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AcheSeuEcoponto: aiding Brazilian cities in the proper disposal of solid waste

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Abstract

Population growth combined with industrial development and increasing consumption has caused several problems related to solid waste management, such as inadequate disposal. Due to global pressures and new polices such as the Brazilian Solid Waste National Policy, managers need to find solutions to reduce, reuse and recycle waste. Information and Communication Technologies and Geographical Information Systems are used worldwide in solutions for waste management. This work presents a system, called *AcheSeuEcoponto*, which aims to assist the population to properly allocate their solid residues. This tool was developed using Geo and Web technologies based on an architecture of four modules. The tool offers some functionalities to citizens, such as querying the nearest drop-off centre by residue type, map visualization and directions. The social network module allows us to disseminate the system, thus, the drop-off centres. In addition, the tool provides managers with strategic reports related to areas lacking of disposal points, the most popular points and the public profile. We answered questions that measure the scope of the system, the influence of Web technologies on the dissemination of *AcheSeuEcoponto*, and the public profile and their knowledge about disposal centres. For this purpose, we collected data using a questionnaire and a Web analytics service. Some results were expected, but the percentage of people who showed a lack of knowledge of drop-off centres was beyond expectations, highlighting the importance of research within the context of solid waste management.

Key words: solid waste management, web system, decision support system, recycling drop-off centres, geo technologies, social networks, proper disposal, municipal solid waste

1. Introduction

The problem of Solid Waste Management (SWM) has repercussions on the world stage, in meetings of the United Nations (UN), the scientific community and in public policy. In Brazil, after 20 years of being discussed in the National Congress, Law No. 12305/2010 was approved in 2010. This law established the National Policy on Solid Waste (NPSW) (BRASIL, 2010). The NPSW has several instruments and guidelines, such as environmental education, shared responsibility, reverse logistics, and recycling.

The solutions adopted for the SWM are linked to the management of one or more steps of the waste life cycle. We developed Figure 1 to illustrate this life cycle. The cycle starts with the industrial production of goods and their disposal as waste at the end of their life. The waste generated is collected and has its proper destination and transportation, depending on its type. Recyclable/reusable goods go through a triage, treatment and processing to produce new goods. Other types of waste are transferred to dumps or landfills or are destined to incineration or composting, or possibly used for power generation. The waste may or may not be properly allocated. An example of inadequate allocation is when the waste is forwarded directly into open-air dumps. The opposite example is the reuse of raw material extracted from manufactured products. In this case, after consumed, the products are collected by a municipal selective collect program, triaged by cooperatives, sent for recycling, and finally, returned to the production chain.

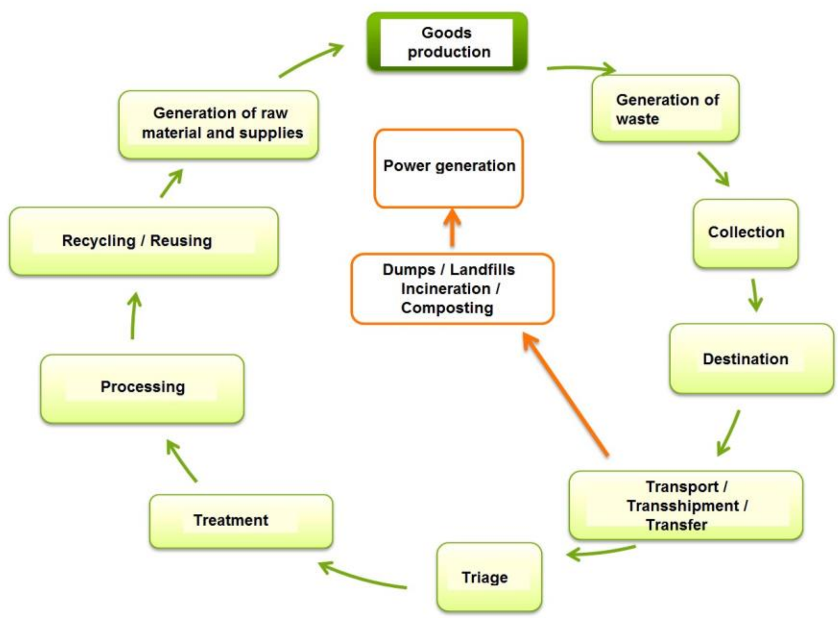

Figure 1: Life cycle of solid waste

According to (Deng et al., 2011) and (Tao, 2010), recycling and proper disposal are considered one of the greatest challenges in waste management. Some researchers have found that its success depends on people's participation, which is influenced by the proximity and access to recycling centres receiving recyclable material. Moura (2011) points out that recycling depends on the contributions made by millions of people, who work without financial interest, only thinking about environmental problems and it is mandatory to provide the right mechanism for them.

