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Research Paper

Analysis of coarse solid waste from operating units of the Insular sewage system, Florianópolis – SC

Análise gravimétrica dos resíduos sólidos grosseiros de unidades operacionais do sistema de esgotamento sanitário Insular, Florianópolis – SC

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ABSTRACT: This study made a gravimetric composition analysis of solid waste retained in the grids of some operational units of the Insular sewage system in Florianópolis, State of Santa Catarina, Brazil. Two sewage pumping stations (Beira-Mar Norte and Hospital Universitário/Trindade) were chosen for this purpose. The following classes of solid waste were used: plastics, construction waste, dead animals, organic matter, rags and cloths, tailings, and others. The analysis showed the solid waste that was found in the greatest quantities in the sanitary sewage system and that may cause damage to the operational units.

Keywords: Solid Waste, Sewage System, Pumping.

RESUMO: *Este trabalho teve como objetivo identificar por meio da análise de composição gravimétrica dos resíduos sólidos retidos nos gradeamentos de algumas unidades operacionais do sistema de esgoto Insular do município de Florianópolis, Estado de Santa Catarina, Brasil. Foram escolhidas duas estações elevatórias de esgoto (Beira-Mar Norte e Hospital Universitário/Trindade). Foram adotadas as seguintes classes de resíduos sólidos: plásticos, resíduos da construção civil, animais mortos, matéria orgânica, trapos e panos, rejeitos e outros. Foram identificados os resíduos sólidos que em maiores quantidades no sistema de esgotamento sanitário podem causar danos às unidades operacionais.*

Palavras-chave*: Resíduos Sólidos, Sistema de Esgotamento Sanitário, Elevatórias.*

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INTRODUCTION

Attaining environmental and sanitary quality in urban areas depends on the effective operation of a series of infrastructures and services, e.g., public basic sanitation services. Sanitary sewage systems and urban solid waste management services are designed to manage effluents and waste that are directly generated by the population and by economic sectors. Therefore, it is crucial that they function properly to ensure environmental preservation and to mitigate or prevent the pollution of water resources, among other important benefits (COSTA, 2011).

All basic sanitation systems and services are closely related and affect one another in the urban environment, as exemplified by sanitary sewage and solid waste: an excessive amount of waste can cause problems for sewage facilities and operating units (NEVES; TUCCI, 2008). They may not only cause damage to pumps, pipes, equipment, or treatment units, but also create a considerable operational demand for cleaning, maintenance and proper management and disposal of solid waste, defined as waste from public basic sanitation services, according to Brazil's National Policy for Solid Waste, established by Act N. 12.305/2010.

The efficient management of public sanitation services positively affects the implementation of water resources management. By serving cities without any stoppages or collapses in the equipment and operating units of the sanitary sewage system, water resources users that provide basic sanitation services can help to mitigate harmful impacts on the environment and on receiving water bodies.

Lack of environmental and health awareness may also be a reason for the improper appearance of solid waste in sewage systems because the population throws several materials into the sanitary plumbing and drainage system, often out of ignorance rather than deliberately, instead of choosing the most appropriate method of disposal.

Poor or non-existent street cleaning and waste collection services in urban areas and the improper transfer of urban rainwater to sanitary sewage system plants may also lead to the presence of waste in sewage facilities (TUCCI, 1997).

The present study analyzed the types of waste that are commonly found in some operating units of the Insular sanitary sewage system in the city of Florianópolis and that are retained in the grids.

A previous review of the literature showed there are not many research studies conducted in Brazil that have focused on these coarse materials, except for those that sought to assess the potential for recycling or reuse of sludge and sand removed from preliminary treatment units.

Therefore, this study is expected to provide further insights into the management of such waste, the management of sanitation services, and the need to search for technological, operational, and environmental as well as sanitary education alternatives that can enhance the proper operation of these units of the sanitary sewage system (SSS) upon the occurrence of solid waste.

