



Revista de Gestão Costeira Integrada -
Journal of Integrated Coastal Zone
Management

E-ISSN: 1646-8872

rgci.editor@gmail.com

Associação Portuguesa dos Recursos
Hídricos

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Revista de Gestão Costeira Integrada - Journal of Integrated Coastal Zone Management,
vol. 15, núm. 4, 2015, pp. 453-465

Associação Portuguesa dos Recursos Hídricos
Lisboa, Portugal

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Solid waste management in coastal cities: where are the gaps? Case study of the North Coast of São Paulo, Brazil*

Andréa de L. Oliveira^{@, a}; Alexander Turra^a

ABSTRACT

Coastal cities are surrounded by important but fragile ecosystems that are under pressure from population growth, tourism and large commercial enterprises. These factors contribute to a complex solid waste management situation, which is exacerbated by lack of planning and sanitation infrastructure, common factors in cities in developing countries. The municipalities of the North Coast of São Paulo State were used as study cases to analyze public policies for solid waste management in the coastal zone, with wide seasonal variations in population and solid waste production. The analysis included planning, implementation, performance indicators and future prospects. The results revealed that some key issues that are critical to the development and improvement of solid waste management in these cities must be considered: (1) the main focus of the plans and future prospects is landfills; (2) only a few of the outputs and outcome indicators are related to MSW; (3) recycling is not well implemented; and (4) no indicators of the amount of waste recycled are established. Solid waste management in these municipalities should be strategically reframed in order to adopt more-sustainable alternatives for waste treatment, with outputs and outcome indicators to evaluate policy implementation. In addition, citizen (residents and tourists) should be encouraged in monitoring and implementing these policies.

Keywords: Solid Waste Management, Coastal Cities, Public Policies.

RESUMO

Gestão de resíduos sólidos em cidades costeiras: onde estão as lacunas? Estudo de caso do litoral norte de São Paulo, Brasil
Cidades costeiras estão cercadas por ecossistemas importantes e frágeis, pressionados pelo crescimento populacional, turismo e grandes empreendimentos comerciais. Estes fatores contribuem para uma situação complexa de gestão de resíduos sólidos, a qual é agravada pela falta de planejamento e infraestrutura de saneamento, comuns em cidades de países em desenvolvimento. Os municípios do Litoral Norte do Estado de São Paulo serviram como estudo de caso para analisar as políticas públicas voltadas à gestão de resíduos sólidos na zona costeira, incluindo o planejamento, implementação, indicadores de desempenho e perspectivas futuras. Os resultados indicam que algumas questões essenciais para o desenvolvimento e melhoria da gestão dos resíduos sólidos estão sendo negligenciadas: (1) o principal foco dos planos e perspectivas estão focados em aterros sanitários; (2) existem poucos indicadores de desempenho relacionados à gestão de resíduos sólidos; (3) a reciclagem não tem uma cobertura adequada nos municípios; e (4) não existem indicadores estabelecidos que quantifiquem o volume de resíduos reciclado. A gestão dos resíduos sólidos deveria ser estrategicamente reformulada nestas cidades, proporcionando alternativas mais sustentáveis para o tratamento de resíduos sólidos, com indicadores de desempenho que avaliem

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* Submission: 20 AUG 2014; Peer review: 18 SEP 2014; Revised: 18 MAR 2015; Accepted: 18 MAY 2015; Available on-line: 22 MAY 2015

adequadamente o as políticas do setor e contribuam para o seu desenvolvimento. Além disso, a participação e engajamento dos cidadãos (residentes e turistas) deveriam ser incentivados, encorajando-os a colaborar na implementação das políticas e no seu controle.

Palavras-chave: *Gestão de Resíduos Sólidos, Cidades Costeiras, Políticas Públicas.*

1. Introduction

The increase of urban solid waste as well as the consumption of disposable items and the inappropriate ways in which this waste is collected and disposed of, lead to a worldwide crisis in urban solid waste management (UNHABITAT, 2010; Gray, 1997). Solid waste management is one of the most challenging problems faced by the world's municipalities (UNHABITAT, 2010). Coastal zones are even more exposed to this crisis due to the lack of appropriate landfill sites, wide seasonal population variations, extensive commercial enterprises and proximity to the marine environment with its fragile ecosystems.

1.1. Solid Waste Management and Marine Litter

The global population is concentrated in low-lying coastal zones, where approximately 2% of the earth houses 13% of its people, a proportion that is rapidly increasing (McGranahan *et al.*, 2007). In coastal cities, environmental features such as mangroves, estuaries, beaches and bays, coupled with population growth, tourism and pressure from commercial projects such as ports, harbors and offshore oil and gas exploration makes difficult solid waste management, already compromised by the lack of planning and basic sanitation infrastructures that is prevalent in developing countries (Jiang *et al.*, 2001; Li, 2003).

In the coastal zone, this situation leads to the proliferation of marine litter (Seco Pon & Becherucci, 2012), defined as any manufactured or solid waste from human activities that enters the marine environment, regardless of the source (land-based or marine-based), but excluding organic matter (e.g. food and plant waste) (Cheshire *et al.*, 2009). Marine litter causes harm to ecosystems and marine life and impacts economic and recreational activities in the marine environment, such as fishing, tourism and navigation (Cheshire *et al.*, 2009).

