CLEISEANO EMANUEL DA SILVA PANIAGUA
(ORGANIZADOR)

*Collection:*

# APPLIED ENVIRONMENTAL AND SANITARY ENGINEERING 2

Atena Editora
Ano 2022

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# Collection: applied environmental and sanitary engineering 2

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## PRESENTATION

The e-book: “Collection: Applied Environmental and Sanitary Engineering 2” consists of fifteen chapters that present works that aimed to contribute both to improving the quality and health of the environment and man, as well as to the development of technologies to reduce costs and improve the quality of basic sanitation, remedying and reducing the environmental impacts resulting from human activities.

Waste management in Brazil is “invisible” in the eyes of government plans at the municipal level, which is why precarious sanitation conditions prevail in most municipalities. In view of this, the scientific community has been reiterating through numerous studies, the need to implement systems for the collection and final disposal of waste in an environmentally more correct way.

The basic sanitation system in Brazil has been restructuring itself due to security and information technology that helps to monitor and automate water and sewage treatment systems, the final disposal of waste, the loss of water resources due to failures or ruptures of pipe among others. Added to this, the numerous software that are developed to improve operating systems that can present information in real time and operation in continuous flow, helping operators.

Finally, the study and development of new treatment technologies from agro-industry residues or from new technologies that aim to implement and improve the efficiency of existing conventional processes,

In this perspective, Atena Editora has been working with the aim of stimulating and encouraging researchers from Brazil and other countries to publish their work with a guarantee of quality and excellence in the form of books and book chapters that are available on the Editora’s website and elsewhere. digital platforms with free access.

Cleiseano Emanuel da Silva Paniagua

## SUMÁRIO

# CAPÍTULO 7

## ONLINE MONITORING OF THE MUNICIPAL SOLID WASTE COLLECTION SYSTEM

*Data de aceite: 01/04/2022*

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**ABSTRACT**: The amount of solid waste generated does not increase gradually with the increase in population and excessive consumption. An ineffective waste collection system can harm public health and the environment. In this work, a methodology was developed and used to assist the waste collection system in the City of Recife, facilitating the management of urban solid waste collection. Such methodology, based on software created by the urban cleaning company of the city. It was possible to verify some problems in the tactical and operational management in the collection of solid urban waste in the city of Recife, such as: not optimizing the fleet of existing vehicles, productivity above the preparations as optimal in most sectors, densities below or above average, among others. Thus, there was a need to identify the collection system so that the management would become more effective. Advantages facilities with the implementation of the system generated a reduction of irregularly dumped waste, making an operation 75% cheaper, thus obtaining an income for investment in equipment, gain of scale and improvements for an operation.

**KEYWORDS:** Garbage, OnLine Management, Collection, Trucks.

**RESUMO**: A quantidade de resíduos sólidos gerada no planeta vem aumentando gradativamente com o aumento populacional e consumo excessivo. Um sistema de coleta de resíduos ineficaz pode trazer danos à saúde pública e ao meio ambiente. Neste trabalho foi desenvolvido e aplicado uma metodologia para auxiliar o sistema de coleta de resíduos na Cidade do Recife, facilitando o gerenciamento da coleta de resíduos sólidos urbanos. Tal metodologia, baseada em softwares criados pela empresa de limpeza urbana da cidade. Pôde-se constatar alguns problemas no gerenciamento tático e operacional na coleta de resíduos sólidos urbanos na cidade do Recife, tais como: não otimização da frota de veículos existente, produtividades acima das estabelecidas como ótimas na maioria dos setores, densidades abaixo ou acima da média, entre outros. Com isso, verificou-se a necessidade de reestruturação do sistema de coleta para que o gerenciamento se tornasse mais eficaz. Vantagens obtidas com a implantação do sistema gerou uma redução de resíduo despejado irregularmente barateando a operação em 75%, obtendo assim, uma renda para investimento nos equipamentos, ganho de escala e melhorias para a operação.

