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COMPARARISON OF THE EMERGIES IN THE COLLECTION OF URBAN SOLID WASTES IN SÃO PAULO, SIENA AND MODENA: RECOVERING OF RECYCLABLE MATERIALS AND PRODUCTION OF PRE-COMPOST

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ABSTRACT

São Paulo generates daily sixteen thousand tons of solid wastes. The collection and discard of solid wastes is a fundamental issue for the city, affecting several areas of the municipality, from economical to social and environmental issues. The large quantity and its importance in life quality of citizens pose great challenges to the public administrators. In this work emergy accounting was employed in order to compare the separation and collection system of municipal solid wastes carried out in São Paulo with that performed in Siena and Modena. These cities were selected because data on emergy accounting were available in proper literature. The data used in this work for the city of São Paulo were obtained from public administrators responsible for the collection and disposal of solid wastes. Two (pre)composting plants were specifically evaluated. Eight per cent (in mass, w/w) of the solid wastes generated in the city are sent to these (pre)composting plants. The solar emergy of the fuel and of labor used in the three cities were employed for comparison, because they are a significant part of the resources used in all three systems of municipal collection (more than 70 % in solar emergy, sej/sej). Benefits brought by materials collection are accounted. The collection and material recovery performance are discussed on the basis of the Net EYR values. It is also proposed that emergy accounting (simplified in this case) is a useful tool to those in charge of collection services and waste treatment.

1. INTRODUCTION

One of today's challenges is to know what to do with municipal solid wastes, which is not an easy task. The wastes issue affects all the systems that form a modern society, from the economical system to the public health. Tools that help those who manage the waste collection in their decision-making are of great importance and in this area emergy accounting proves to be a useful tool. In a society, increasingly more complex and richer, the quantity and variety of wastes generated is remarkable.

The quantity of solid wastes generated in São Paulo daily is sixteen tons, from which 90 % (w/w) are dispatched to sanitation landfills. Thus, the challenges are to diminish and to manage the quantity of solid wastes delivered to landfills. Among the proposals to diminish the wastes land filled, there are processes to generate organic compost and to recover materials that can be recycled, like plastic, paper, glass, iron/steel and aluminum.

The aim of this work is to compare the results of emergy accounting for the collection and separation of municipal solid wastes in the cities of Sao Paulo, Siena and Modena, with respect to the use of fuel and labor. The performance of each system and the methodology use were evaluated.

2. COLLECTING SYSTEMS

2.1. São Paulo

During the period studied, from January to December 2002, São Paulo had two active sanitation landfills, three transshipment stations, one treatment station of health wastes, two (pre)composting plants and one incinerator. In the present, the incinerator and one of the (pre)composting plants are not working. The city was divided in nine groups of waste collection. Eight private companies perform the collection of solid wastes night and day. The urban solid wastes are generally packed in plastic bags left in front of the residences from where they are taken by a collecting team. A collecting/compacting truck, a driver and four collectors usually form the collecting teams. In some cases, there may be three collectors per team at night. From the solid wastes collected 55 % (w/w) are sent straight to the landfills, 35 % (w/w) to the transshipment stations, 2 % (w/w) to incinerators and treatment stations of health wastes and 8 % (w/w) to the (pre) composting plants. The focus of this study is the solid waste sent to the (pre)composting plants. In figure 1 the diagram shows the energy flow for the portion of solid wastes that goes to the (pre)composting plant in São Paulo.