Land-based activities are the major source of marine litter, responsible for 80% of the marine litter collected in the marine environment (Balas *et al.*, 2001; Hetherington, 2005). Coastal cities have a responsibility to avoid generating marine litter, by implementing and conducting appropriate waste management procedures (UNEP & NOAA, 2011).

The second United Nations Conference on the Environment and Development, also known as the Earth Summit, Rio Summit and Rio-92, held in the city of Rio de Janeiro in 1992, was an international benchmark for waste management and protection of coastal zones.

Agenda 21 of this convention established the priority objectives of protecting the oceans, seas and coastal zones, and reducing pollution from solid waste. The convention envisioned a serious international commitment to improving solid waste management, minimizing waste generation, maximizing reuse and recycling, promoting adequate disposal and treatment, and expanding waste services (UN, 1992).

In 2011, an international conference organized by the US NOAA (United States National Oceanic and Atmospheric Administration) and the UN (United Nations) published the Honolulu Strategy, a results-oriented framework of action with the overarching objective of reducing the impacts and amounts of marine litter over the next 10 years. The Honolulu Strategy is divided into three main goals that focus on reducing the amounts and impacts of marine litter from land-based and sea-based sources and the accumulation of marine litter in the marine environment (shorelines, benthic habitats and pelagic waters) (UNEP & NOAA, 2011).

1.2. Solid Waste Management on the Brazilian Coast

In Brazil, 24.6% of the inhabitants live in coastal municipalities (IBGE, 2011). Waste-collection coverage varies among municipalities, but is over 80% in all regions (North, Northeast, Southeast, South and Midwest) (Astolpho & Gusmão, 2008). Nevertheless, half of Brazilian municipalities dispose of their waste in inappropriate areas (MMA, 2011), highlighting the urgency of pursuing alternative treatments for solid waste under the principles established in Agenda 21.

In Brazil, the federal law that establishes the National Plan for Coastal Management (PNGC), published before Agenda 21, had already defined the coastal zone as an area in need of changes in management (Lei nº 7.661, 1988). A federal law regarding solid waste management was promulgated only in 2010, establishing the National Policy on Solid Waste (Lei nº 12.305, 2010).

One of the tools of the PNGC is the Macrodiagnosis of the coastal and marine zones of Brazil, which combines socio-environmental information from the entire Brazilian coast. This diagnostic procedure uses data on the collection and disposal of urban solid waste, coupled with the average per-capita income and the existence of other sanitation services, to calculate the social risk indicator, given that residents of cities with poor sanitation services and infrastructure are more likely to encounter problems affecting their living conditions (Astolpho & Gusmão, 2008). Currently, 18% (75 of 395) of

Brazilian coastal municipalities are classed as “high” or “very high” social risk (Astolpho & Gusmão, 2008). Metropolitan regions with higher population densities tend to have higher social risk.

In southeast Brazil, for instance, almost half (33 of 68) of the coastal municipalities, including 8 of 16 in the State of São Paulo, are classed as high or very high social risk (Astolpho & Gusmão, 2008). These indexes reveal the vulnerable situation of coastal municipalities, even though they are not directly related to solid waste management.

In addition, several published studies have reported the occurrence of marine litter on beaches and other marine environments in Brazil. Araújo & Costa (2007) studied contamination by marine litter on an isolated beach in Pernambuco State. The main source of contamination was the Várzea do Una River, and the results indicated an exceptionally high level of contamination of the beach by plastics of urban origin, exposing the gravity of the basic sanitation situation in the urban centers of this river basin. Other studies also reported a high occurrence of marine contamination along the Brazilian coast, from the South to Northeast regions (Araújo & Costa, 2004; Ivar do Sul & Costa, 2007; Oigman-Pszczol & Creed, 2007; Cordeiro & Costa, 2010; Oliveira *et al.*, 2011). All these studies suggested that the waste mismanagement was one of the major causes of contamination.

1.3. Study Objectives

In order to analyze this issue closely and to increase understanding of the coastal zone of Brazil, the North Coast of the State of São Paulo was chosen for a case study. Despite their particularities, the municipalities of the North Coast of São Paulo have similar conditions to other coastal areas, including fragile environments; an economy based on tourism, especially vacation homes, with a marked seasonal variation in population; prospects for new projects that will conflict with existing activities; and the potential to produce marine litter.

This study analyzed the solid waste policies in these coastal municipalities. The following questions related to public policies for solid waste management were posed: Are there policies regarding solid waste? What are their main objectives and targets? How are the policies implemented? What are their main indicators for solid waste management assessment? Are the prospective future projects suitable for the area?

2. Research Method

2.1. Study Area

The North Coast of São Paulo is composed of three municipalities on the mainland, Caraguatatuba, São Sebastião and Ubatuba; and one island, Ilhabela (Figure 1). The region is an administrative unit of the State of

São Paulo, for coastal management (Lei nº 10.019, 1998) and water resources (Lei nº 9.034, 1994), i.e., the North Coast has not only a physiographic identity but a management identity as well. This concept can also be applied to solid waste management.

