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Papers

Mapping of healthcare waste generating sources through the use of GIS

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Summary

Healthcare waste (HCW) impacts public health and the environment when inadequately managed. The lack of knowledge about the risks of such waste by health professionals and by the population leads to the incorrect destination of the waste. It ends up being sent to the selective collection program and, later, to cooperatives of recyclable materials. Thus, this study aimed to analyze the routes traveled by the selective collection truck of Pelotas/RS in the areas covered by the program to identify the types of HCW generating sources that can be found on these routes. Because this is an exploratory research, we used tools of the Geographic Information System (GIS). It enables the user to perform spatial analysis and data generation through maps. It was possible to identify in one zone 99 health establishments; and, in another, 15 establishments, which refers to both human and animal healthcare. The presence of HWC in recyclable waste evidences the need for greater educational and enforcement actions, and for this last one, GIS can be used as an auxiliary tool.

Keywords: Geographic information systems. Waste management. Public health.

Introduction

In addition to the generation of solid household waste, which represents a challenge for public and private administrators, urbanized environments produce other types of waste, which require proper management (GÜNTHER, 2008). Among the waste generated, we can highlight healthcare waste (HCW), which is an important part of the total

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urban solid waste, not because of the quantity generated (around 1% to 3% of the total), but because the potential risk it represents to health and to the environment (BRASIL, 2006).

The risks inherent to HCW are due to the presence of pathogenic organisms and/or toxins, chemical products (drugs, chemotherapeutic agents, among others), as well as radiological risks and perforating/cutting materials (SCHNEIDER; STEDILE, 2015). As a result, this waste represents a physical, socio-economic, sanitary and environmental problem, from its handling, segregation to its final disposal (TAKAYANAGUI, 2004).

Federal Law No. 12.305 of 2010, which establishes the National Policy on Solid Waste (*Política Nacional dos Resíduos Sólidos* - PNRS), makes all generators of waste responsible for the environmentally appropriate disposal of solid waste. Non-generation, reduction, reuse, recycling and solid waste treating are among the objectives of this Law, as well as the environmentally appropriate disposal of waste (BRASIL, 2010). In this sense, one of the guidelines of this policy is the implementation of selective collection programs, an activity that represents an alternative to the reuse and recycling of the recoverable part of the waste (CONKE, 2015).

PNRS also establishes the stimulus and strengthening of selective collection with the integration of waste pickers organized in associations or cooperatives (BRASIL, 2010). According to Cherfem (2016), waste pickers seek associations or cooperatives looking for better work conditions and social security. However, even in these places, the workers are still exposed to several occupational hazards, which, according to Cockell et al. (2004) and Almeida et al. (2009), are related to incorrect waste segregation by society. People usually forward recyclable materials mixed with other types of waste for selective collection.

Nazari (2017) found HCW in picker cooperatives in the city of Pelotas, Rio Grande do Sul (RS) – Brazil. This type of waste was inadequately destined to these places alongside recyclable waste. Through the qualitative and quantitative characterization of the HCW performed in this study, it was possible to verify a cooperative of pickers from the city of Pelotas, which received more HCW through the selective collection program, as well as the days of the highest occurrence of this type of waste. Therefore, it was defined that this cooperative would be the focus in the present study.

Faced with this problem, our objective was to analyze selective collection routes in the city of Pelotas, Rio Grande do Sul – Brazil, (31º 46 '34" S; 52º 21'34" W) through the use of Geographic Information Systems (GIS) to identify and characterize sources that generate HWC.

Methodology

The cooperative studied was selected based on the study by Nazari (2017). From the days of higher occurrence of HCW in the cooperative which were Wednesday and Friday, the neighborhoods that sent waste to this

cooperative were delimited. These neighborhoods are also known as "Zones". These zones were characterized as Zone 1 and Zone 2 and, subsequently, they were analyzed spatially to categorize the sources that generate HCW and the area of coverage of the selective collection route.

To carry out the spatial analysis and mapping of the selective collection truck in the city, we used the Quantum Gis Program (QGIS), version 2.18.4 (Las Palmas). It also enables the visualization of raster and vectorial data, attached to a geodesic information system, providing several mapping functions, such as: georeferencing, vectorial analysis and geoprocessing (TYLLER, 2005; RISTOW, 2014).

In this study, we used the data presented in Table 1, which was obtained through the following sources:

Table 1. Database.