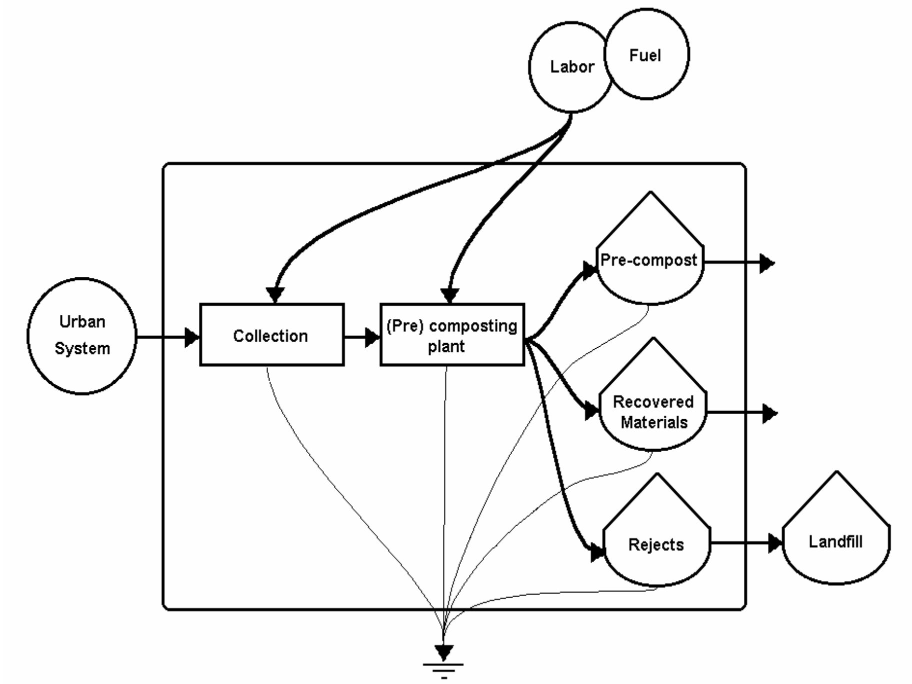

Figure 1. Flows of energy in waste collection and separation of a composting factory in São Paulo

After the collection phase, the waste is sent to the (pre)composting plants where it is submitted to separation processes. The objective is to separate materials that may harm the quality of the pre-compost produced with the organic waste. At the (pre)composting plant the following steps are performed for the waste treatment: a) distribution of the waste in cesspools; b) conveyor belts for the recyclable materials; c) separation of the rejects; d) electromagnets; e) biodigestors; f) storage shed for discard of the process rejects.

The collecting/compacting trucks deposit the waste in a yard in the plant. From the yard the wastes are placed in cesspools. A conveyor belt carries the waste to the biodigestors. Next to each conveyor belts there are four workers who collect the recyclable materials: one person separates the glass, other separates the paper, the next one separates the aluminum and the last one separates the plastic. The materials separated from the conveyor belts are placed in proper containers. At the end of each conveyor belt there is an electro magnet that separates ferromagnetic materials. After the passage through the electro magnet the wastes go to the biodigestors. The organic materials stay in the biodigestors for partial decomposition. The pre-compost produced goes to conveyor belts and pass through a bolter that performs a last separation. The pre-compost that goes through the separation bolter falls on a last conveyor belt, ready for commercialization. The pre-compost produced in the (pre)composting plant cannot be applied directly to soil, without stabilization, because it still presents intense microbiological activity. The pre-compost purchased must be placed in plastic baskets (1 m diameter per 1.5 m height), revolved and moistened weekly, by 52 days to achieve maturation of the organic compost [1]. The Vila Leopoldina plant is located in an area close to a vegetable and fruit distribution center. The producers bring their products to this distribution center and go back to their farms with the (pre)compost produced by the Vila Leopoldina (pre)composting plant, optimizing the use of their vehicles.

2.2. Siena and Modena

The information about the collection in the city of Siena was obtained from the work of Luchi and Ulgiati [2]. The city of Siena may be divided in an inner older city and an outer modern city. The inner city is internal to medieval walls, the modern city external to the walls. Because of the physical nature of old Siena (on a hill, with stairways and narrow streets without pavement) the waste collection is a hard task. The administration of the city offers plastic bags for disposing and separating waste materials that may be used according to the size and color of the bags. The pre-selected waste is left next to the streets and is collected manually by an operator in a small truck every morning. This kind of collection must be fast, so that the waste does not remain in the street for too long. Outside the medieval walls, the streets are built according to modern construction regulations and the collection is easier. People separate organic and reusable materials at home and place these materials in large containers located at a short distance from their homes. Big semi-automatic trucks, driven by a single operator, do the collection. Organic materials are collected every day and reusable materials once a week. Therefore, there are two different collection processes: the collection of the old city and the collection that takes place in the modern city. For each process, three different kinds of collection were identified: a) paper collection, b) multi-material (glass, iron, aluminium and plastic) collection and c) organic material collection. Paper collection is exclusive for this material. The data from the city of Modena, shown in Table 4, were obtained from Tiezzi´s work [3]. The treatment of wastes in Modena comprises the selective collection, recycling, composting, thermo combustion with recovery of heat and production of electricity. As to the process of collection itself, there is no information in the mentioned work.