**PALAVRAS-CHAVE**: Lixo, Gestão On-Line, Coleta, Caminhões.

## INTRODUCTION

The urbanization process that Brazil has been going through since the 1950s, with the consequent density of urban centers, has caused many Brazilian cities, especially those that grow rapidly, to suffer serious environmental, social and sanitary problems (MARTINS, 2012). The sanitary problems are mainly caused by the inadequate management of Municipal Solid Waste (USC) where they are thrown in a disorderly way in the streets, squares, streams, and wastelands causing risks to humans and the environment (WHO, 2007).

Economic and cultural aspects together with the demographic issue acceleratethe deterioration of natural resources, where the amount of solid waste produced by populations is related not only to the level of wealth, but also to the values and habits of life, determinants of the degree of willingness to perform consumption. Americans, for example, generate about two kilograms of municipal solid waste (USC) per inhabitant per day, and the Japanese, also of high purchasing power, exhibit behaviors that result in a significantly lower generation, slightly more than one kilogram (GODECKE *et al*. 2012).

The amount of waste produced by a population is variable and depends on several variables such as: income, climate, floating population, festive periods, etc. And to perform an efficient collection, it is necessary to understand that the operation encompasses from the departure of the vehicle from your garage, in addition to the efficiency of the collection during the route for removal of local waste to the return to the starting point (CUNHA; CAIXETA FILHO, 2002).

Often, these paths that should be carried out by fleets can be diverted by numerous factors without the prior knowledge of a company. The use of technological systems has been one of the great solutions for companies in order to control possible deviations of paths of fleets of waste collection trucks, in addition to inspection for an adequate packaging of waste. This work aimed to bring solutions to the problems presented and strategies to improve the efficiency of collection trucks in the collection and packaging of municipal solid waste (US) in the city of Recife, Pernambuco, Brazil.

## METHODOLOGY

Recife is a municipality in the State of Pernambuco, Brazil. With a territorial area of approximately 218.435 km², being formed by an alluvial plain, islands, peninsulas, and mangroves as its main geographical characteristics. It consists of 94 neighborhoods, with an estimated population of 1,653,461 inhabitants (IBGE, 2020).

The generation of waste in Recife was analyzed according to the weighing data in the CTR - Candeias landfill, provided by DLU (Urban Cleaning Board), in which it belongs to EMLURB (Urban Maintenance and Cleaning Company). The relational data of urban waste weighing in the landfill were analyzed in variation of the total values collected from the first

half of 2016 to the first half of 2018, in order to relate the intrinsic virtues to the aspects mentioned, the study was based on pre-existing parameters in books and articles on the generation of municipal solid waste.

The weighing record began with the arrival of the vehicle and/or equipment at the landfill, where the vehicle was previously registered and linked to the collection/cleaning service it performs. Weighing was carried out at the entrance and exit of the vehicle in the landfill.

## RESULTS AND DISCUSSION

Regarding the amount of garbage generated, according to Brown data (1993), garbage production can range from approximately 0.46 to 2.27 kg/inhabitant/day, depending on the city and the reference country. Corroborating the author, the weighing data obtained show that Recife has values like the estimated margin. Table 1 shows the variation of the average garbage production from the first half of 2016 to the first half of 2018 using as a basis the population growth obtained through IBGE (2020).

| Semester | kg/et/day |
|---|---|
| 2016.1 | 1,63 |
| 2016.2 | 1,66 |
| 2017.1 | 1,51 |
| 2017.2 | 1,50 |
| 2018.1 | 1,63 |

Table 1 - Generation of Solid Waste in Recife.

Source: EMLURB - DLU (2020).

According to Peral (1989), the generation of waste, that is, the amount of waste produced by a population, is quite variable and depends on several factors, including:

- the population's standard of living: the volume generated grows as the population's income increases.
- the time of year.
- way of life of the population: it is influenced by the daily migration between the city center and the periphery.
- movement of the population during the holiday periods, weekends and festive days.
- new methods of packaging goods, such as the use of packaging and packaging without a return.