The region has 11 federal, state and municipality Conservation Units, including one National Park, three State Parks, one Ecological Station, two Environmental Protection Areas and four Private Natural Heritage Reserves (CBHLN, 2011). The parks are fully protected areas where the main objective is to preserve nature, and only indirect uses of their natural resources are permitted. These areas comprise 76% of the entire area of the North Coast region (SMA, 2006). These numbers illustrate two important factors for the region. The first is tourism, which depends on the natural landscape; and the second is the limited space available for urban expansion and, as a result, for landfills and other solid waste management facilities.

2.1.1. Local Economic and Sanitation Context

The coast of São Paulo is the site of several large projects related to transportation (ports and roads) and offshore oil and gas exploitation. The State of São Paulo published a document titled “Strategic Environmental Assessment – Port, Industrial, Naval and Offshore Dimensions on the São Paulo Coast” that analyzed several ongoing and future projects in the area (ARCADIS, 2010). According to this document, if all the projects planned for the region were to be implemented within the next 15 years, the total cost could be 93 billion USD (209 billion BRL). The majority of these projects are located in the Central Baixada Santista (where the Port of Santos is located), where 92% of the total would be spent; 7% would be allocated to the North Coast, and less than 1% to the South Baixada Santista (ARCADIS, 2010).

Despite the small percentage of the total funds invested in the North Coast region, the contrast between the natural tendency for environmental protection and tourism and the possibility of increased urbanization is stark. Urbanization based on these large projects would compromise the environmental features and the natural situation of this coast.

These investments in the North Coast would be for infrastructure, such as the expansion of the Port of São Sebastião, construction of divided highways, and installation of oil and gas pipelines, among others. The municipalities have been conducting public hearings to discuss these new projects, including the environmental permitting process, installation and operation. These projects are likely to increase the population growth rate, putting pressure on the sanitation infrastructure.

The local economy is based mainly on services related to tourism activities, such as accommodation, food and

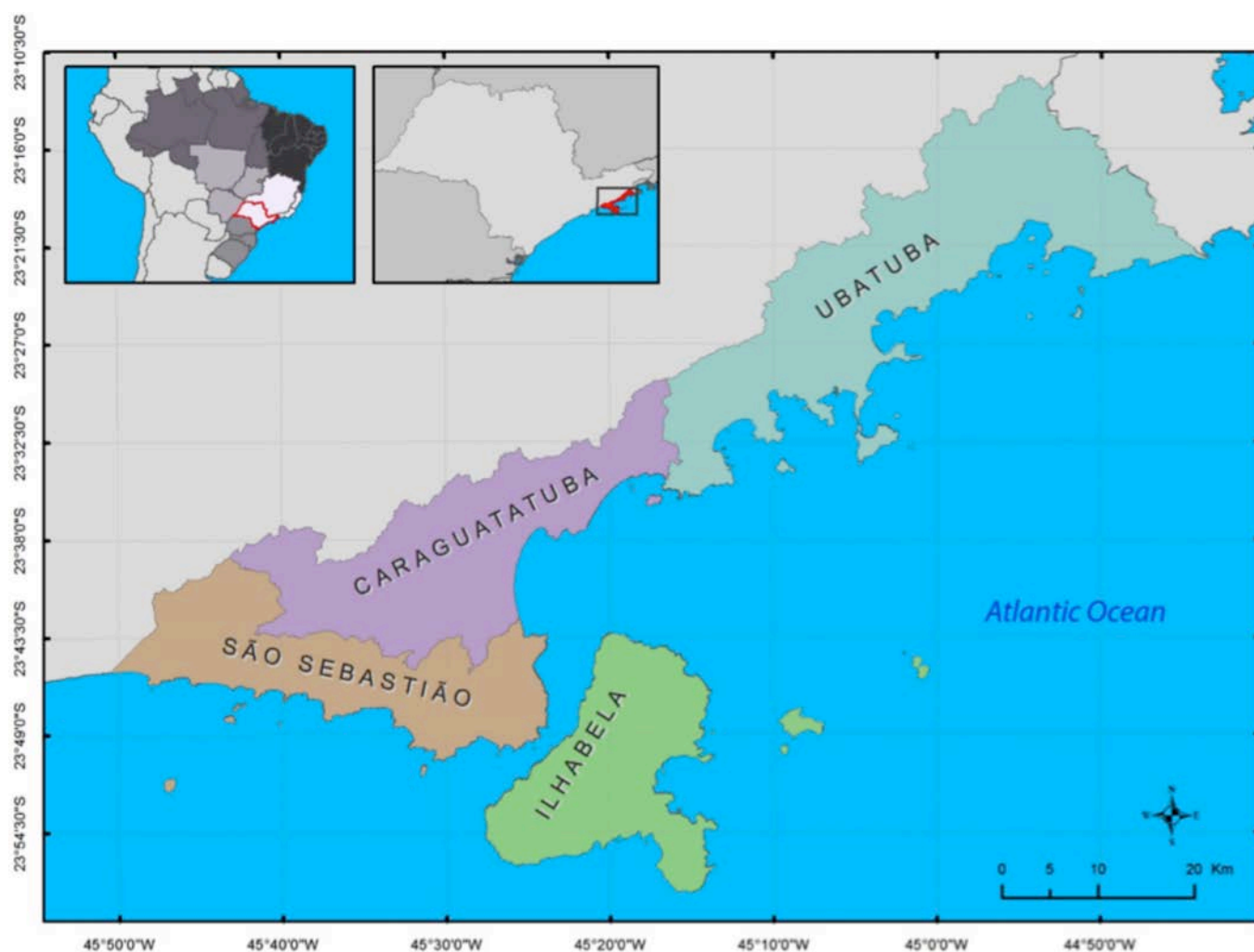


Figure 1 - Map of the North Coast of São Paulo State. Image: Mariana Corá.

