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Use of Geographic Information System for Management of Municipal Solid Waste of M'sila City - Algeria

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ABSTRACT

The municipal solid waste exacerbates particularly the public health problems in the country. M'sila city is experiencing a strong population growth accompanied by a spatial extension which is poorly controlled. In addition, there are no mapped and documented inventories of them. The aim of our study is to highlight the applications and the main factors determining the management of the solid waste through a GIS approach by a case study covering sectors of the M'sila city. The traditional techniques used in the waste management study are based mainly on manual methods, which results are generally incorrect. With the emergence of the new tools such as GIS and the remote sensing, it has become easy to create, Identify, analyze and model the data, and draw thematic maps of a study area. This technique has made it possible to set up a spatially referenced database on the management of the solid waste. The latter includes various information concerning waste collecting operators, subscribers to this service, and the waste collection points in the sectors of the two services: Technical Burying Centers (TBC) and People's Municipal Council (PMC). The use of GIS makes it possible to increase the speed and precision of the mapping, mainly in relation to our study.

Keywords: *Municipal Solid Waste, Urban Management, GIS, M'sila City.*

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1. INTRODUCTION

The solid waste management (SWM) is a global issue and has proven to be a key challenge facing in many developing countries (Kadafa et al, 2014). Thus, "biodegradable waste" can be defined as "any waste that may undergo anaerobic or aerobic decomposition, such as food waste and garden waste, as well as paper and cardboard ones" (Pichat, 1995).

Environmental protection is becoming increasingly an overall concern. Today, more and more waste is being produced by the people in cities. The waste is an everyday issue, and concerns every human being, both professionally and personally. Consumers, producers, garbage collectors, recyclable waste sorters, citizens and taxpayers, everyone can and must participate in a better waste management. Gharaibeh and Masad (1989) reported that the dissolution of the solid wastes combined with rainfall produces a large quantity of polluted water in the form of leachat. One of the most serious and growing potential problems of the solid waste management is the shortage of land for disposal (El-Fadel et al., 1997).

According to Gouhier (2000 & 2005), waste management is the collection, transportation, treatment, re-using or disposal of the waste, usually produced as a result of human activity, in order to reduce their effects on human health, environment, aesthetics or local amenities. The GIS utilization for screening is normally carried out by classifying an individual map, based on the selected criteria, into exactly defined classes, or by creating buffer zones around geographic features to be protected. Charnpratheep et al (1997) and Keir et al. (1993) suggested the use of both raster-based and vector-based GIS for the full-scale site selection process.

The main objective of this study is to create a spatial database, managed by GIS aimed at capitalizing the information available in order to better monitor and evaluate the performance of the actions concerning the waste collection component organized by the city. The residential neighborhoods (sectors) of M'sila city constitute the framework of the study. Three specific objectives have been set: To define the usefulness of a GIS and spatial analysis indicators for the Solid Waste Management, map the residential neighborhoods (sectors) of M'sila city and the collectors circuit, and analyze relations between the populations, the quantity of the waste generated, and the collection services.

2. MATERIEL AND METHODS

Study area

This study was conducted between the years 2016-2017 in M'sila City-Algeria (35°46'05'' and 35° 50'23'' N, 4°30'28" and 4°35'52'' E) far about 248 km to the south-east of Algiers. This city has a population of 294624 in 2016 with a population density of 970 inhabitants / km2, and belongs to the Central Highlands region, and covers an area of 232 km2. (Figure 1).