- **The Collection System**

According to Table 2, it is observed that it is possible to select the types of collection of the highest volume of residue. This analysis demonstrated, in a summarized way, that garbage collection still takes place largely in the Household Collection, that is, a collection method in which the citizen has the residue in front of his residence usually in plastic bags that seek to facilitate the operation. However, only this procedure is not enough for the perfect operation of the operation, ideally, the residue is arranged outside the reach of animals, in a capped dumpster, with sufficient protection to avoid accidents to the worker and still be made available only when the collection time of the region is close. However, it is noticeable that society often does not receive the proper instructions, making it difficult for the operation to be optimized. It is also emphasized that it is a collection service most used in Brazil, being considered one of the most expensive.

| Collection Type | 2016 | 2017 | 2018 |
|---|---|---|---|
| HOME | 60,12% | 64,61% | 77,91% |
| SCRIPTED | 8,97% | 9,04% | 10,56% |
| SELECTIVE SEVERAL | 0,26% | 0,27% | 0,35% |
| OTHER | 30,66% | 26,08% | 11,19% |
| **Total Collected(t)** | **482** | **448** | **486** |

Table 2 - Volume by collection type.

Source: EMLURB (2020).

The data presented in Table 2 show a significant increase in household collection. This growth is through the implemented logistics that sought to serve the hard-to-access residences with tipping strategies. Thus, known due to the “pulls” that occur through a manual collection with workers as pedestrians to access limited access locations, such as alleys and staircases and through a motorized collection by smaller vehicles compared to the traditional collection truck of 15 or 18m³. These other vehicles are smaller trucks and motorcycles that access narrow, steep streets where the truck would not be able to access. After collection, the garbage is taken to the main corridors and left in planned locations, called containment points that are local where the residue remains for a maximum of 1 hour until the traditional collection truck arrives at the site and makes the collection.

All this operation is timed and accompanied by real-time tracking, where a monitoring center is performing the aid so that deadlines are met, and all collection sites are met. At all times the plant receives tracking information, traffic, misuse and any other done that may endanger the fulfillment of the operation at the due time.

The collection of waste in daily life becomes a routine, and with this, it became

realized that the vehicles followed the same route from time to time until the collection cycle was closed and thus return the same route of the first day. Emlurb's inspection began to observe the need to reduce the size of the cycle so that the same site was cleaned with a shorter time interval, and so it was done until the cleanness of the site was noticed. In the same way, it happens when you want to reduce costs, where logistics increases the interval of the cycle and thus runs the risk of making the site at the mercy of collection with the material waiting. Regarding the frequency of waste collection, Monteiro (2001) points out that the minimum frequency of permissible collection in a warm climate country such as Brazil is three times a week. For Guerra (2011), one way to evaluate the quality and efficiency of USManagement is the analysis of data on the frequency of household collection and treatment given to waste in the municipality.

The monitoring center, in turn, begins to study these cases, with the help of weighing readings and photographic records performed in the field before and after the collection, and thus define the intervals of the cycle, also called collection frequency. With this, we can create collection routes per day of the week, increasing the frequency in places most in need and reducing in less needy places. With this financial and time savings, some vehicles began to serve more than one location or service with strategic logistics. Canassa (1992) managed to reduce a course from 54,182 meters to 47,131 meters (13%) in Florianópolis (Santa Catarina - Brazil). Eisenstein and Iyer (1997) defined conjuntos of routes different from those being used for collection in Chicago (Illinois - United States), which could reduce the capacity of the trucks used by between 12 and 16%, which means a potential reduction of US$ 9 million in the costs involved.

The scripted collection had a somewhat lower scale increase when compared to the growth of household collection. This type of collection brings with it a major environmental, economic, and social problem, because the garbage storage sites are usually sidewalks, wastelands, squares and public roads. Your material can be as variable as household waste and can still contain household waste. The materials found deposited irregularly usually have a large volume and difficult access. However, thus, it can be classified as scripted because the site now presents a constant amount of waste to collect.

- **Monitoring strategies**

Faced with such demand and responsibility towards society, the strategy adopted for management was based on routine and cyclical planning on a weekly basis. The technology implemented as the main aid in the monitoramento of the collections was the tracking of vehicles and equipment, as shown in Figure 1.

Figure 1. Rastreamento system for waste collection in Recife.

Source: EMLURB – DLU (2020).