Figura 1 - Mapa do Litoral Norte do Estado de São Paulo. Imagem: Mariana Corá.

transport. São Sebastião is the only exception; the royalties (taxes) that it receives from the Port of São Sebastião and the Almirante Barroso Transpetro Terminal provide it with the highest Gross Domestic Product (GDP) in the region (IBGE, 2010). The main source of tax revenue for the other municipalities is the service sector.

The permanent population of all municipalities of the North Coast is 290,429 inhabitants, but this number increases significantly during the summer high season (Table 1). As an indicator of this process, all the municipalities have a high proportion of non-occupied households (seasonal residences), especially Ubatuba, where 50% of the households fall in this category.

The sanitation situation varies widely among the municipalities, according to an assessment by IBGE (2010), Caraguatatuba has the highest proportion of households with adequate sanitation (88.7%). Ilhabela has the highest proportion of households classified as inadequate (32.2%). In São Sebastião the majority are considered semi-adequate (84%) and in Ubatuba more

than half of the households have adequate sanitation (Table 1).

The local sanitation systems are deficient, and when overloaded may fail and themselves become a source of pollution. The region's solid waste collection coverage is good, with almost all households covered (99.5%) (CBHLN, 2011). However, the lack of regular collections leads the residents to discard their waste in vacant lots and waterbodies, increasing diffuse pollution (CBHLN, 2011).

2.2. Local Policies and Policy Implementation

Local policies were organized and analyzed, in order to identify the issues related to solid waste management and their approaches. Policy implementation was analyzed based on the Multiannual Plans (MAPs), Municipal Integrated Solid Waste Management Plans (MISWMPs) and Municipal Sanitation Plans (MSPs) when available.

The Multiannual Plans (MAPs) were analyzed through the identification of programs related to solid waste

Table 1 - Gross Domestic Product (GDP), population (permanent and temporary), occupancy rate of households and the sanitation situation in the municipalities of the North Coast of São Paulo State.

Tabela 1. Produto Interno Bruto (PIB), populacional (fixa e flutuante), taxa de ocupação dos domicílios e situação sanitária dos municípios do Litoral Norte do estado de São Paulo.

	Caraguatatuba	Ilhabela	São Sebastião	Ubatuba
GDP (in thousands, BRL) ¹	1,345.63	343.63	3,131.27	920.54
GDP per capita (in BRL) ¹	13,371.55	12,218.06	42,433.17	11,697.83
Permanent population in 2010 ¹	100,840	28,196	73,942	78,801
Temporary population ²	1,120,000 (annual)	100,000 (summer)	336,560 (annual)	Not specified
Occupancy rate of households ¹	43%	28%	38%	50%
Adequate Sanitation Situation ¹	88.7%	None	7%	52.8%
Semi-adequate Sanitation Situation ¹	11.3%	67.8%	84%	47%
Inadequate Sanitation Situation ¹	None	32.2%	9%	0.2%

Sources: 1- IBGE (2010). 2 – CBHLN (2011).

1 USD is equivalent to 2.2 BRL.

Sanitation Situation criteria: 1. adequate: there are drains connected to the network or general septic tank, water is provided by the water-supply system, and waste is collected directly or indirectly by cleaning services. 2. semi-adequate: at least one of the above services is classified as adequate. 3. inadequate: sewage enters a rudimentary sewage ditch, river, lake, the ocean or other sewer; water is obtained from wells, springs or other sources, and waste is not collected, but burned, buried or discarded into vacant lots, rivers, lakes or the ocean.

management, their indicators, and the resources invested. The MAP is a planning tool that must be prepared and approved for a period of four years. The plan organizes governmental actions, with programs oriented toward strategic goals defined for the period when the plan is in effect (Lei nº11.653). The municipal MAPs from 2010 to 2013 were analyzed with respect to budget items related to solid waste management, as well as the policy indicators used to evaluate these initiatives.

The Municipal Sanitation Plans (MSPs) and Municipal Integrated Solid Waste Management Plans (MISWMPs) analyzed were published after 2012, and the MISWMPs from Ubatuba and Caraguatatuba were published in 2014. The aspects considered in the analysis were (1) if the diagnosis in the plan considered the population growth during high season and the kind of solid waste collected and disposed of; (2) if the municipality had a well-established recycling program; (3) if the municipality established a target for the plan; (4) if the municipality had adequate performance indicators.

2.3. Data Analysis

The analyses were based on qualitative parameters, and a general profile was drawn for each municipality based on the public policies, MAPs, MSPs, and MISWMPs (when available).