Data	Source
Map of Pelotas	National Spatial Data Infrastructure (*Infraestrutura Nacional de Dados Espaciais* - INDE) Website
Blocks of Pelotas	Basic Urban Map (*Mapa Urbano Básico* - MUB) of the city of Pelotas granted by the Civil Defense
Allotments of the blocks	MUB of the city of Pelotas granted by the Civil Defense
Delimitation of Zones	Municipal Plan for Integrated Solid Waste Management (*Plano Municipal de Gestão Integrada de Resíduos Sólidos* - PMGIRS, 2014) of Pelotas
Sources that generate HCW	Google Maps Website

Organization: Author, 2017.

We carried out the delineation of the route used by the selective collection truck. This procedure defined the zones that send the waste to the analyzed cooperative. The zone was then vectorized by using the map of the selective collection of the city and the blueprints of the route of the waste collection as a guide.

We identified the sources that generate HCW through the Google Maps program by adopting Silva's methodology (2004), which attribute to each point its spatial location (coordinates X, Y). To categorize these sources it was used employed the "Street View" tool of Google Maps, with the "Satellite" function active. Then, we sought the exploration of the route's coverage area the generating source was identified by its facade. The geographic coordinates of the sources were exported to the QGIS Program and added to the belonging batch.

For the mapping stage, we used the following data: type of generating source, route and coverage area. From this, we defined the appropriate set of colors through the ColorBrewer 2.0 software (BREWER, 2009). This software offers a series of color schemes for thematic maps which allows for the clear representation and mapping of data (LEANDRO, 2013).

The Reference System and the Projection System used were the Geocentric Reference

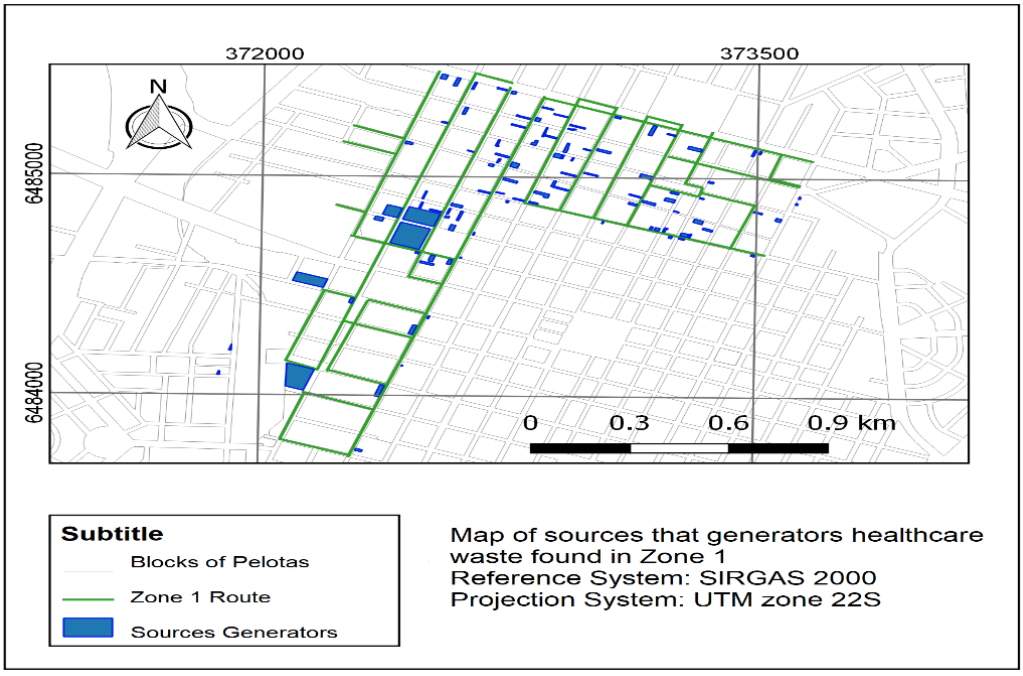
System for the Americas 2000 (SIRGAS 2000) and the Universal Transverse Mercator (UTM) zone 22 South, respectively. The Coordinate Reference System code found in the program was the European Petroleum Survey Group (EPSG): 31982, at a 1:2000 scale.

Results and Discussion

Map 1 shows the sources that generate HCW that were found in Zone 1. We noted the significant presence of 99 sources, most of which are near the route used by the trucks. The sources that generate HCW reported in this zone are mostly located near frequently accessed roads. Thus, authorities must be aware of the disposal of solid waste in these places, since in the selective door-to-door collection the recyclables are placed in front of residences and establishments.