The overall objective of this work is to describe a Web system, *AcheSeuEcoponto*[1] to encourage proper municipal solid waste disposal and to assist both citizens and city managers. Our indirect goal is to contribute with environmental orientation for citizens/individuals and the Brazilian NPSW.

In order to accomplish the general goal, the specific objectives are:

1. to instruct citizens about the existence of proper drop-off centres;
2. to define system features to comply with users and managers;
3. to discover relations between visitors and the proper disposal of municipal solid waste.

By Municipal Solid Waste, we mean waste originating from domestic activities in urban residential and commerce areas. Specifically, we are considering as types of municipal solid waste: recyclables (paper, plastics, glass and metal), electronics (e-waste) and batteries, cooking oil, and debris. Old furniture, gardening and construction remains are included as debris.

AcheSeuEcoponto strongly works with Geo and Web technologies such as map servers, geoprocessing and georeferencing, social networks and analysis tool domains. These Information and Communication Technologies (ICTs) can be used as decision support tools at all stages of the waste life cycle (Figure 1), as shown by the research described in (Melaré et al., 2016).

For testing and validation, the system's database was fed with drop-off centres in the cities of Sorocaba, Itu and Votorantim. Currently, *AcheSeuEcoponto* has data from fourteen Brazilian cities, such as São Paulo, Santos, Salto, Rio de Janeiro, Porto Alegre and Campinas. The goal is to expand to all the

[1] In Brazilian Portuguese, "*ache seu ecoponto*" means "*Find your recycling drop-off centre*"

cities of the federation. *AcheSeuEcoponto* can be accessed at URL `http://www.acheseuecoponto.com.br`. The interface does not have an English version, as it is intended to be used by Brazilian citizens.

The paper is organized in seven sections. Section 2 addresses solid waste management in the context of Brazil. Section 3 describes the system architecture and features, satisfying the first and second specific objectives. Section 4 presents the experiment protocol, in compliance with the third specific goal and also describes the data gathering and pre-processing stages. In Section 5, we discuss the results. Section 6 describes the related work and, finally, Section 7 presents some concluding remarks.

2. Brazilian Solid Waste Management

In Brazil, the NPSW (BRASIL, 2010) and Law No. 9.605/1998 of Environmental Crimes (BRASIL, 1998) provide for penalties for environmental offenders, and Decree No. 7.404/2010 of the NPSW establishes standards for Reverse Logistics and Shared Responsibility.

The population needs to fulfil its role to adequately provide its reusable and recyclable solid waste for collection or return (Article 6 of the Decree). Manufacturers, because of the law of Reverse Logistics, should seek alternatives to motivate people to give their materials in appropriate locations. City managers need to have a real knowledge of the issues related to solid waste disposal, such as to manage the installation and maintenance of recycling centres in underserved areas.

Recycling Drop-off Centres or Town Dumps - Solid Waste and Recycling are the locations containing containers or waste receptacles for receiving various types of waste, including recyclable or reusable waste. In this paper, we refer them as drop-off centres or recycling centres.

In some Brazilian cities, the local government maintains selective waste collection programs and provides public areas for recycling centres. Selective waste collection is a program to be implemented in districts. The foundation of selective collection is that the person, who generates the waste, detaches her/his own recyclable materials (paper, plastics, glass and metals) from other refuse. In addition, we have the triage cooperatives, organizations of persons that receive the waste to recycle, reduce or reuse.

Recyclable waste, classified as dry, can be paper (cardboard, newspaper, notebooks, long life packaging), plastics (tubes and pipes, product packaging, disposable cups and plates, bags, bottles, toys), glass (bottles, cups, jugs, vessels) and metal (cans, window frames, aluminium, copper, iron, pots). Many waste items can be composed of plastic components, metal and glass, as is the case of electronic waste (or e-waste). Examples are laptops, voltage stabilizers, UPS[2], vacuum cleaners, television sets and hair dryers, among others.