The indicators were classified and analyzed according to Mosse & Sontheimer (1996) and Greene & Tonjes (2014), evaluating if they were inputs or process indicators, and discussing their weaknesses and strengths.

3. Results

3.1. Landfill Crises on the North Coast of São Paulo

Inappropriate disposal of solid waste is a chronic problem in the region. Caraguatatuba and São Sebastião had their landfills classified as inadequate for the first time by CETESB (Companhia de Tecnologia de Saneamento Ambiental, or Environmental Sanitation Technology Company of the state of São Paulo) since the classification process started in 1997; Ilhabela had its landfill classified as inadequate for the first time in 1998; Ubatuba had its landfill classified as inadequate in 2000 (CETESB, 2012).

In 2008, a newspaper article appeared, with the headline “Collapse in the waste sector affects North Coast”. The article described the sanctions on all the landfills of São Paulo’s North Coast, since all of them were classified as inadequate. As a result, the municipalities began to export their solid waste to private landfills in other municipalities (Tremembé and Santa Isabel), which requires trucks to travel 100 to 200 km through mountainous areas¹. Consequently, the cost of waste transport and disposal has increased.

Ilhabela was the first municipality to export its solid waste, in 2004, to a private landfill in Tremembé; next, in 2005 São Sebastião also sent its waste to Tremembé; Caraguatatuba began to send waste to a private landfill in Santa Isabel in 2007; and Ubatuba also began to send

¹ Folha de São Paulo (2008) - Colapso na área do lixo afeta Litoral Norte. Cotidiano: São Paulo, p. C1, 30 Nov. 2008.

its solid waste to Tremembé in 2008. In 2011, São Sebastião began to send part of its waste to a landfill in Santos (also a coastal city) (CETESB, 2012). Caraguatatuba sent its waste to Tremembé after the landfill in Santa Isabel was closed in 2012².

The waste is transported on trucks that travel on the main roads, the Tamoios Highway (SP-99) and the Rio-Santos Highway (SP-55 or BR-101). Many stretches of these roads are dangerous, steep, with sharp curves and no shoulders, which increases the risk of accidents. A survey of newspaper reports of accidents involving waste trucks in the region indicated that they are infrequent. However, these accidents do cause traffic jams and leachate.

These risks are continuing, with no prospects for improvement in the short term, even though they generate environmental problems and burden municipal budgets. After the publication of the National Solid Waste Policy, several new concepts and principles regarding regulation of the sector entered into force, including reverse logistics, waste hierarchy (reduction, reuse, recycling and disposal) and shared responsibility, all of which were novel features of Brazilian legislation. Municipalities with cooperative management systems (a consortium among municipalities in order to co-manage) had priority in receiving federal funding. This sort of consortium might be a possible alternative for the North Coast.

The four North Coast municipalities have been studying alternatives for cooperation in waste management since 1999 (Kaslauskas, 2001). According to Kaslauskas (2001), the region has a shortage of suitable sites for landfills because of its geographical features and the presence of Conservation Units. One suggestion was to construct a landfill in Caraguatatuba to receive waste from all four municipalities. The landfill was also planned to house a triaging area for recyclable materials³. The bureaucratic requirements for an environmental permit for the landfill are being analyzed by CETESB.

3.2. Implementation

3.2.1. Multiannual Plans

The administration of Caraguatatuba presented three programs focused on solid waste management. These dealt with the recovery of degraded areas (former landfill areas), implementation of municipal recycling, and

appropriate disposal of solid waste. The indicators adopted in the MAP were based on the amount of funds invested in the program (Table 2). The amount reserved for these activities corresponded to 0.40% of the expected budget for the period (2010-2013), according to the municipal MAP.

The administration of Ilhabela presented two programs for solid waste management, one to provide resources for exporting waste, and the other to promote environmental education. The indicators adopted in the MAP were based on the amount invested and the maintenance of the program (Table 2). The amount reserved for these activities comprised 5.23% of the expected budget for the period (2010-2013), according to the municipal MAP. Although some of this amount was reserved for other actions linked to environmental preservation, such as protecting conservation areas, the largest proportion was related to solid waste management.

The administration of São Sebastião presented one program focused on solid waste management. The program's objective was to keep the city clean through street sweeping, waste collection and waste treatment. The indicator adopted in the MAP was based on the degree of satisfaction of the residents (Table 2). The amount reserved for these activities corresponded to 4.0% of the expected budget for the period (2010-2013), according to the municipal MAP.

The administration of Ubatuba presented one program focused on solid waste management, with a very broad objective of environmental protection. However, it specified landfill maintenance, waste transshipping, recycling and collection. The indicator adopted in the MAP was based on the percentage of the program that was implemented (Table 2). The amount reserved for these activities corresponded to 6.28% of the expected budget for the period (2010-2013), according to the municipal MAP.

The amounts indicated in the MAPs were not necessarily invested, because of cost-containment provisions in the annual budgets (Table 2).

The indicators presented in the MAPs are performance indicators, focused on the human and financial resources invested in the programs, known as input indicators (Mosse & Sontheimer 1996). For a plan focused on the allocation of financial resources this is a very important monitoring device. However, the MAPs did not adopt indicators regarding the outcomes related to solid waste management.