Richter (2014) emphasizes that the waste deposited on sidewalks to be collected by the selective collection trucks can cause problems with animals, because they often tear bags looking for food. Then the wind and the rain carry the waste contained in the bags, fostering the proliferation of bad odors and vectors that can cause diseases. Moreover, the author mentions the situation of autonomous pickers who collect recyclable materials segregating them from other waste and often spreading the waste trough public roads, being prone to disease.

Map 1- Sources that generate HCW found in Zone 1



Source: Autonomous Service of Sanitation of Pelotas (Serviço Autônomo de Saneamento de Pelotas - SANEP), 2014; Google Maps, 2017.

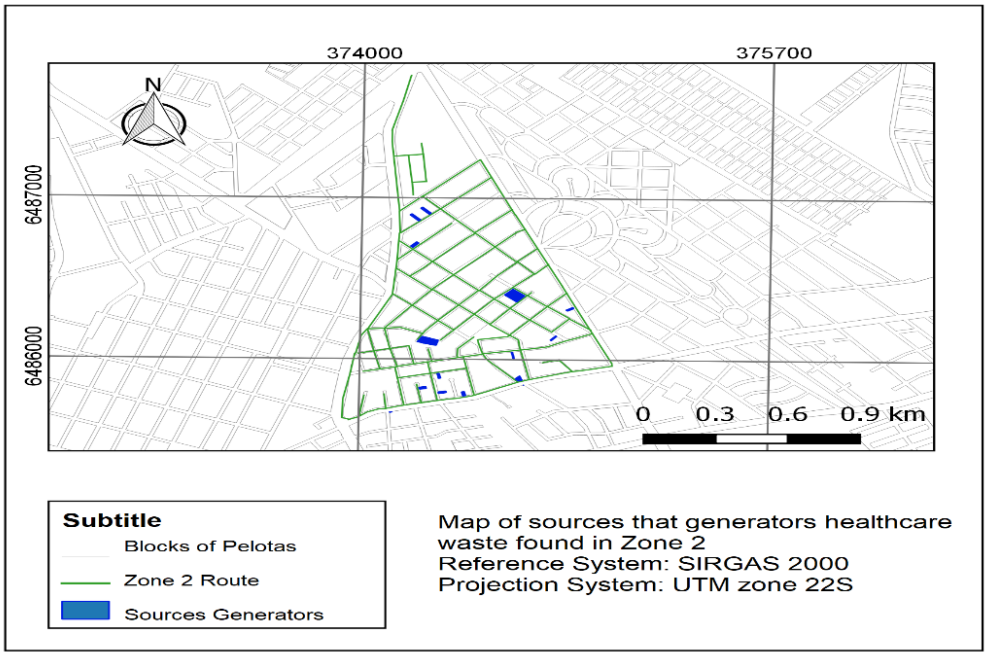
Organization: Author, 2017.

In this context of inadequate segregation, it should be noted that the HCW discarded alongside the recyclables destined to the selective collection can put the community's health at risks . It may happen because different actors in the waste chain come into contact, direct or indirectly, with infectious or contaminating material, causing environmentally harmful situations that exceed the local limits of generation (SCHNEIDER et al., 2015).

The correct segregation may reduce infected HCW, making it impossible to contaminate the total mass of waste generated, which prevents the occurrence of facts typified like environmental crimes (TAKADA, 2003). The absence or the inadequate segregation of biological waste propitiates the contact between this type of waste and regular waste, making it infectious also (TAKADA, 2003). This increases the risks faced by health workers and the general population.

Map 2 shows Zone 2, which was also pointed out as one of the zones that contributed to the inappropriate routing of HCW to the cooperative. In this zone, we verified the presence of 15 sources that generate HCW. Compared to Zone 1, the quantity found is significantly inferior. One of the factors that can justify such a fact may be in the identification process. Not all establishments were mapped due to problems in viewing the façade of the buildings. We should also consider the existence of places with no identification. Besides, we noted that the sources that generate HCW found are close to the route the trucks use during the collection of waste.

Map 2 - Sources that generate HCW found in Zone 2.