According to the content, the waste is allocated in recycling cooperatives, landfills, inert landfills or taken back by the manufacturers. As examples, construction waste and old furniture items are forwarded to inert landfills, with the exception of furniture in good condition which is sent to charitable institutions; tires, fluorescent lamps, medicines, batteries are taken back by the manufacturers; electronic waste items are sent from the drop-off centre to recycling plants; cooking oil is forwarded to manufacturing cooperatives and used to make ecological soap; and containers of dry waste are sent to recycling cooperatives.

3. *AcheSeuEcoponto*

AcheSeuEcoponto seeks to spread awareness and information on legalized recycling centres for enabling the reduction of waste sent to landfills and for reducing environmental impacts. This section presents the adopted solutions to attend to the specific goals and the functionalities for citizens and managers.

3.1. Design Principles

According to (Wilson et al., 2012), in order to achieve an integrated and sustainable solid waste management, one of the strategies to deliver a well-functioning waste governance system is user inclusivity, providing transparent spaces to contribute as users. Therefore, the design principles that guide *AcheSeuEcoponto* are:

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2 Uninterruptible Power Supply

- to aid in minimizing problems related to the unsuitable disposal of solid waste, supporting the NPSW guidelines. For this purpose we planned to use Geo technologies.
- To aid citizens to be aware and let them know more about the disposal of solid waste (problems and solutions). For this purpose, we planned to use Web technologies such as social networks.
- To ensure information integrity for users, *AcheSeuEcoponto* should be maintained by the authorities of each town, which will be responsible for managing (inserting and updating) data related to recycling centres.

Figure 2 illustrates the elements that guided the design of this proposal. We believe that a contribution to the problem of SWM is to explore information and communication technologies. So, Geographical Information Systems (GIS), georeferencing and geoprocessing can aid decision-making, and social networks to widely spread the right orientation to citizens. Environmental education and awareness is tied with the active involvement of the population. This can be achieved using social networks to disseminate information more quickly, reaching a larger number of people. Facebook and Twitter, for example, have enabled mass collaboration of different social movements, affecting people of all social classes, from different locations and different age groups.

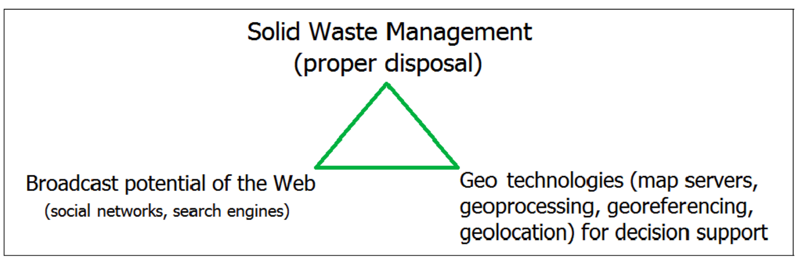

Figure 2: Basics of *AcheSeuEcoponto* architecture

3.2. AcheSeuEcoponto architecture

AcheSeuEcoponto architecture has four modules: **Geo technology Module**, **Decision-support Module**, **Persistence** and **Awareness Module**. Figure 3 shows the integration between these modules. Data such as name, address, phone numbers of the drop-off centre and its geographical coordinates are stored using the Persistence Module. This data is used by the Geo technology Module to carry out the mapping of drop-off centres and related user queries. The Persistence Module also stores information about the user queries such as type of waste and locations. The data collection captured from user queries is used by the Decision-support Module for reporting and for further analysis of inter- est to managers. Finally, the Awareness Module intends that citizens become aware and disseminate the correct drop-off locations, social and environmental projects, as well as the *AcheSeuEcoponto* tool itself. Most of the functionalities of *AcheSeuEcoponto* are related with the Geo module because they depend on geolocalization, georeferencing and geoprocessing.