3.2.2. Municipal Sanitation Plans and Municipal Integrated Solid Waste Management Plans

According to the analysis of the MSPs and the MISWMPs, all municipalities conducted some sort of evaluation, considering the difference between the

² G1 (2012) - Cetesb suspende licença de aterro sanitário, em Santa Isabel, SP. Mogi e Suzano. 14 Nov. 2012. Available on-line at <http://g1.globo.com/sp/mogi-das-cruzes-suzano/noticia/2012/11/cetesb-suspende-licenca-de-aterro-sanitario-em-santa-isabel-sp.html>.

³ Folha de São Paulo (2003) - Aterro único do litoral será em Caraguá. Folha Vale: São Paulo, p. C3, 23 Jan. 2003.

Table 2 - Programs related to solid waste management in the municipalities of the North Coast of São Paulo State, in the Multiannual Plans from 2010-2013 (Lei nº 1.768, 2009; Lei nº 773, 2009; Lei nº 1012, 2009; Lei nº 3287, 2009).

Tabela 2: Programas relacionados à gestão de resíduos sólidos nos municípios do Litoral Norte de São Paulo, nos Planos Plurianuais de 2010-2013 (Lei nº 1.768, 2009; Lei nº 773, 2009; Lei nº 1012, 2009; Lei nº 3287, 2009).

Caraguatatuba			
Program	Amount (in BRL)	Indicator	Objective
Recovery of degraded areas	1,992,500.00	- Material and heritage management (amount invested) - Services and Support Management (amount invested)	Implement a municipal program for recovery of areas degraded by inappropriate disposal of solid waste, as well as degraded areas affected by unregulated land occupation, through specific programs.
Recycle Caraguá	1,717,500.00	- Collection and implementation of recycling cooperatives (amount invested) - Communication plan for the new collection system (amount invested)	Implement an official system of sorting waste prior to collection, and minimize budget impacts from export of solid waste; social support for residents who make their living by collecting recyclable materials, and also promote correct sorting methods for recycling.
Solid Waste Center	1,500,000.00	- Construction of the Center (amount invested)	Develop an appropriate site for disposal of urban solid waste with construction of a processing plant, in order to improve the quality of recyclable materials.
Total	5,210,000.00		
Ilhabela			
Program	Amount (in BRL)	Indicator	Objective
Municipal Waste Collection	10,020,000.00	- General investments (monthly amount) - Unit Maintenance (monthly amount)	Provide for operational needs and enable export of waste.
Environmental Preservation	10,810,000.00	- General investments (monthly amount) - Unit Maintenance (monthly amount)	Develop projects on environmental education, cleaning and conservation of protected areas.
Total	20,830,000.00		
São Sebastião			
Program	Amount (in BRL)	Indicator	Objective
Clean City	76,607,440.25	- Degree of satisfaction of inhabitants (%)	Keep the city clean through waste collection, street sweeping and waste treatment
Ubatuba			
Program	Amount (in BRL)	Indicator	Objective
Environmental Protection	52,924,697.50	- Maintenance and expansion (%) - Equipment and durable goods (%) - Materials and services (%) - Human resources and costs (%)	Support maintenance of the administrative units with environmental policy development; preservation; and maintenance of the landfill, waste transshipping, manure control, recycling, collection from domiciles and hospitals.

1 Brazilian Real (BRL) is equivalent to 0.45 US Dollars.

mean amount of waste produced during the high and low seasons, and the classification of solid waste with respect to the type of material, organic matter or recyclable items.

The daily mean amount of waste produced during the low seasons increases by around 30% during the high seasons in Caraguatatuba and São Sebastião, around 20% in Ilhabela, and around 90% in Ubatuba (Table 3). During holidays this increase can be even greater; the maximum values recorded in these municipalities were 86% in Caraguatatuba, 185% in Ilhabela, 115% in São Sebastião and around 300% in Ubatuba (Table 3). As a result of the increase in waste production during high season, the costs of disposal increase in the same proportion, as well as the effort required in collection and street sweeping.

Selective collection is offered to some degree by all municipalities. However, only Ilhabela and São Sebastião have well-established recycling programs, while Caraguatatuba and Ubatuba are in the initial stages of the project (Table 3).

The main objectives of the MSPs and MISWMPs of all the municipalities were related to providing universal service of regular collections and increasing the reuse of waste (recycling and composting) (Table 4). Caraguatatuba also included targets related to reducing inappropriate waste disposal and implementing reverse logistics for electronic waste (Table 4). The indicators to monitor the outcomes of the targets proposed are both absolute indicators, i.e. direct figure, taken from input-output analysis (e.g. tons of waste produced, tons of waste disposed inappropriately), and indexed indicators, i.e. indicators expressed as a percentage with res-

pect to the total (e.g. percentage of residences with regular collection service, percentage of reuse of total collected solid wastes).

The performance indicators proposed by the plans for overall monitoring are mainly indexed indicators (Table 5). An important indicator is related to the landfill conditions, known as “Landfill Quality Index” or IQR, in the Portuguese acronym. The IQR is measured by CETESB, and classifies a landfill according to its general conditions and pollution monitoring. The landfill lifetime estimation is also important because it is derived from the projected amount of waste produced and the capacity of a landfill.