MATERIAL AND METHODS

Study area

This study was conducted in the city of Florianópolis, the capital of the State of Santa Catarina (SC), located in the southern region of Brazil, between parallels 27° 10'

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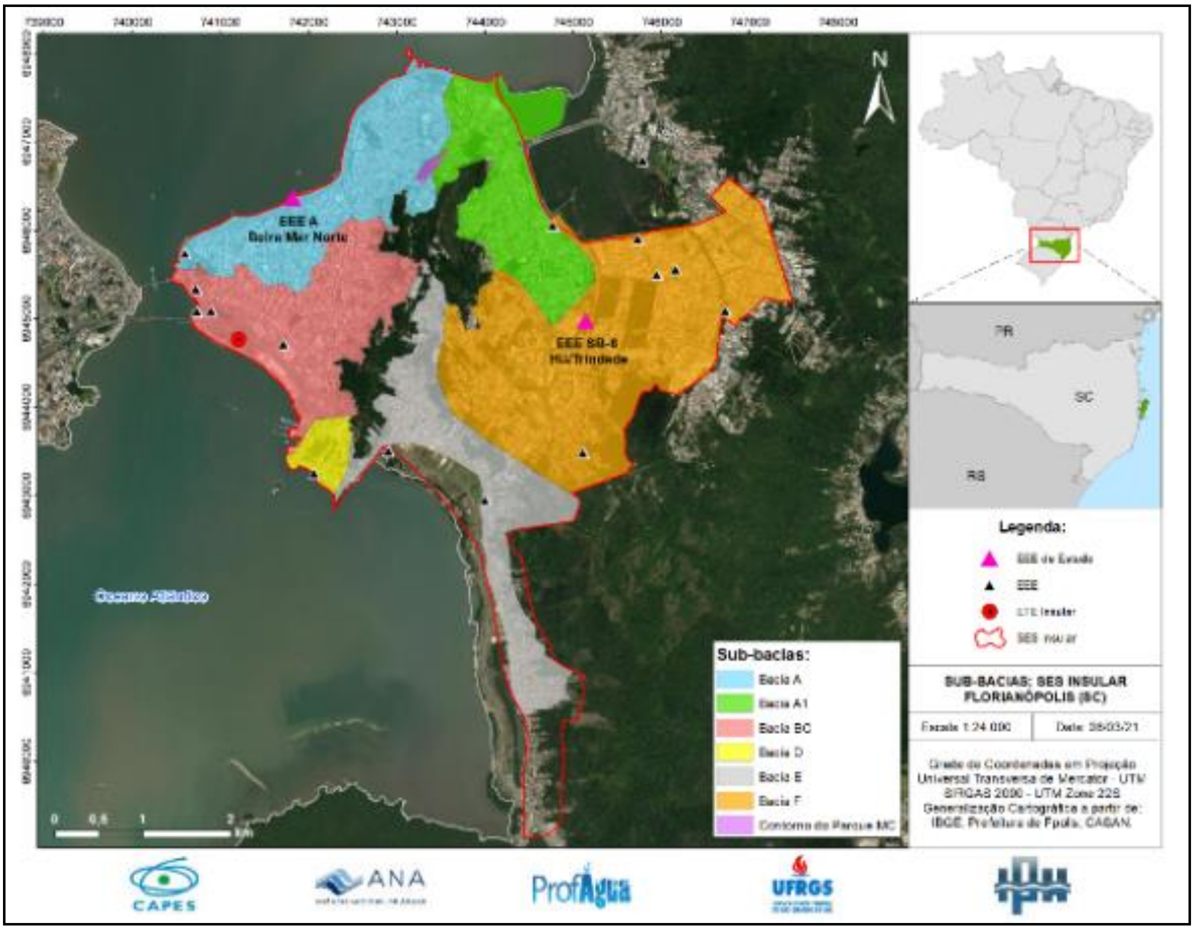
and 27° 50’ (South latitude) and between meridians 48° 25’ and 48° 35’ (West longitude). It extends over an area of 438.5 km^2 (Prefeitura Municipal Florianópolis, 2021), with a total estimated population of 508,826 inhabitants (IBGE, 2020).