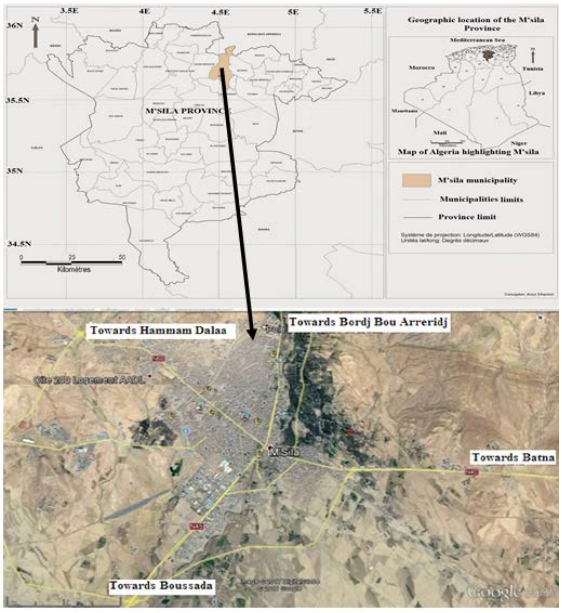

Figure 1. Geographic location of the investigated area and its position in Map data 2016, Google Earth Pro.

Sampling

The approach applied in this research requires a compilation of the data relating to several disciplines such as geomorphology, geology, hydrology, climatology, demography and the use of a waste collection plan of the M'sila city (Issued by the Directorate of Environment, Year 2016). The collection of these data allowed the establishment of a database Information System with Spatial Reference (ISSR), and therefore the establishment of a Geographic Database Model (GDBM). The multidisciplinary character intervenes both at the level of the information collected on the study area and its analysis (Collet, 1992).

The ArcGis 10.2.2 software was used for the data processing and establishment of GDBM. This study is proposed by the joint use of SIRS and analysis, for mapping of the best facilities for solid waste storage for this city.

The studies concerned two technical services of waste collection: People's Municipal Council (PMC) and Technical Burying Centers (TBC) (Figure 2).

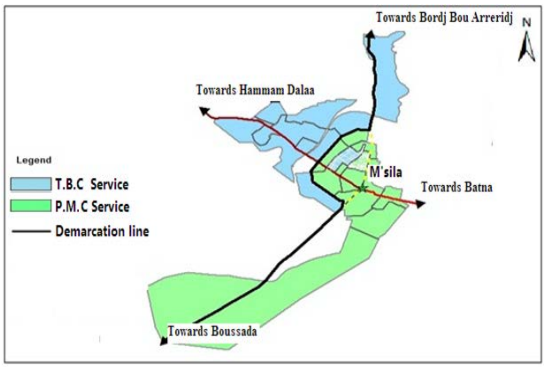

Figure 2. The technical services of waste collection: PMC and TBC in M'sila city

I – PMC consists of several departments comprising thirteen (13) sectors (Table 1). Each of them covers several districts.

II - TBC has nine (09) sectors where each covers several districts (Table 1).

Table 1. Current Collection

Services	Sectors	Subscribers	Waste (Kg)
People's Municipal Council (PMC)	01	15416	10791.2
	02	8648	6053.6
	03	1890	1323
	04	7648	5353.6
	05	11883	8318.1
	06	9492	6644.4
	07	10770	7539
	08	2851	1995.7
	09	1957	1369.9
	10	6918	4842.6
	11	2430	1701
	12	4979	3485.3
	13	4252	2976.4
Technical Burying Centers (TBC)	01	14418	10092.6
	02	12123	8486.1
	03	10368	7257.6
	04	17616	12331.2
	05	14836	10385.2
	06	13309	9316.3
	07	13124	9186.8
	08	18637	13045.9
	09	13223	9256.1

Source: Personal survey (2017)

This TBC is situated in the M'sila city. It is 0.5 km far, and includes an area of 31 hectares. This structure concerns 294624 inhabitants where the amount of waste received makes up 165 tons/day.

Data collection

The data collection is supported by different tools. A standard survey guide was sent to the municipal services to obtain more information on the socio-demographic characteristics of the M'sila city on the one hand, and to know the organizational structure of the waste and the municipal role in the management of the household waste, on the other.

The geographic coordinates of the pre-collection operators for solid waste subscribers to pre-collection services, and waste collection points in sector 22 were recorded by Global Positioning System (GPS) and Google Earth Professional 7.1.