3. METHODOLOGY

The emergy values for Siena and Modena were taken from the literature [2, 3]. The data concerning the quantity of collected wastes and the quantity of people working in the collection and separation of solid wastes for generating the pre-compost in São Paulo were obtained from reports of the Department of Services and Buildings [4-6] of the São Paulo municipality. Visits have been made to the Vila Leopoldina plant to study the flow of wastes since their arrival at the plant until the transformation in pre-compost. The values of the transformities shown on Table 1 were obtained from the literature. The transformity adopted for labor was that corresponding to Italy in [7]. The same labor transformity was used for all systems compared herein, because it was intended to compare only the physical and technological reality of each system. In this way, the economic level of both countries does not affect the results. In order to normalize the working units, the value of the human labor that in Luchi and Ulgiati [2] is given in years was converted into joules in this work.

Table 1. Emergy per unit used in this work

Item (*)	Unit	Emergy Per Unit (sej/unit)	Ref.
Labor (value calculated for Italy)	J	7.38 E+06	7
Fuel	J	6.60 E+04	8
Paper	g	3.88 E+09	9
Glass	g	2.16 E+09	10
Iron/steel	g	4.13 E+09	10
Plastic	g	5.85 E+09	10
Aluminium	g	1.25 E+10	10
Pre-Compost	g	1.27 E+08	11
Fraction for compost	g	1.27 E+08	11

(*) emergies per unit are relative to materials production. The emergy per unit used for pre-compost and for the fraction for compost were assumed to be that of organic manure.

For São Paulo, the mass values of recovered materials and of the produced pre-compost are shown on Table 2. The emergy of the labor to recover the recyclable materials is the sum of the labor used in the collection of wastes plus the labor used for selecting the recyclable material carried out in the (pre)composting plant. The human labor to obtain the pre-compost is formed by the labor used in the collection plus the sum of all labor used in materials separation and the biodigestion process performed in the (pre)composting plant. The fuel expended was calculated only for the process of solid wastes collection, disregarding the fuel used inside the (pre)composting plant, as this value is negligible compared to that associated to collection. With the values calculated for the recovered materials (plastic, paper, aluminium, iron and steel and glass) and pre-compost, human labor and fuel, the corresponding emergies were calculated as shown on Table 2. The values corresponding to outer Siena, inner Siena and Modena are shown in Tables 3, 4 and 5, respectively.

Table 2. Emergy and Net EYR of recovered materials and pre-compost produced in São Paulo plant

Notes	Item	Unit	Unit / yr	Emergy Per Unit (sej/unit)	Solar Emergy (sej/yr)	Net EYR (*)
1	Paper	g	2.58E+09	3.88E+09	1.00E+19	0.99
2	Labor	J	1.35E+12	7.38E+06	9.96E+18	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
4	Glass	g	1.02E+09	2.16E+09	2.20E+18	0.22
2	Labor	J	1.35E+12	7.38E+06	9.96E+18	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
5	Iron/Steel	g	5.44E+09	4.13E+09	2.25E+19	2.22
2	Labor	J	1.35E+12	7.38E+06	9.96E+18	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
6	Plastic	g	4.99E+09	5.85E+09	2.92E+19	2.89
2	Labor	J	1.35E+12	7.38E+06	9.96E+18	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
7	Aluminum	g	1.54E+08	1.25E+10	1.93E+18	0.19
2	Labor	J	1.35E+12	7.38E+06	9.96E+18	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
8	Pre-compost	g	2.07E+11	1.27E+08	2.62E+19	1.97
2	Labor	J	1.78E+12	7.38E+06	1.31E+19	
3	Fuel	J	2.33E+12	6.60E+04	1.54E+17	
Net EMERGY yield ratio (Net EYR) of the system (**)						**1.44**