Data were collected at two sewage pumping stations (SPS) of the Sanitary Sewage System – Insular SSS, operated by Santa Catarina state’s water supplier, *Companhia Catarinense de Águas e Saneamento* – CASAN (**Figure 1**). Insular SSS covers the central portion of the Island of Santa Catarina, Administrative District Headquarters, and serves the following districts: Centro, Agronômica, Maciço do Morro da Cruz, José Mendes, Prainha, Saco dos Limões, Costeira do Pirajubaé, Pantanal, Córrego Grande, Itacorubi, Santa Mônica, Trindade (Prefeitura Municipal de Florianópolis, 2021).

Figure 1. Sub-basins of Insular SSS and study operating units (SPS).



The system serves a population of around 138,519 inhabitants with 15,291 connections and 59,296 households. It has 27 SPS and the current treatment flow is 278.23 L/s in the Insular effluent treatment plant (ETP) through extended aeration activated sludge. The treated effluent is disposed of into the sea near the city’s south bay (“Baía Sul”) (City Hall of Florianópolis, 2021).

These are the study SPS of Insular SSS:

(i) SPS HU/Trindade (SPS SB6): located on Sewage Basin F, at the back of the Polydoro Ernani São Thiago University Hospital, Federal University of Santa Catarina – UFSC, Rua Profª. Maria Flora Pausewang, Trindade District;

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(ii) SPS Beira Mar Norte (SPS A): located on the system's Sewage Basin A, in a setback area on an avenue called Jornalista Rubens de Arruda Ramos, in central Florianópolis, by the square of the Military Police, named Praça do Seisquicentenário.

Figure 2 shows an on-site view of the SPS and the grids installed in each unit. The SPS HU/Trindade (SPS SB6) has only one grid while the SPS Beira Mar Norte (EEE A) has two.

Figure 2. External view and grids of the study operating units: (A) SPS HU/Trindade – SB6; (B) SPS Beira-mar – A.

Development of the study

The present study used gravimetric composition analysis as a method to identify the main coarse solid waste retained in the grids of the operating units of the Insular System.

The basic methodology followed the technical guidelines of the Brazilian Institute of Municipal Administration - IBAM (2001) for studies on gravimetric characterization of urban solid waste. These guidelines were adapted to the conditions of the waste that was removed from the grids of the pumping stations of SSS. **Figure 3** shows a composition with numbered photographs that illustrate aspects of the methodology used in this study.

The following steps were taken: collecting the samples while cleaning the grids (01); transporting the waste in plastic drums to the location provided by CASAN for the development of the research activities (02); spreading the waste on canvas in a flat area (03); separating the waste into each of the previously selected classes and classifying as "others" the materials that do not fit into the previously selected list or that could not be visually identified (04); weighing each component separately (05); weighing the whole sample (06). The data were then compiled; the weight (kg) of each component was divided

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by the total weight of the sample (kg) and gravimetric composition was calculated in percentage terms.

Figure 3. Example of the main steps of the gravimetric study (in this case, image 01 shows the removal of waste from the grid in SPS HU/Trindade).

The main components, i.e., the classes of materials, were defined prior to analysis. In this case, the research reported by Morgado and Inácio (2014) was used as a reference, especially because it is the only study conducted in Brazil that focused on coarse solid waste found in SSS units in the State of São Paulo. However, not all of those authors' classes, which had even undergone laboratory analyses, could be used in the present study. However, the major classes were selected, as shown in **Table 1**.

The gravimetric analysis was performed based on the total wet mass of coarse waste removed from the grids during the operational cleaning activities of the units of the study system. Coarse waste was removed from the grids by the staff of the SSS operator, CASAN, as part of its regular operational maintenance routine. The total amount of waste corresponds to the total volume removed from the units during one day of maintenance, that is, the cumulative amount of material collected in the units during cleaning activities, which take place once or even twice daily. The waste was collected one day before the study for the purpose of natural removal (drying) of the excess liquid sewage sludge present in the material.

Table 1. Classes for coarse solid waste

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Classes	Waste
Plastics and latex	bags, food packaging, condoms, etc
Molded plastics	packaging, bottles, caps, containers, cotton swabs, etc
Construction materials	fragments of cement, wood, broken bricks, etc
Dead animals and the like	fetuses, rats, etc
Rags and cloths	old clothes, sponges, fabrics in general)
Organic matter	fat, leaves, etc
Other and/or tailings	materials that cannot be identified or segregated or that are already in an advanced state of putrefaction, etc

Source: Based on Morgado and Inácio (2014).