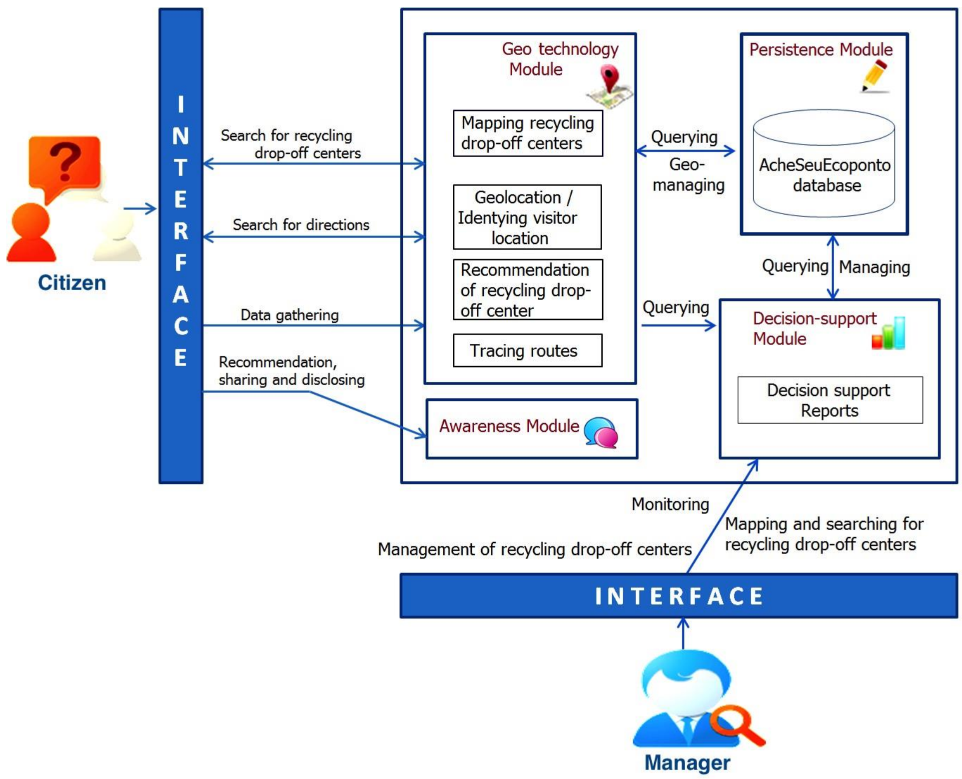

Figure 3: Architecture of *AcheSeuEcoponto*

The users are: citizens and managers. A citizen user can be a legal entity or an individual. Managers are town, state and/or federal managers, environmental researchers or any person with the capacity to make decisions on the behaviour of SWM.

3.3. Overall description of AcheSeuEcoponto

The functional requirements of *AcheSeuEcoponto* were designed to attend to the first and second specific goals of the system, which are: (1) to instruct citizens about the existence of the proper disposal locations and (2) to define system features to comply with users and managers. For that, we divided them into two groups: citizen-oriented features and decision-support features.

For citizens, *AcheSeuEcoponto* includes features such as filter conditions, mapping and recommendation of drop-off centres, directions to specific drop-off centres and for sharing on social networks. Among the decision-support facets for managers are: to assist in identifying underserved types of solid waste and geographical areas underserved with drop-off centres; to allow for the monitoring of the geospatial information of drop-off centres and to provide decision supporting reports.

3.3.1. Citizen-oriented features

Figure 4 represents a screenshot of the *AcheSeuEcoponto's* main page, where we marked numeric labels to describe the use of the tool. When the user first accesses the site she/he can provide her/his location (Marker 1). The location is important to map the location of the drop-off centres in the user's city. In the figure, we see the map centred on São Paulo. At this moment, the map indicates the concentration of the 749 drop-off centres in the state of São Paulo, 2 in the city of Rio de Janeiro, 4 in the state of Santa Catarina and 37 in the city of Porto Alegre, using grouping markers.

Figure 4: *AcheSeuEcoponto* interface

The user can also write a location (using the text box in Marker 3) to set in the roadmap (Marker 4). Map markers are mapped using the KML language. These map markers are objects that move as the map scales. The enlargement and reduction of the map view helps in recognizing the areas in which drop-off centre are available in the city. This process is called overlay and is handled by Google Maps API. The spatial projection of the drop-off centre enables the manager to see the drop-off centre concentrations, information such as population around recycling centres, lack of drop-off centres in certain areas, and residential and deforested surrounding areas.