(*) The simplified Net EMERGY yield ratio of each material was calculated dividing the net emergy of each material by the sum of labor and fuel emergies. (**) The simplified Net EMERGY yield ratio of the system was calculated dividing the sum of all materials net emergies by the sum of the highest values of inputs emergies. For fuel, 1.54E+17 sej/yr was used, and for labor 1.31E+19 sej/yr.

Notes

1. Data obtained from the Department of Services and Buildings [4-6] of the São Paulo municipality.

2a. Labor used in the collection/separation of paper, glass, iron and steel, plastic and aluminum in the (pre)composting plant.

People employed in the collection	356	workers
Days of work per year	301	days/year
Energy of the metabolism	3.00E+03	kcal/day
Conversion factor	4.19E+03	J/kcal
Total energy per year	**1.35E+12**	**J/year**

2b. Labor used to obtain the pre-compost in the (pre)composting plant:

People employed in the collection and in the (pre) composting plant	470	workers
Days of work per year	301	days/year
Energy of the metabolism	3.00E+03	kcal/day
Conversion factor	4.19E+03	J/kcal
Total energy per year	**1.78E+12**	**J/year**

3. Fuel for collection

Kilometers per fuel liter	1.80E+00	km/L
Distance covered per month	6.78E+04	km/month
Months of collection per year	12	months/year
Liters spent in the collection per year	4.52E+05	L/year
Total of wastes collected per year	3.55E+05	t/year
Total collected per fuel liter	7.86E+00	t/L
Total collected for composting per year	4.95E+05	t/year
Fuel for collection per year	6.33E+04	L/year
Conversion factor	36.80E+06	J/L
Energy for collection per year	**2.33E+12**	**J/year**

From note 4 to note 8. Data obtained from reports of the Department of Services and Buildings [4-6] of the São Paulo municipality.

Table 3. Emergy and Net EYR for collection in Siena (outer city)

Item	Unit	Unit [a]/ yr	Emergy Per Unit (sej/unit)	Solar Emergy (sej/yr)	Net EYR(*)
Specific collection					
Paper	g	3.09E+09	3.88E+09	1.20E+19	473.61
Labor [b]	J	2.67E+09	7.38E+06	1.97E+16	
Fuel	J	8.50E+10	6.60E+04	5.61E+15	
Multimaterial collection					
Glass	g	8.20E+08	2.16E+09	1.77E+18	93.74
Labor [b]	J	1.80E+09	7.38E+06	1.33E+16	
Fuel	J	8.50E+10	6.60E+04	5.61E+15	
Iron/steel	g	9.91E+08	4.13E+09	4.09E+18	216.62
Labor [b]	J	1.80E+09	7.38E+06	1.33E+16	
Fuel	J	8.50E+10	6.60E+04	5.61E+15	
Plastic	g	1.26E+08	5.85E+09	7.37E+17	39.01
Labor [b]	J	1.80E+09	7.38E+06	1.33E+16	
Fuel	J	8.50E+10	6.60E+04	5.61E+15	
Aluminium	g	4.48E+06	1.25E+10	5.60E+16	2.96
Labor [b]	J	1.80E+09	7.38E+06	1.33E+16	
Fuel	J	8.50E+10	6.60E+04	5.61E+15	
Net EMERGY yield ratio (Net EYR) of the system(**)					**282.19**

[a] values taken from Lucchi and Ulgiati [2]. [b] In the original paper [2], labor quantity is represented in years. The conversion of year in joules was done as follows: Labor emergy (sej/yr) divided by solar transformity (sej/J) equals labor quantity (J). This procedure warrants that the total emergy remains the same. (*) The simplified Net EMERGY yield ratio of each material was calculated dividing the net emergy of each material by the sum of labor and fuel emergies. (**) The simplified Net EMERGY yield ratio of the system was calculated dividing the sum of all materials net emergies the sum of fuel and labor emergies.