With this tool aligned with monitoring, it was inserted in an online platform for monitoring and extraction of reports, with tracking indexes verified with the previously registered planning, as well as the display of all vehicles and / or equipment in real time, being possible also the classification of equipment, issuance of alerts, quick responses and other functions of great impact for the operation to mitigate its failures, achieving speed gain in solutions and corrections.

The number of vehicles and equipment in operation at the same time, both in business hours and in other times occurs on a large scale, starting to require a team that contains many employees, which may be financially unfeasible for the operation. Thus, filter and sampling methodologies were analyzed to indicate where most of the problems were occurring, in addition to the most severe cases.

The methodology was achieved through automation of verification processes, creation of performance indicators, warnings that would help identify possible risks to the operation, thus causing an improvement in the response time to unforeseen events, enabling decision-making for correction or changes in search of appropriate adjustments to the route.

As well as vehicle monitoring by means of coordinates registered as collection points, other collection points are inserted daily by municipal inspectors, who seek irregular dumping of waste. These locations are registered through a mobile application, where it is launched directly on an online platform requesting the collection and cleaning of the site.

On the other, the selective collection service carried out in Recife is divided into two methods that seek to meet and give the opportunity to all citizens to be able to select their garbage and thus contribute to the environment. It is important to remember that to join this public service the citizen will not have cost and will receive instructions for the dumping of the selected garbage. The citizens receive plastic bags of different colors for the selection of the residue periodically and according to the availability of the resident along the conditions offered by the public power . In general, selective collection methods happen as follows:

- Through the Voluntary Delivery Points (PEV's), which is a stationary collection box located throughout the city, to adapt the demands offered by each region, being available for 24 hours for the dumping of the material. At predetermined frequencies, EMLURB removes THE PEV's with waste, replacing it with a sanitized box, transporting the waste to the sorting centers. Then, the company performs a sanitization of the collector and leaves it prepared for a next replacement.
- The collection at the citizen's door, with date and time marked by trucks suitable for this service, is triggered when there is no PEV, or when there are many employees nearby. It is a faster collection and a higher cost since the whole procedure is repeated to the truck when it reaches its limit or closes the day of activity. To register and participate in such service, the resident must seek EMLURB and inform themselves of the days and times of collection not their address or call the call center dialing 156. With this, the resident will receive the instructions to dispose of the material and the colored bags for the separation of the residue. It is important to say that the city has a limited number of participants due to the small availability of vehicles for such an operation, but in contrast, this number of participants has increased, as well as the volume of weighing of this service. The growth is symbolic, but it does not yet have the speed desired by managers and municipal leaders. According to EMLURB, there was an increase in registration by 0.01% between 2016 and 2017 and 0.08% between 2017 and 2018. These values are still derisory when compared to the most recent value of waste generated in the municipality, onde in 2018, in the best brand, selective collection reached 0.35% of the total volume of waste generated.

## FINAL CONSIDERATIONS

- According to the analyses for 2016, 2017 and 2018, the figures are a proportional order of magnitude among some main services. Most of the time, the residues are placed in the "common garbage" and are not quantifiable, which demonstrates how the issue is treated in a secondary way, a situation that deserves to be changed, because observed individually at the points of generation the volumes may not be significant to enable a system, which does not occur when observing the picture.
- These individual initiatives end up bringing a non-uniform treatment to disposal, the same waste that in some points are discarded, are recycled in others. This fact shows not only the waste of resources but also that, just as it seeks to give correct destination in some points, in others the issue is over considered.
- In the economic aspect, the online collection service has an operational cost of approximately 1/4 of the cost at which the Household Collection would have to collect a similar volume in equal operating time. And consequently, selective collection was evaluated according to the same criteria and obtained a ratio of 1/3 for door-to-door collection and 1/6 for the collection performed in ENP. These

values state that the advantages in reducing irregularly dumped waste cheaperate the operation by 75% simply because it leaves the garbage in the correct place and at the correct time, and even though this value can still be reduced to 12.5% if the waste is selectively separated and taken to a voluntary delivery point, thus obtaining a possible income for investment in equipment, gain of scale and improvements to the operation.

- In general, the software technology allowed to record information pertinent to waste management, identifying those involved and optimizing processes such as the request for collection, preparation of routes, issuance of documents, preparation of reports, etc.

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