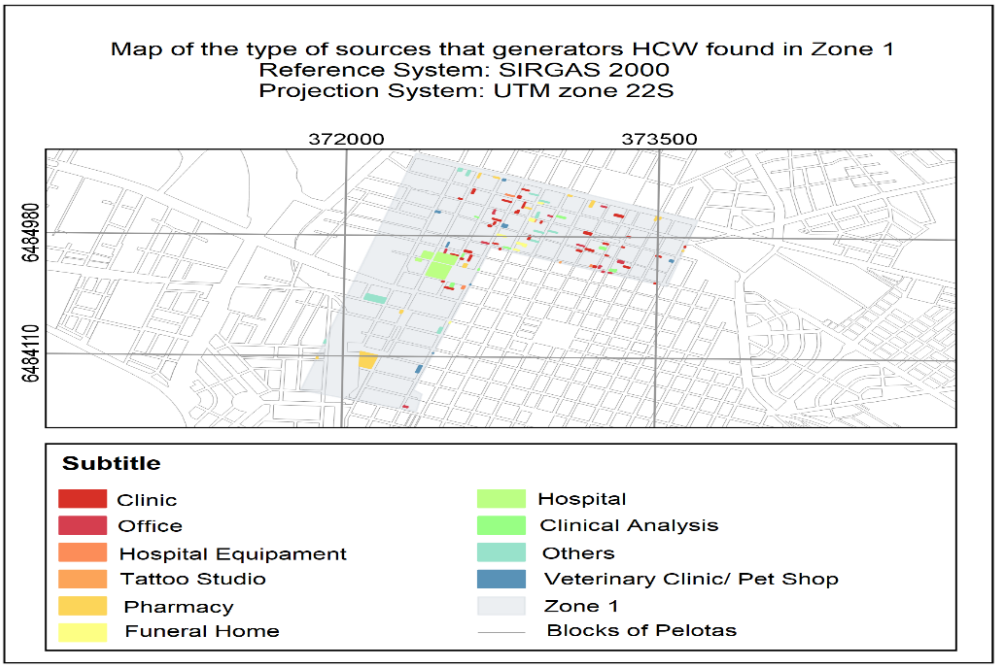
Source: SANEP, 2014; Google Maps, 2017.
Organization: Author, 2017.

For the types of sources that generate HCW, we performed a judicious search to identify them. The sources were separated into 10 categories for better qualification and quantification: clinics, offices, hospital equipment, tattoo studios, pharmacies, funeral homes, hospitals, clinical analysis laboratories, veterinary clinics/pet shops, among others.

It is important to highlight that HCW is not restricted to waste generated in hospitals, but also in all establishments that generate health waste, such as laboratories of pathology and clinical analysis, veterinary clinics, research centers, laboratories, blood banks, medical offices, dental offices and similar places (BRASIL, 2005).

Map 3 shows the relation of sources that generate HCW found in Zone 1.

Map 3 - Types of sources that generate HCW found in Zone 1.



Source: Google Maps, 2017.
Org.: the Author, 2017.

We found 33 clinics characterized as: dental, aesthetic, gynecological, pediatric, specialties, besides those of general care. There were 9 clinical analysis laboratories, encompassing human analysis and veterinary analysis. There were 4 establishments of hospital equipment, where we can find service providers for the equipment found in health establishments.

We found 11 offices, specified as dental, aesthetic, pediatric and general care. We could locate 6 funeral homes, 12 pharmacies and only 1 tattoo studio.

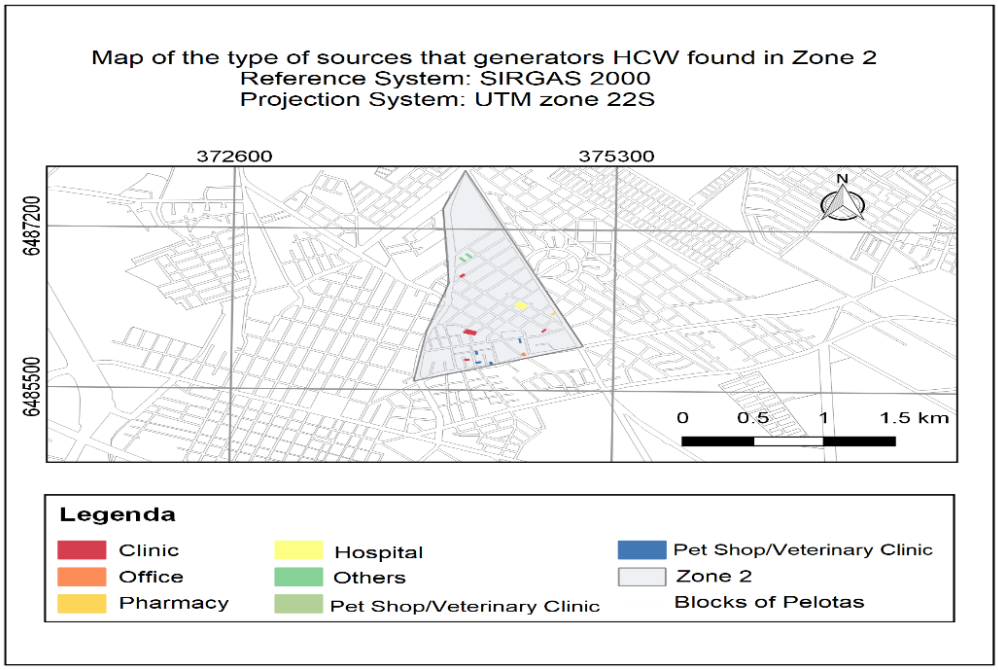
We found 8 veterinary clinics and pet shops, which are shown in one single