Table 4. Emergy and Net EYR for collection in Siena (inner city)

Item	Unit	Unit [a]/ yr	Emergy Per Unit (sej/unit)	Solar Emergy (sej/yr)	Net EYR(*)
Paper	g	3.60E+08	3.88E+09	1.40E+18	10.01
Labor [b]	J	1.69E+10	7.38E+06	1.25E+17	
Fuel	J	2.27E+11	6.60E+04	1.50E+16	
Glass	g	9.52E+07	2.16E+09	2.06E+17	1.47
Labor [b]	J	1.69E+10	7.38E+06	1.25E+17	
Fuel	J	2.27E+11	6.60E+04	1.50E+16	
Iron/steel	g	5.02E+08	4.13E+09	2.07E+18	14.86
Labor [b]	J	1.69E+10	7.38E+06	1.25E+17	
Fuel	J	2.27E+11	6.60E+04	1.50E+16	
Plastic	g	1.93E+07	5.85E+09	1.13E+17	0.81
Labor [b]	J	1.69E+10	7.38E+06	1.25E+17	
Fuel	J	2.27E+11	6.60E+04	1.50E+16	
Aluminium	g	5.50E+05	1.25E+10	6.88E+15	0.05
Labor [b]	J	1.69E+10	7.38E+06	1.25E+17	
Fuel	J	2.27E+11	6.60E+04	1.50E+16	
Net EMERGY yield ratio (Net EYR) of the system(**)					**5.44**

[a] values taken from Lucchi and Ulgiati [2].
[b] In the original paper [2], labor quantity is represented in years. The conversion of year in joules was done as follows: Labor emergy (sej/yr) divided by solar transformity (sej/J) equals labor quantity (J). This procedure warrants that the total emergy remains the same.
(*) The simplified Net EMERGY yield ratio of each material was calculated dividing the net emergy of each material by the sum of labor and fuel emergies.
(**) The simplified Net EMERGY yield ratio of the system was calculated dividing the sum of all materials net emergies by the sum of labor and fuel emergies.

Table 5. Emergy and Net EYR of collection in Modena

Item	**Unit**	**Unit [a]/ yr**	**Emergy Per Unit (sej/unit) [b]**	**Solar Emergy (sej/yr)**	**Net EYR(*)**
Paper	g	2.38E+09	3.88E+09	9.23E+18	48.26
Labor	J	2.26E+10	7.38E+06	1.67E+17	
Fuel	J	3.72E+11	6.60E+04	2.46E+16	
Glass	g	2.17E+09	2.16E+09	4.69E+18	154.26
Labor	J	1.81E+09	7.38E+06	1.34E+16	
Fuel	J	2.58E+11	6.60E+04	1.70E+16	
Aluminum	g	8.24E+06	1.25E+10	1.03E+17	1.32
Labor	J	7.53E+09	7.38E+06	5.56E+16	
Fuel	J	3.44E+11	6.60E+04	2.27E+16	
Plastic (Quartiere Crocetta)	g	7.92E+07	5.85E+09	4.63E+17	15.79
Labor	J	1.31E+09	7.38E+06	9.67E+15	
Fuel	J	2.98E+11	6.60E+04	1.97E+16	
Fraction for Compost	g	5.10E+08	1.27E+08	6.48E+16	0.19
Labor	J	7.53E+09	7.38E+06	5.56E+16	
Fuel	J	4.29E+12	6.60E+04	2.83E+17	
	Net EMERGY yield ratio (Net EYR) of the system(**)				**42.96**

[a] values taken from Tiezzi [3].
[b] the transformities used are the same used to São Paulo and Siena, different from the original paper.
(*) The simplified Net EMERGY yield ratio of each material was calculated dividing the net emergy of each material by the sum of labor and fuel emergies.
(**) The simplified Net EMERGY yield ratio of the system was calculated dividing the sum of all materials net emergies by the sum of inputs emergies (fuel and labor).