The full amount of coarse waste was weighed and used in the amount taken from the operational units, that is, the samples were not quartered. All coarse waste was identified and weighed, and the total amount collected daily was also weighed.

Samplings were carried out in the units every two weeks, after the materials had been removed from the grids. Importantly, this study is underway, and the samples will continue to be collected until July 2021. However, this article reports the first results for the sampling period from February to April 2021.

RESULTS AND DISCUSSION

Table 2 shows the preliminary findings for the classes used in this study. There is a great deal of variation in the individual samples, either in the total weight of the sample, or in the characteristics of the solid waste categorized in the predefined classes. Thus, a longer sampling period is needed in this study for an adequate analysis of variability over time.

In this study, all the materials that cannot be visually characterized - and, therefore, manually separated - are labeled as “tailings and others”. In qualitative terms, the material retained in the grids was in an advanced state of putrefaction, and there was an excessive occurrence of textile fibers that are particularly used to manufacture wet wipes used by the population. These materials form a compact, difficult-to-handle paste-like mixture adhered to other organic substances.

According to Morgado and Inácio (2014) the occurrence of these fibers accounted for about 26.4% of the composition of the waste retained in the medium grids. In the present study, a visual analysis showed that these materials were the largest part of the waste categorized as “tailings and others”; however, they could not actually be separated thoroughly. Wet wipes are commonly made of nonwoven fabric, composed of some plant fiber (e.g., viscose) or polyester, and plastics.

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Table 2. Preliminary results of the gravimetric analysis of the study SPS (Feb.-Apr. 2021).

	SPS HU/Trindade - SB6										Total	
Weight (kg) per Class	04/02	%	18/02	%	04/03	%	18/03	%	01/04	%	kg	%
Plastics/Latex	0.65	2.63	0.42	3.64	0.73	5.42	0.02	0.20	0.08	0.89	1.91	2.7
Molded Plastics	0.08	0.31	0.06	0.55	0.10	0.75	0.10	0.89	0.04	0.43	0.38	0.5
CW	0.08	0.33	-	-	-	-	-	-	-	-	0.08	0.1
Dead Animals	-	-	-	-	-	-	-	-	-	-	-	-
Rags and Cloths	-	-	-	-	-	-		-	-	-	-	-
Organic Matter	4.57	18.40	0.50	4.29	-	-	0.25	2.22	-	-	5.32	7.5
Tailings and others	19.45	78.32	10.67	91.53	12.57	93.84	10.88	96.69	9.28	98.68	62.85	89.1
Total Sample (kg)	**24.83**	**100.00**	**11.66**	**100.00**	**13.40**	**100.00**	**11.25**	**100.00**	**9.40**	**100.00**	**70.54**	**100.0**
	SPS Beira Mar Norte - A										**Total**	
Weight (kg) per Class	04/02	%	18/02	%	04/03	%	18/03	%	01/04	%	kg	%
Plastics/Latex	0.03	0.12	0.31	2.34	0.43	2.62	0.08	0.69	0.40	1.66	1.25	1.4
Molded Plastics	-	-	-	-	-	-	0.03	0.22	0.15	0.61	0.17	0.2
CW	-	-	-	-	-	-	-	-	-	-	-	-
Dead Animals	-	-	-	-	-	-	-	-	0.12	0.50	0.12	0.1
Rags and Cloths	0.06	0.24	0.15	1.13	0.04	0.24	-	-	-	-	0.25	0.3
Organic Matter	-	-	0.25	1.86	-	-	2.21	19.05	0.57	2.37	3.03	3.3
Tailings and others	25.22	99.64	12.54	94.67	15.93	97.13	9.28	80.03	22.86	94.85	85.83	94.7
Total Sample (kg)	**25.31**	**100.00**	**13.25**	**100.00**	**16.40**	**100.00**	**11.60**	**100.00**	**24.10**	**100.00**	**90.66**	**100.0**

Notably, these materials are commonly found in the sewage systems and, consequently, on the grids, because they are not easily degradable as compared to toilet paper; actually, they are materials or waste that should be sent to dumps and disposed of in the municipal solid waste collection management system, rather than in the SSS.