The interface also provides filters by type of waste (Marker 2). Each class is associated with an icon marker as shown in Figure 5. New types of waste can be easily added to the system.

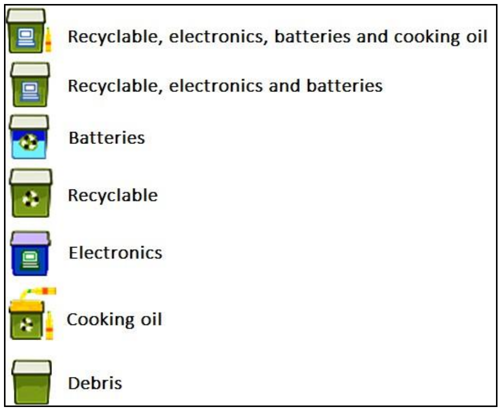

Figure 5: Icon marker for each class of residue

Once the filters are set, the user can search by recycling centres receiving the selected types of waste. At this point, the user can also write other types when not included in the check-boxes, for example, car tires. The purpose of the free text area is to register the types of interest that users have to later be passed onto managers.

The next option is the recommendation of drop-off centres. The recommendation goal is to search for the nearest locations which satisfy the filter condition (Marker 5) from the given location (Markers 1 or 3). The recommendation of the drop-off centres also depends on other variables such as traffic congestion areas, peak hours and the possibility of combined routes linking different drop-off centres, among others.

The supplied address will appear at the centre of the map with the drop-off centres' markers in a three kilometres radius (indicated within a green circle). Figure 6 illustrates this situation. If necessary, the user can zoom in and out on the map view to analyse drop-off centres outside of the radius also returned from the query. An information window may be displayed when the user selects the recycling centre marker to have access to more information, such as the recycling centre's name, unit type, types of waste allowed for disposal and telephone numbers.

Figure 6: Use case for *AcheSeuEcoponto*

In the case that no initial location is given, the map shows individual markers or grouping markers in the region according to the filter condition. If no results were returned from a query, the user can send suggestions for improvements or information about new drop-off centres, using the available contact form on the *Suggestion* menu.

It is important to highlight that queries with no results are collected to show to managers via reports. Furthermore, all requested queries and filters are stored in the database system with the user location. Reports to managers will be beneficial because they can expose the most searched drop-off centres, the most wanted types of solid waste and even other types of waste typed by users.

In addition to these features, the user still has the possibility to exploit other resources provided by Google Maps, such as alternate between map view types (e.g. map, satellite) and report a map error of non-geocoded addresses. Still taking advantage of these resources, the tool offers directions from an established location to a selected drop-off centre (Marker 6 in Figure 4). The tool also allows to switch the means of transportation. The default is by car, but you can choose to go on foot. The library responsible for calculating the distance is the geoprocessing library `Geolib`.

3.3.2. Sharing on Social Networks

Social networks are our means to disseminate information. Both citizens and managers can share information about drop-off centres. In order to allow comments, likes, sharing and recommending, we use the available plugins from Facebook and Twitter. These plugins allow user authentication on the networks.

On Twitter, we are `@AcheSeuEcoponto` and we display the tweets on our site. On Facebook, we have a group (`https://www.facebook.com/acheseuecoponto/`). We also disclose socio-environmental projects on both social networks.

The major or other environmental manager of the district can interact in this context to answer questions from citizens related to environmental governance or even to disclose recycling programs. This direct participation helps to show the public transparency performed by the authorities involved.

3.3.3. Decision-support features

The managers have a different interface to access the reports. In this interface, they can access the various features:

- thermal map of underserved areas;
- reports of underserved areas;
- reports of the requested drop-off centres.

The Geo technology module of the system architecture also allows access to the geospatial information of drop-off centres by managers. The thermal map visualizes a coloured overlay layer with the underserved neighbourhoods of drop-off centres (Figure 7). The greater the number of unsuccessful queries referring one neighbourhood the greater the colour intensity is for that area.

The report of underserved areas contains a list of addresses (or neighbourhoods) grouped by refuse type (recyclable, e-waste, batteries, etc.). These addresses were parts of queries which were returned without results. The report of the requested drop-off centres contains a list of types of residue focused on the queries along with the number of times each type was requested and grouped as successful/unsuccessful (considering the three kilometres radius).