The systems were analyzed regarding the net Emergy yield. In this case, output was evaluated with an independently determined transformity, which is preferable for comparison of efficiency [8]. The evaluation of the net Emergy yield ratio (Net EYR) was performed for each material and for each system. The outputs of the systems are plastic, paper, aluminum, iron and steel, glass and pre-compost. The transformities considered for the outputs are those associated their production. The solar emergy of fuel and labor corresponds to more than 70 % (sej/sej) of the total solar emergy in the three cities. Thus, emergies of labor and fuel were employed in a first simplified comparison.

When output net emergy is lower than the emergy invested for material recovering or pre-compost production, the process brings no benefit in terms of emergy accounting that is no benefit at larger scale of the biosphere. The recovery of these materials would result in an emergy trap. The comparison among the calculated net Emergy yield ratio shows which are the recovered material that uses less resources (fuel and labor) in the processes of collection and separation.

4. RESULTS AND DISCUSSION

The analysis of the results was done evaluating how much net emergy of recovered materials is obtained in relation to what was spent in emergy of labor and fuel to collect and separate this same material. Figure 2 shows the relation between the invested emergies in labor and fuel and the net emergies of the materials recovered by São Paulo, Siena and Modena. In São Paulo more net emergy of iron and steel, plastic and pre-compost is recovered, than that invested in labor and fuel, which means that recovering these materials is profitable. For paper, the relation between materials net emergy and labor and fuel emergy is close to 50 % (sej/sej), suggesting that the recovering process for this material may be improved to be profitable. For glass and aluminium, the emergy investment in labor and fuel is higher than the net emergy recovered.

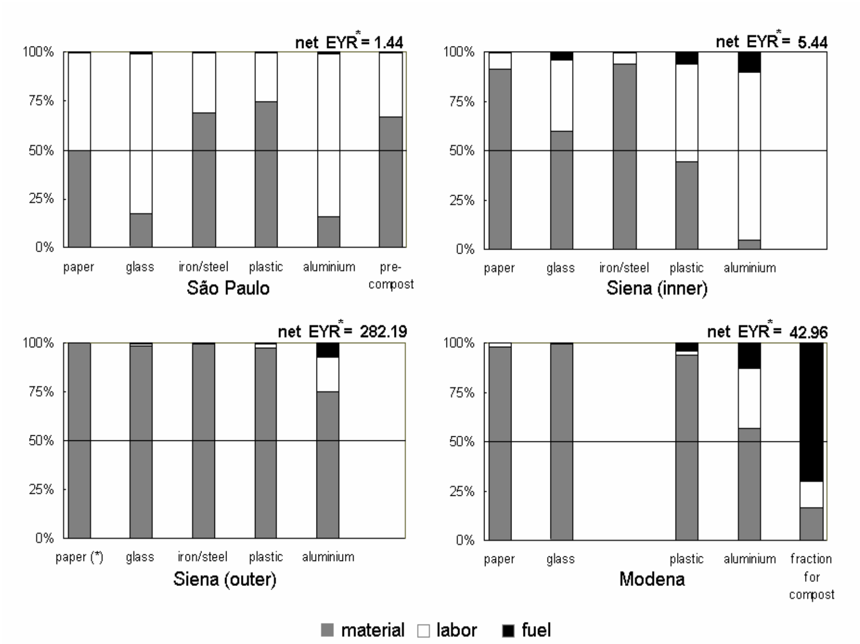

Figure 2. Relative values of materials, fuel and labor emergies in São Paulo, Siena and Modena. Paper (*) represents specific paper collection and net EYR* indicates simplified indice, see Table 2 to 5

The use of intensive labor in inner Siena process is clear through the relation between the recovered materials net emergy and the emergy invested in labor and fuel (Fig. 2). The net recovered emergy is profitable for paper and iron/steel. There's still benefit in glass recovery, but less than that obtained for the other materials. In outer Siena all materials are recovered with net emergy benefit.

The selective collection of Modena has advantages concerning all recovered materials, except for the fraction for compost, due to the great amount of spent fuel. It is worthy to attention that the expenses with labor to obtain aluminum are the highest among all materials, although the relation between the emergies is still advantageous for this material.

