open air garbage dump. A correct USW management is important to reach environmental returns in a region with a lot of waterfalls, rivers and water streams.

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