The Geographic Information System (GIS) helps to manipulate data in the computer to simulate alternatives, and to take the most effective decisions (Narayan,1999).

The processing of the collected data was carried out in various forms as follows:

- The transfer of data from Google Earth professional 7.1 of our study area;
- The database created by the software ArcGIS (10.2.2 version) transposing the various information concerning the garbage collecting operators, the households subscribed to the service,

as well as the points of the waste consolidation in the districts and the lots of the city;
In general, it should be noted that analyzing was fulfilled with the help of ArcGis software for thematic mapping, depending on the nature of the information sought.

The main stages of database creation with spatial reference

Structuring and creating a Geographic Database Model (GDBM)
A database is a "data structure for receiving, storing and providing on demand data to multiple independent users" (AFNOR-ISO, computer dictionary, 1989). After the definition of the data to be integrated into the system, they had to be organized and structured. In order to pass from the complex reality to a computerized representation, a Geographic Database Model (GDBM), as well as the implementation of the structured data in the informational system is needed.
The GDBM is an easily understandable representation of the information system. The GDBM serves to formalize the description of the information that is stored in the GIS.
A review of related literature reveals that the most advanced methodology used to automate the waste planning and management process is the design and construction of integrated systems using GIS environments (Karadimas and Loumos 2008).
The core of GIS-Waste Management is a geographic database integrating a set of layers (sectors, waste consolidation points, administrative divisions ...) and the data from the analysis work like the examples of the Sector 08 (Figure 3). There is a specific GIS application offering a set of tools including data capture and control, statistical processing, spatial analysis and cartographic representations.
The GIS-Waste Management was designed and developed to be used by the P.M.C. and T.B.C. services, to assist in their activities concerning the processing, analysis, communication of information on the waste management. It also allows the production of the indicators and dashboards as a decision-making support.
The designed database must be usable and comprehensible for people who do not necessarily master the GIS software. For this reason, it was necessary to create a simple and user-friendly graphical interface (forms), both for starting a session, entering and updating the data, and working with the data.

Geographic data and information processing

In this part, the coordinates of the geographic entities (operators collecting, subscribers to the collection service, and points of consolidation of waste) distributed in the form of the points have been integrated into the GIS as follows:
- 02 Points representing the coordinates of waste collection operators;
- 216788 Points representing coordinates of subscribers to the waste collection service;
- 1095 Points representing the coordinates of the landfills or waste consolidation points.

After the coordinates of the geographical entities (sectors, collection operators, waste collection subscribers, waste collection points) being materialized in the GIS and their various attributes being stored in the database, it was necessary to create a link between the database and the GIS software used (ArcGis 10.2.2).
The GIS software memorizes the location of the disk where the file resides, recalls, and contains the data each time the document is opened. Associated with each point, the collected data can enable us to fulfill a more targeted thematic mapping to be available as institutional actors acting in the waste management.

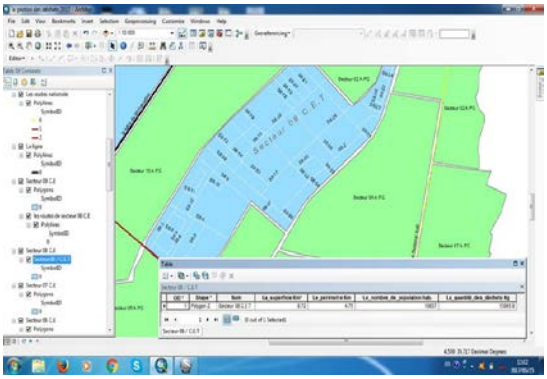

Figure 3. Model of a Geographical Database /GIS- Solid waste management applied for the sector 08.

3. RESULTS AND DISCUSSION

Waste management analysis

Today, the M'sila city counts mainly two services officially declared as collectors in the collection zone (Table 2).