The highest value calculated net Emergy yield ratio corresponds to outer Siena and the lowest belongs to São Paulo. In this way, the technological comparison among the four systems, measuring efficiency and practicality, points to outer Siena as the best system. It is worthy to note that São Paulo's system is not devoted to collect and separate materials for recovery. Although materials are collected and separated to improve the pre-compost quality, the net EYR for São Paulo system (1.44) is still higher than one, which means that the system obtains more net emergy than that required for fuel and labor.

In Figure 3 comparison for each material is made among the cities of Siena, Modena and São Paulo. The relations between labor and fuel emergies and the recovered paper net emergy show that the collection and separation of paper brings no benefits in São Paulo, which may improve the collection/separation process. To Siena and Modena the process is advantageous. The case of selective paper collection in outer Siena presents the highest net EYR (473.61) employing a collection specific for paper. It is interesting to point out that in this kind of collection the final consumers separate the material, and that the labor expenses are rather reduced. The expenses with fuel are also reduced since the collection occurs just once a week.

Collecting and separating glass is profitable in Modena and in Siena. The highest net EYR (154.26) corresponds to the Modena´s system. In inner Siena the relation is close to 60 % (sej/sej), and this system presents a net EYR of 1.47. Glass recovery is very disadvantageous in São Paulo, where there is also a higher use of labor.

The recovery of iron and steel presents high values in São Paulo and Siena. The best result belongs to outer Siena with a net EYR of 216.62. In plastic recovery, inner Siena is in disadvantage when compared to the other three collection systems. Among the results obtained in São Paulo, this corresponds to the highest net EYR (2.89).

Aluminum recovery proves to be disadvantageous for the cities of inner Siena and São Paulo (Fig. 3). It is important to point out that in São Paulo aluminum is a high-value product collected by independent collectors that do not belong to the official collection system. Thus, the quantity of aluminum collected by the municipality is very low. It is evident the relation between the fuel spent in Siena (outer city) and the labor used in Siena (inner city) due to the different nature of collection. São Paulo’s systems is the one that uses less fuel.

The collection of organic materials to produce compost in Modena presents no net benefit and uses a great amount of fuel. On the other hand, the pre-compost in São Paulo (Net EYR = 1.97) is advantageous from the point of view of emergy recovery, reaching ratios higher than 60 % (sej/sej) of recovered material emergy in relation to the emergy investment in terms of labor and fuel necessary for the collection and separation. It is important to remember that São Paulo´s pre-compost is already partially digested and that in Modena the fraction for compost correspond the domestic organic fraction collected that must be processed.