Types of waste typed by users are included in both reports. Hence, managers can observe if it is a residue without a drop-off centre or if users have difficulties identifying refuse types. For example, in some cases users typed “construction remains” which is part of debris. Other relevant types can be easily included on the system, if necessary.

Figure 7: Thermal map of underserved areas

As a result, the government decision-maker has indeed another aid to propose public policies related to solid waste management or to execute grounded solutions for the city.

3.4. System implementation

The Geo and Web technologies adopted for developing *AcheSeuEcoponto* are open source. In order to attend the W3C specifications for the Web, we use AJAX, HTML5, JavaScript and PHP, JQuery and JSON data format.

Table 1 presents the technologies used for the implementation of the system, according with the modules of the *AcheSeuEcoponto* architecture.

Table 1: *AcheSeuEcoponto* technologies

Technology	***AcheSeuEcoponto* module**
Google Maps	Geo technology
HTML5	Geo technology, Persistence
GeoLib	Geo technology
KML	Geo technology
Google	Decision-support
Facebook API	Awareness
Twitter API	Awareness
PHP	Persistence
JavaScript	Geo technology, Persistence
JQuery	Geo technology, Persistence
MySQL	Persistence
CSS	Geo technology, Persistence

4. Experiment protocol

In order to accomplish the third goal, to discover relations between users and proper disposal of municipal solid waste, we defined three questions:

1. What is the scope of *AcheSeuEcoponto*?
2. Do web technologies have an influence on the dissemination of information regarding the proper disposal of solid waste?
3. What members of the public use the system and what is their knowledge regarding drop-off centres?

These questions guided the process of collecting data. We defined three representative cities: Sorocaba, Itu and Votorantim in the southwest of São Paulo state. We mapped all the legal drop-off centres in these cities, checked ahead by the environmental departments of the municipal governments. All cities have selective collection programs, recycling drop-off centres and cooperatives and they are inline with the NPSW national policy.

AcheSeuEcoponto became available on February 27th, 2014. Two strategies were used to collect data: a questionnaire and the Google Analytics service. We defined ten multiple choice questions for the questionnaire to capture users' demographic information such as age, gender, education, line of work, country, state and city of residence, as well as system-related information such as how she/he found the tool, knowledge about her/his nearest drop-off centre and her/his reasons to know the system. All variables and their possible values are presented in Table 2. Also, we stored the timestamp of the user filling out the questionnaire. Filling out the questionnaire was mandatory on the first access, from March 17th until March 28th, 2014. After that period the user could choose to fill out the questionnaire or not.

Table 2: Variables defined to collect users data

Variable	**Values**
Gender	Male, Female
Age	≤ 17, 18 -25, 26 -35, 36 - 50, 51 - 64, ≥ 65
Education	Elementary - incomplete, Elementary - complete, Secondary - incomplete, Secondary - complete, Undergraduate - incomplete, Undergraduate - complete, MBA degree - incomplete, MBA degree - complete, Master degree - incomplete, Master degree - complete, Doctorate degree - incomplete, Doctorate degree - complete
Work (multivalued)	Does not work, Government employee, Student, Environment, Health / Medicine, Industry, Commerce, Education, Construction Cleaning and maintenance, Culture/Sports, Computer Science, Agriculture, Foods, Autonomous, House-husband/Housewife, Retired
Country State City	Brazil, Other <list of Brazilian states> <list of Brazilian cities according to the selected state>

How did you meet the system?	Social Network, Friend, Web site, Newspaper (digital or paper), Other
Do you know your nearest recycling drop-off centres?	Yes, No
Why do you want to know the system?	I am curious about the system works, To provide proper destination for waste, Other

From Google Analytics we obtained user information related to visitors' personal data, and traffic and location. Traffic sources could be organic, social (accessed from social networks), referral or direct. Google Analytics define a user as new or recurrent depending on the number of sessions in which the user interacts with the system. During each session, we collected the visitors' personal data such as age, gender, sites of interest (sport, news, technology, environmental), their geographical location, whether he/she is new or recurring visitor, how long the visitor was staying on the site, number of pages accessed, traffic source, web browser, type of device of the access (desktop, mobile) and operating system, among other data. All data included in the experiment was collected from March 17th, 2014 until October 11th, 2014.