Despite the importance of landfills, the other indicators proposed are very important, such as the “Residence Solid Waste Reuse Indicator”, which could indicate the percentage of waste sent for recycling or composting. The “Selective Collection Indicator” considers the percentage of residents covered by the selective collection.

4. Discussion

One of the reasons for the worldwide crisis in solid waste management is the prevailing waste disposal method, landfills. The major reason for the dominance of landfills is that this is a relatively simple, inexpensive and familiar method (Gray, 1997). This method requires large areas prepared to receive the waste, but these areas have a limited lifetime, so that in the medium to long term it is not an effective strategy for waste management (Gray, 1997).

There are also economic reasons to avoid landfills; they are wasteful of natural resources. According to Gray (1997), landfilling not only buries materials that have

Table 3: Diagnostic data related to solid waste management in the municipalities of the North Coast of São Paulo.

Tabela 3: Dados diagnósticos relacionados à gestão de resíduos sólidos nos municípios do Litoral Norte de São Paulo.

	Caraguatatuba ¹	Ilhabela ²	São Sebastião	Ubatuba
Maximum Amount of Waste Produced in holiday periods (tons/day)	200	80	250 ⁶	318 ⁵
Mean Amount of Waste Produced in High Season (tons/day)	139	33	150 ⁶	155 ⁴
Mean Amount of Waste Produced in Low Season (tons/day)	107	28	116 ⁶	80 ⁴
Mean landfill cost (BRL/tons/month)	200	156	156 ⁶	156 ⁴
Mean waste removal cost per month in High Season (BRL)*	834,000.00	140,400.00	702,000.00 ³	725,400.00 ⁴
Mean waste removal cost per month in Low Season (BRL)*	642,000.00	48,204.00	542,880.00 ³	374,400.00 ⁴
No. of trucks (High Season)	-	-	-	14 ⁵
No. of trucks (Low Season)	11	7	18 ³	9 ⁵
Selective Collection	No	Yes	Yes ³	No ⁵

*1 Brazilian Real (BRL) is equivalent to 0.45 US Dollars.

1 - MISWMP Caraguatatuba; 2 - MISWMP Ilhabela; 3 - MSP São Sebastião; 4 - MISWMP Ubatuba; 5 - MSP Ubatuba; 6 - Jung, 2012

Table 4: Main objectives, targets and indicators used in the MSPs and MISWMPs.

Tabela 4: Principais objetivos, metas e indicadores usados nos Planos Municipais de Saneamento e nos Planos Municipais de Gestão Integrada de Resíduos Sólidos.

Municipality	Objective	Target	Indicator
Caraguatatuba ¹	Universal regular collection services	100% of the population served by the waste collection	Regular collection service
	Increase the reuse* of waste	60% of the waste will be reused in 2018	Residence solid waste reuse indicator
	Total treatment of waste	Reduce inappropriate disposal of waste by 70%	Amount of waste disposed inappropriately
		Implement reverse logistics for electronic waste	Businesses committed to reverse logistics
	Reduce waste production	Reduce waste production by 15%	Amount of waste produced
Ilhabela ²	Universal regular collection services	100% of the population to receive waste-collection services	Regular collection service
	Increase the reuse of waste	60% of the waste will be reused in 2015	Residence solid waste reuse indicator
São Sebastião ³	Universal regular collection services	100% of the population to receive waste collection services	Regular collection service
	Increase the reuse of waste	60% of the waste will be reused in 2018	Residence solid waste reuse indicator
Ubatuba ⁴	Universal regular collection services	100% of the population with waste-collection services	Regular collection service
	Increase the reuse of waste	60% of the waste will be reused in 2020	Residences solid waste reuse indicator

1 - MISWMP Caraguatatuba; 2 MSP Ilhabela; 3 - MSP São Sebastião; 4- MISWMP Ubatuba.

* Reuse includes composting and recycling

some value and causes environmental problems (i.e. leachate, green gas emission, local impacts), it also means that fresh materials and energy are required, with all the environmental consequences and costs associated with resource exploitation, energy generation and manufacturing processes. There are also other problems related to landfills, including the shortage of suitable sites and rising costs imposed by the transport and landfill costs (Gray, 1997).

In many cities in developed countries, the landfill crisis started in the 1970s and continued during the 1980s and 1990s (Gray, 1997; Wagner, 2007; Sidique *et al.*, 2010). As a result, these cities have been changing the waste paradigm in recent decades. Most of them have established the waste hierarchy (i.e. reduce, reuse and recycle, in order of importance) as a guideline for waste management (Gray 1997; Wagner, 2007). In these countries, waste management is framed as a sustainability issue, and focuses on environmental impacts and benefits of the waste management strategies (Greene & Tonjes, 2014).

On the other hand, most developing countries still dispose of their solid waste in landfills that are not constructed to prevent soil and water contamination (UN-HABITAT, 2010). They also lack infrastructure and services related to waste management, as well as other sanitation sectors (water supply, sanitation facilities, drainage, urban roads, land management) (Abdrabo, 2008; Buenrostro & Bocco, 2003; Choguill, 1996). In other words, solid waste management in developing countries is mainly framed as a public health issue, instead of an environmental issue as well.