Table 2. Solid waste collection services operating in the common level

Services	sectors	waste collection points	Waste (Kg)
People's Municipal Council (PMC)	01	54	10791.2
	02	34	6053.6
	03	16	1323
	04	27	5353.6
	05	46	8318.1
	06	34	6644.4
	07	39	7539
	08	14	1995.7
	09	15	1369.9
	10	28	4842.6
	11	18	1701
	12	31	3485.3
	13	18	2976.4
Technical Burying Centers (TBC)	01	77	10092.6
	02	58	8486.1
	03	52	7257.6
	04	105	12331.2
	05	80	10385.2
	06	79	9316.3
	07	63	9186.8
	08	126	13045.9
	09	82	9256.1

Source: Personal survey (2017)

Both services deal exclusively with the collection of household waste; they also raise awareness about environmental protection and the need to collect the waste. In all areas of the city, the subscribers to the waste collection service, which includes most of the residents will deposit their waste in bins installed in certain central areas and in collection centers.

Waste grouping points

Once the waste is collected from the subscribers, the collection operators convey it to the different waste consolidation points. During our fieldwork, we were able to identify 1,095 major waste grouping points (Figure 4).

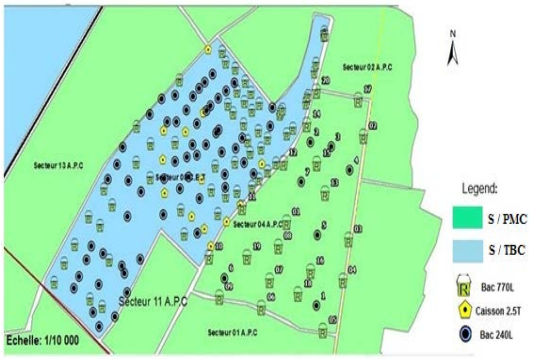

Figure 4. The map shows the waste collection points

According to the guidelines given by the Waste collection plan of the M'sila city (Issued by the Directorate of Environment, Year 2016), the waste collected from the users must be transported to the T.B.C. through the collection centers. Possible causes for the low usage of the collection points such as waste transit sites include the design problems of these centers and the malfunctioning of some of them. The following map shows the relationship between the actors and the waste quantity using the quantitative thematic analysis of GIS software /Arc Map/ (Figure 5)**.**

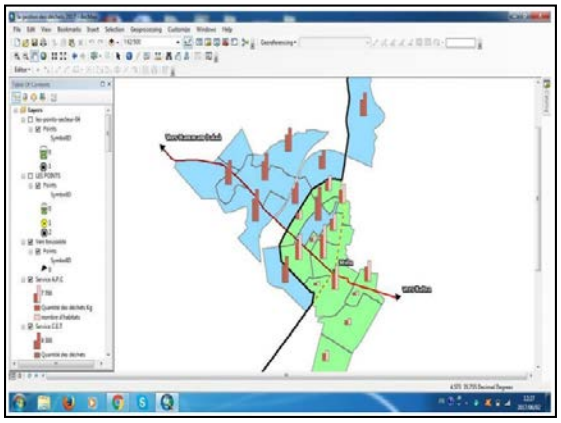

Figure 5. Relation between the three actors (Waste Collection Services, Subscribers, Collection points) and the quantity of waste

The city of M'sila must begin working on a research to validate a comprehensive solid waste management plan by improving the collection and activation of the control of the work of the P.M.C. and the T.B.C. The latter is working on the management of the municipal landfill to address the problems of the solid waste management of this city.

4. CONCLUSION

Managing our waste, reducing it, and sorting it for better value are urgently needed. A sustainable waste management is everyone's business. GIS analysis methods were used in this study with specialized data of heterogeneous origin as a part of a research project on the solid waste management. Waste management sites in the city of M'sila have been mapped from the joint use of GIS. The visits to these sites made it possible to map the potential sites for waste management located between PMC and TBC (Figure 5). These cards highlight two categories of the sites: good and doubtful ones. The sites classified as good are those that can be explored for the installation of a landfill site.

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