The same applies to the plastics and latex found in the samples. The big amount of waste is indicative of the population's low awareness of the materials that are sent to the sanitary plumbing and drainage system connected to the sewage systems.

It should be noted, however, that part of these plastics and other materials, such as construction waste, may be carried to the sewage collection systems owing to interference from the urban rainwater drainage system and improper connections, as well as the non-existent or poor provision of public street cleaning or solid urban waste collection services in urban areas. As a result, waste is accumulated on sidewalks, roads and in other environments, and it can be carried by rain to the units of the sanitary sewage system (POMPÊO, 2000; TUCCI, 2002; CASTILHO JÚNIOR, 2003; BERTOLINO et al., 2018).

Neves and Tucci (2008) reported that street cleaning services are more closely related to the presence of waste in urban drainage, as they are more likely to carry it to the system. Consequently, the presence of solid waste in sanitary sewage units may be because rainwater is carried to the sewage system.

Tucci (1997) explained that most sewage collection systems in Brazil are conceptually used as an absolute separator, that is, there is a distinction between the management of rainwater and that of sanitary sewage, i.e., there are independent operating systems. Pompêo (2000) argues that there is "hardly ever" a distinction between the use of rainwater drainage systems and sanitary sewage systems. The reason, which is agreed upon even by Tucci (1997) and Pompêo (2000), is the lack of investment in sanitary sewage structures in cities, which ultimately leads to a mixed-use approach to the systems, although they were not, in fact, conceptually designed for the same purpose.

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So far, there has been low frequency of construction waste (CW), dead animals, rags, and cloths. These materials were only found in a few samples.

Soft plastics and latex, which could be separated manually, were found at a relevant frequency in the two operating units, accounting for about 2.7% of the total amount in the SPS HU/Trindade and 1.4% in the SPS Beira Mar Norte. Organic matter - which, in this study, corresponded particularly to the separation and weighing of the lumps of fat retained in the grids that came off the system pipes - was the most relevant class: about 7.5% and 3.3% of the total amounts found in the SPS HU/Trindade and in the SPS Beira Mar Norte, respectively.

In the study of Morgado and Inácio (2014), for the study medium grids, fabrics (rags and cloths), fats and soft and molded plastics were also the materials most frequently found in percentage terms: 30.1%, 9.5%, 16.4% and 14.9%, respectively. In the present study, molded plastics, for example, have not been found very frequently so far, which tends to be a positive result, since these materials should not be present in sewage systems.

Thus, the development of this study will enable these researchers to check the occurrence of waste typologies in Insular SSS, determine the possible origin of such waste, and check if there are differences between the two units, based on the results to be found for each one of them, although they are part of the same SSS.

These data may be helpful for making decisions on the management of solid waste in the system, as they may not encourage only the review of the solid waste management plans of the operating units, but also further analyses of the types of waste according to the management guidelines of the National Solid Waste Policy (PNRS) (Act No. 12.305/2010).

It has already been found that there was an excessive presence of solid waste - soft plastics, latex, molded plastics, and waste characterized as wet wipes - in the units of Insular SSS. This finding indicates that sectoral plans lack initiatives and policies for environmental and health education of the population in areas such as basic sanitation, solid waste management and water resources.

CONCLUSIONS

The results for the solid waste found in the operating units of Insular SSS can encourage further research on basic sanitation and water resources management policies. Problems caused by solid waste (which is not supposed to be found in excess amounts) in these units result in occurrences that may negatively impact the environmental and sanitary quality of the urban environment and the receiving water bodies, urban rainwater drainage systems, etc.

The lack of instruments and effective actions for environmental and health awareness-raising, as well as for the management of sanitation services, e.g., in sectoral plans (sanitation, water resources, solid waste), indicates the need for specific alternatives that can integrate these themes with a view to reducing potential damage and negative impacts that are associated with them.

Therefore, the preliminary results of the present study showed that there is a need to define ways to make the population more aware of the proper management of solid waste generated in buildings and its relationship with the sanitary plumbing and drainage system connected to the SSS.

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