group for better viewing. It is important to point out that many pet shops offer animal health care services. In the category of hospitals, we found 4 establishments, encompassing one ambulatory, which was placed in this category. Lastly, the category "others" contemplates 11 establishments, such as nursing homes, children's homes, geriatric homes, social support houses and the Department of Public Health.

Map 4 shows the categories of sources that generate HCW found in Zone 2. The 5 clinics identified are divided into esthetic, geriatric, dental and general care. We found the same quantity of veterinary clinics and pet shops. The only office was a dental office, whereas the hospital found was characterized as a Basic Health Unit (*Unidade Básica de Saúde*). Additionally, we located a pharmacy in this selective collection route.

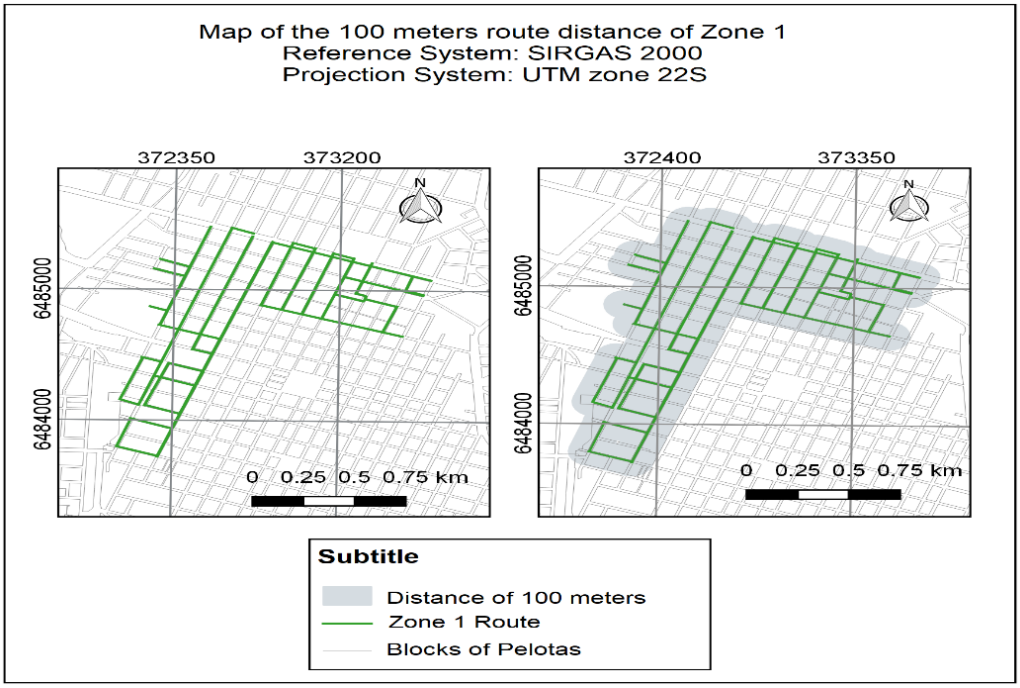
Regarding the coverage of the routes, we can see in Maps 5 and 6 the delineation of these routes and how much they can cover in a distance of 100 meters.

Map 4 - Sources that generate HCW found in Zone 2.