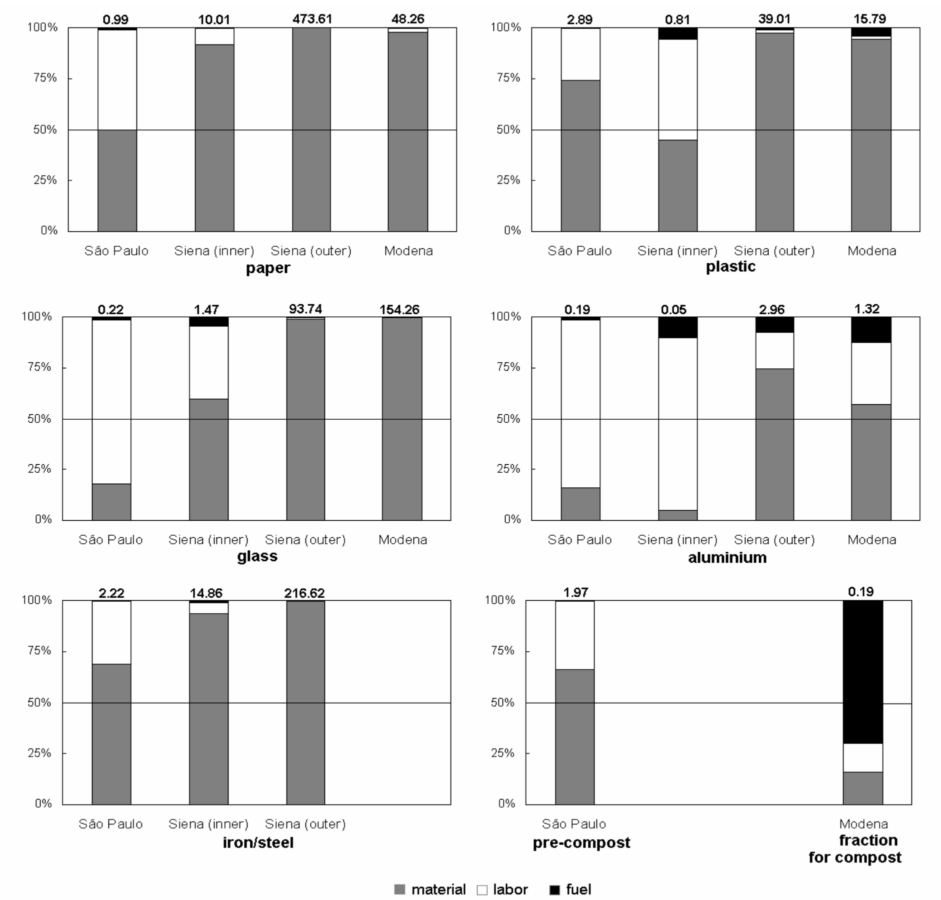

Figure 3. Relative values of fuel, labor and materials emergies in São Paulo, Siena and Modena. Values represented on top of each bar in the graphic correspond to the net EYR* of the recovered materials

Among the best Net EYR evaluated for each material only that associated to aluminum (outer Siena) and to pre-compost (São Paulo) are lesser than three. A rank based on the Net EYR will show paper (outer Siena) > iron/steel (outer Siena) > glass (Modena) > plastic (outer Siena) > aluminum (outer Siena) > pre-compost (São Paulo).

Among the worst Net EYR, that is, among the collection processes that represent emergy traps using more resources than that recovered, it can be ranked: aluminum (inner Siena) > fraction for compost (Modena) > aluminum (São Paulo) > glass (São Paulo) > plastic (inner Siena) > paper (São Paulo). The Net EYRs for fraction for compost in Modena and for aluminum in São Paulo have the same value. However, the relative use of fuel in more intensive in Modena.

5. CONCLUSION

5.1. Concerning the performance of São Paulo's system

From these data it can be inferred that São Paulo presents advantages concerning emergy in the generation of pre-compost and recovered recyclable materials. To half of the recovered materials (plastic, iron/steel and pre-compost) the return in emergy is higher than 50 % (sej/sej) compared to the investment in labor and fuel. Paper presents an index of 50 % (sej/sej) between the investment in labor and fuel and the investment in the recovery of materials. It must be pointed out that the analysis developed here only takes into consideration the expenses with fuel and labor. For pre-compost, the difference between São Paulo and Modena is in the fact that in São Paulo labor is a greater burden whereas in Modena fuel is the main burden.

Specific collection systems as that of paper performed in outer Siena would be recommended to São Paulo. Multi-material collection comprising plastic, aluminum, glass and iron/steel supplied by the final consumers apart from the organic fraction, might be an improvement in the relationship between the net emergy of the recyclable materials and the emergy invested in labor and fuel, since the labor used to separate recyclable materials would be reduced. All these actions require commitment of those in charge of the treatment of solid wastes as well as the change in the final consumer's habits.

5.2. Concerning the use of emergy accounting for evaluate systems performances

This paper shows that emergy accounting (simplified in this case) is a useful tool to those in charge of the collection services and waste treatment, being useful to: (a) the evaluation of the principal inputs of direct and indirect resources employed, (b) account the benefits for the biosphere and (c) to compare different collection systems (geographically, culturally and technically). Also, the results show that the materials recycling process (organic and inorganic in the (pre)composting plants) in São Paulo presents benefits (for iron/steel, plastic and pre-compost). For some of the segregated materials no benefits for the municipality were found, but there is a great potential for development.

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