Brazilian Solid Waste Policy is attempting to introduce the practice of waste hierarchy in Brazilian solid waste management, to reduce the amount of waste sent to landfills. However, as the example of the North Coast of São Paulo showed, this is not an easy task. The main focus of the solid waste management plans and indicators on the north coast of São Paulo is related to landfills (e.g. Landfill Quality Index). For this reason, in the medium term, these municipalities' main strategy is to install a new landfill in Caraguatatuba.

Table 5: Main indicators proposed in the MSPs.

Tabela 5: Principais indicadores propostos nos Planos Municipais de Saneamento.

Solid Waste Management Indicators	Definition	Indicator Classification**
Street Sweeping Service Indicator	Considers the percentage of the total length of paved streets with sweeping service.	Indexed indicator
Regular Collection Service	Considers the percentage of residences with regular collection service.	Indexed indicator
Selective Collection Indicator	Considers the percentage of residences with selective collection.	Indexed indicator
Residence Solid Waste Reuse Indicator	Considers the percentage of reuse of total collected solid wastes.	Indexed indicator
Residence Solid Waste Final Destination Indicator	Considers the conditions of the landfill that receives the Municipal Solid Wastes.	—
Treatment and Final Disposal Saturation Indicator	Considers the remaining lifetime of the available landfill sites.	—
Industrial Solid Waste Reuse Indicator	Considers the percentage of reuse of total collected Industrial solid wastes.	Indexed indicator
Industrial Solid Waste Final Destination Indicator	Considers the conditions of the landfill that receives Industrial Solid Wastes.	—
Health Services Waste Management Indicator	Considers the conditions of the Health Services wastes treatment and disposal	—

* Reuse includes composting and recycling

** ISO14031

Appropriate disposal of waste is very important. Nevertheless, are the other management options in the waste hierarchy being adequately targeted and encouraged? The analysis of the targets and indicators suggested that the investments in other management options, such as reduction of waste production and recycling initiatives, were considered in the municipal plans and even have process indicators related to them. Nevertheless, only two of the four municipalities have well-established recycling programs; and reduction initiatives are cited only in the Caraguatatuba plan. This is very serious for municipalities that are passing through a landfill crisis, with wide seasonal changes in population. Reducing, composting and recycling should be considered at least as important as landfills.

One of the reasons for the more sustainable options in waste management not being strongly targeted, as noted by Moghadam *et al.* (2009), is because politicians give a low priority to solid waste management compared to other municipal activities. Zotos *et al.* (2009) noted that local authorities occupy a key position in supporting sustainable development, but the often fragmented local approach to problem-solving is frequently inadequate for designing and implementing large-scale projects.

The local authorities also give little attention to the role of the citizenry in managing solid waste. As noted by Guerrero *et al.* (2013), the operational efficiency of solid waste management depends upon the active participation of both the municipal agency and the citizens.

Participation of both the municipal agency and the citizens. The participation of local people in decision-making is essential (Sharholly *et al.*, 2008). Administrators should involve the citizens more closely in the planning process, and also request their collaboration in reducing solid waste and in separating recyclable items at the source.

Another important issue is the wide seasonal population variation, which involves a huge increase in waste generation and the need to involve and properly inform tourists about the waste management routine, to encourage them to reduce, reuse and recycle.

5. Conclusions

The National Policy on Solid Waste mentions the need for integrated management, pressing the municipalities to prepare their Municipal Solid Waste Plans and search for cooperative solutions, adopt policies for waste reduction, recycling and composting, with only the non-recyclable refuse destined for landfills. However, the analysis of the North Coast showed that the main discussions, actions and indicators still focus on disposal. This situation reflects the difficulties faced by other coastal municipalities in Brazil, and is one of the main sources of pollution in watersheds and marine environments, due to the diffuse contamination caused by waste mismanagement.

The solid waste management situation in the cities of the North Coast of São Paulo is quite advanced com-

pared to cities in other developing countries and even to other Brazilian cities. Waste is disposed in appropriate sites (landfills), nearly 100% of the population has a waste-collection service, and at least two municipalities (São Sebastião and Ilhabela) have a well-established recycling program. However, some key issues are critical to the development and improvement of solid waste management in these cities: (1) the main focus of the plans and future prospects is landfills; (2) there are only a few outputs and outcome indicators related to MSW-Municipal Solid Waste; (3) recycling is not well served; and (4) there are no established indicators regarding the amount of waste recycled.

A change in this picture will require reframing of the problem by the local and state administrations, as well as a change in commitment of public administrators and in the involvement of local residents, who must track the public investments and demand transparency from governments in the implementation, accountability, and use of proper indicators in the programs. Maintaining channels of communication with tourists is also a key point to encourage them to cooperate with the solid waste management routine. The engagement of the local residents in the municipal environmental councils should be encouraged, where they can propose changes in environmental policies, rethinking not merely the solid waste management issue, but also citizen participation.

Acknowledgements

The authors thank CAPES for financial support, and the local managers who kindly received the authors.

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