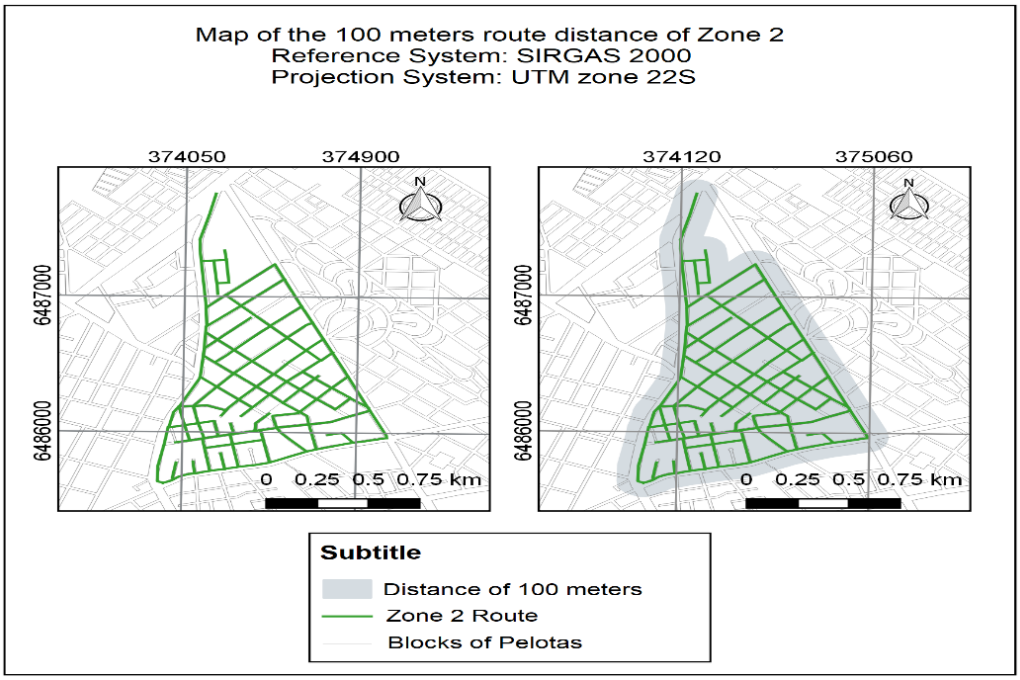
Source: Google Maps, 2017.
Organization: Author, 2017.

Map 5 - 100-meter route distance of the selective collection truck that travels Zone 1.



Source: SANEP, 2014.
Organization: Author, 2017.

Map 6 - 100-meter route distance of the selective collection truck that travels Zone 2.



Source: SANEP, 2014.
Organization: Author, 2017.

Faced with these figures and the spatial analysis, we can see that the 100-meter distance encompasses other blocks that go beyond the delimitation of zones. The analysis showed that in addition to the health establishments found in the routes, other sources are not included directly in the selective collection route, but they can also generate HCW to the cooperatives.

The apparent irresponsibility of the sources in not performing the adequate segregation of the waste, as well as the lack of awareness and misinformation of sending this type of solid waste together with recyclables to the selective collection program, depicts a serious flaw in waste management.

For Corrêa et al. (2007), the inappropriate segregation of HCW is an ethical matter to the professionals who work in health establishments, because the management of this waste in sources that generate HCW depends mainly on the collaboration of people who work with the correct management. The authors emphasize that this awareness of professionals reflects the responsibility for the environment and the improvement to the quality of life of the establishment, the patients, the community in general and to the professionals who deal directly in the waste chain.

Besides, we would like to point out the lack of supervision by the licensed public organs in verifying how HCW is managed and in implementing the Health Care Waste Management Plan (*Plano de Gerenciamento de Resíduos de Serviços de Saúde* – PGRSS, healthcare waste management of Policy instrument) in health care establishments. This plan aims to promote the well-being of the health care professional in their work environment, as well as the well-being of the community in general (TAKADA, 2003).

With regard to GIS, in the same way we used this tool in our study, Máximo (2004) used this technology to map urban criminality and verified its usefulness in public security. In addition, Carvalho et al. (2007) report for the spatial approach with the use of GIS in the health area, performing the spatial analysis associating health events with the use of socio-environmental indicators and/or variables to meet the demands of a Health Surveillance System.

Final considerations

The use of spatial analysis through GIS in waste management is a theme to be explored, mainly because of its versatility and increase in usage in the last few years. Through the mapping carried out in this study, we could delineate the zones of coverage of the selective collection program. We could also quantify and qualify the sources that generate HCW and classify them into categories.

It was identified 114 health establishments which are for human and animal health care in two zones from the selective collection program. It was also possible to classify different types of HCW generating sources, and the category “clinics” is the most found, with 33 and 5 establishments in Zone 1 and Zone 2, respectively.

Finally, the correlation between the incidence of HCW in the cooperative of recyclable material and the mapping of sources

that generate HCW through the QGIS Program can facilitate inspection services and, thus, ensure the environmental health and, especially, the professionals directly involved with waste management.

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