4.1. Data Pre-processing

The site gathered 359 records of visitors formed of the eleven attributes (ten nominal and one of date type). After cleansing records with missing or inconsistent values, we finally obtained 343 valid records (excluding 16 records - 4.1% of the primary set) ready to perform the analysis. Furthermore, forty one visitors chose not to declare their gender. At this point, we created a class for gender: "undeclared".

The Google Analytics dataset contained 1.666 sessions, of which 1.127 were new visitors and 539 were recurrent visitors. Some entries had access durations of close to zero seconds, because they were artificial accesses caused by bots (crawlers) designed to track information on sites and were also unwanted spam. These sessions contain values that interfere in the analysis, such as time of the session and geographical location. The 69 invalid sessions, representing 4.14%, were not considered for analysis. At the end of the pre-processing stage, we gained 1.597 cleaned sessions composed of 1.058 new visitors and 539 recurring visitors.

5. Results and Discussion

Tables 3, 4 and 5 summarize the relevant results within the established period to answer the proposed questions.

Table 3: Information gathered for answering Question 1

What is the scope of AcheSeuEcoponto?
• Accesses
– 1597 visitors - 1058 new users e 539 recurring
– 6008 viewed pages - average access duration: six minutes
– access peak: 75 sessions in March 17th, 2014
– 1564 access from Brazil, 15 from United States, 3 from Portugal, 3 from Russia, 2 from Germany, 1 from United Kingdom, 1 from Canada, 1 from Colombia, 1 from Costa Rica, 1 from Belgium, 1 from Spain, 1 from Sweden.
– 16 states of Brazil - São Paulo (91.94%), Rio Grande do Sul (2.17%), Minas Gerais (1.53%), Rio de Janeiro (1.40%), Paraná (0.76%), Espírito Santo (0.64%)
– 65 cities of Brazil - Sorocaba (49.29%), São Paulo (14.51%), Itu (8.12%), São Carlos (2.3%)
• Questionnaire answers
– 343 answers
– 11 states of Brazil - São Paulo (95.04%), Rio de Janeiro (1.46%)
– 54 cities of Brazil - Sorocaba (55.98%), Itu (8.75%), São Carlos (7.0%), São Paulo (4.66%)

Concerning the first question, "*What is the scope of AcheSeuEcoponto*?", the tool is reaching several Brazilian cities as well as some different countries. The cities with the highest number of visitors (and questionnaire answers) match the represented cities, as expected, because their drop-off centres were available on the site for querying. The details can be observed in Table 3.

Regarding the second question, "*Do web technologies have an influence on the dissemination of information regarding the proper disposal of solid waste*?", more than a third of the visitors knew *AcheSeuEcoponto* from social networks. From the user interface, several shares and recommendations allowed for the disclose of *AcheSeuEcoponto* even in other countries and Brazilian states. Details can be seen in Table 4.

Table 4: Information gathered for answering Question 2

Do web technologies have an influence on the dissemination of information regarding the proper disposal of solid waste?
• 31% of the answers met *AcheSeuEcoponto* through social networks; 81% of them were unaware of drop-off centres • 30% of the sessions provided from organic search (search engine results pages) • 8.8% of the sessions provided from news web sites and from other web sites • 7.7% of the sessions provided from social networks • 206 recommendations/shares of the related news published by the Sorocaba's newspaper Cruzeiro do Sul • 237 recommendations/shares from within *AcheSeuEcoponto* interface • 70 several recommendations/shares from personal pages, companies and news sites • reached 3 countries, Germany, Canada and Belgium (through social networks), 5 Brazilian states (Paraná, Rio de Janeiro, Rio Grande do Sul, São Paulo e Mato Grosso) and 21 Brazilian cities. • Type of device for sessions   – 85.8% accesses from PC and 12.4% from mobile devices

Discussing the third question, "*What members of the public use the system and what is their knowledge regarding drop-off centres*?", we were able to determine a user profile (Table 5). Visitors were predominantly male, between 18 and 35 years with undergraduate degrees. The visitors showed a significant lack of knowledge regarding the drop-off centres. However, most users, when filling out the questionnaire, revealed an interest to properly allocate the waste.

Table 5: Information gathered for answering Question 3

What members of the public use the system and what is their knowledge regarding drop-off centres?
• User profile – predominantly male visitors (51.60% from the questionnaire and 57.11% from sessions) – predominantly visitors with age range of 18 to 35 years – predominantly visitors with undergraduate education - incomplete or complete (56,85%) – Line of work: student 16.03%, Computer Science and IT 16.03%, Government employee 11.66%, Education 8.45%, Industry 7.87%
• User's knowledge about drop-off centres – 81.92% were unaware of the nearest drop-off centres – 82.8% of the Sorocaba visitors were unaware of the drop-off centres – 86.7% of the Itu visitors were unaware of the drop-off centres – 75% of the Votorantim visitors were unaware of the drop-off centres – 65.5% of all users want to properly allocate the solid waste - of them, 87.35% were unaware of the drop-off centres

6. Related Work

In (Melaré et al., 2016), we presented eighty-nine proposals around the world addressing the question "What is the progress of the global scenario on Decision Support Systems aimed at Solid Waste Management". As a result, we concluded (among others) that GIS-based systems are helpful in multiple stages of the SWM process, as we also showed in this paper. Some of these works are summarized below.

Concerning the management of collection, route and transportation of waste, in Pallavapuram, India, a system was designed to integrate GIS and GPS technologies in order to plan and optimize the collection and transportation of waste (Kanchanabhan et al., 2011). In Asansol, also in India, a GIS was proposed to determine the cost and the minimum distance based on route optimization (Ghose et al., 2006).

Regarding management and monitoring of drop-off centres, a Portuguese proposal develops a GIS integrated with the method of Mixed Integer Linear Multiobjective Programming for defining locations to install green recycling centres (Tralhao et al., 2010). The proposal in (Samanlioglu, 2013) was developed in Turkey. The model employs Multiobjective Mathematical Analysis and GIS to calculate routes and the locations of treatment, recycling and disposal centres, considering costs and risks.

Related to recycling and material classification, a Web-based decision support system including georeferencing, that manages the waste from construction and demolition, was proposed by Banias et al. (2011). This system aims to minimize the cost and maximize the recovery and reuse of materials.

Spatial multi-criteria and GIS were used for the mapping and selection of potential locations for landfills. The model considers criteria related to environmental aspects, economic aspects and social aspects. This proposal was applied in Egypt (Effat and Hegazy, 2012), Sierra Leone (Gbanie et al., 2013) and Iran (Rafiee et al., 2011).

The model proposed in (Lin et al., 2010) uses GIS, Linear Regression and Mixed Integer Programming to analyse the collected amount, and types of recyclable material, the geographic proximity of the population to the drop-off centres and for identifying areas in need.

Focusing on urban governance, geo technologies help in the decision-making process for the management of urban properties, real state taxation, traffic control and transportation and solid waste management, among others (Lewis and Ogra, 2010). The authors described good practices of GIS in cities from India, Africa and South Africa, The USA and Canada.

AcheSeuEcoponto goes beyond its geographic basement. It follows the guidelines of a national policy (the NPSW) and explores the social networks used to spread awareness between citizens about recycling and responsibility for the proper disposal of solid waste. Also, it serves as decision support for municipal government decision-makers.

7. Conclusion

The results show that the goals were achieved and the research questions were satisfactorily answered. Finally, we concluded that:

- we develop a web system to contribute with the correct orientation of the population for the proper disposal of urban solid waste. *AcheSeuEcoponto* brings features to encourage the proper disposal by citizens throughout the national territory.
- The research and the system had repercussions in the scientific world and in the printed and digital media.
- The use of web technologies was successful in the disclosure of the system.
- Social networks played an important role, as 31% of the visitors reached *AcheSeuEcoponto* by them. The system was shared and recommended via social networks more than 500 times.
- Within the established period, *AcheSeuEcoponto* reached 1600 visitors, 33% of which were recurring. The availability of drop-off centres had a direct influence in the number of visitors. That is why the representative cities had the highest number of visitors (and questionnaire answers).
- A significant percentage (82%) of users are unaware of how to forward solid waste and also, a good percentage (65%) of users want to perform proper disposal.
- *AcheSeuEcoponto* reached a predominantly young audience, with higher education levels, most were male and were active in several different business areas.

AcheSeuEcoponto can be accessed from a browser of any computer device including mobile devices. The app for Android can be downloaded from the site.

8. Acknowledgement

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