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Solid waste management as an urban area regulation in Algeria. Case of El-Khroub city

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Abstract

The phenomenon of urban pollution is one of the most serious problems that affect people in the world, as it causes the spread of epidemics and diseases that threaten their health. As in the case of other societies, this also represents an important issue for Algeria. Therefore, through this work, we decided to take an example of urban pollution in an Algerian city of historical and administrative importance, represented by the city of El-Khroub located in the province of Constantine; the aim was to monitor the reality of urban waste management in the city center, the disinfection and disposal of urban solid waste. Through this, we monitored the most important ways that local authorities follow to eliminate solid waste, including landfill or incineration, where household waste annually reaches 2045328 tons. The dirt still floats in the city neighborhoods, because of the ignorance of the population, as well as the lack of authorities to ensure a clean and sustainable environment.

Keywords: *pollution, waste management, El-Khroub city, urban solid waste, inert waste, Algeria*

Rezumat. Managementul deșeurilor solide ca reglementare urbană în Algeria. Cazul orașului El-Khroub

Poluarea urbană este una dintre cele mai serioase probleme care afectează oamenii din întreaga lume, contribuind la răspândirea epidemiilor și a bolilor ce reprezintă o amenințare la adresa sănătății tuturor. Ca și în cazul altor societăți, deșeurile sunt o problemă și pentru Algeria. Prin urmare, în cadrul acestei lucrări ne-am propus să luăm ca exemplu poluarea urbană dintr-un oraș algerian important din punct de vedere istoric și administrativ, respectiv orașul El-Khroub, localizat în provincia Constantine. Scopul l-a reprezentat monitorizarea managementului efectiv al deșeurilor urbane în cadrul centrului orașului, dezinfectarea și eliminarea deșeurilor solide. Astfel, am monitorizat cele mai importante mijloace prin care autoritățile locale încearcă să elimine deșeurile solide, în principal gropile de gunoi sau incinerarea, întrucât deșeurile din gospodăriile populației se ridică la 2045328 tone/an. Mizeria plutește în continuare în toate cartierele orașului, datorită nepăsării populației și lipsei unei autorități care să asigure un mediu curat și sustenabil.

Cuvinte-cheie: *poluare, managementul deșeurilor, orașul El-Khroub, deșeuri urbane solide, deșeuri inerte, Algeria*

Introduction

The phenomenon of urban pollution is one of the most serious problems that people in the world suffer from, as it causes the spread of epidemics and diseases that threaten their health. Therefore, it is considered as one of the most important issues that concern societies (Shafi, 2005). Moreover, studies made by specialists in the world demonstrate that pollution in underdeveloped countries appears as a result of emissions of the same order of magnitude as industrial sources in northern countries (Liousse & Galy-Lacaux, 2010).

Algeria has experienced a rapid urbanization growth after independence. However, without so many environmental problems related to pollution have emerged in the urban areas (Abdelkebir, 2021). Through its local and regional administrative bodies, Algeria proceeded at overcoming these catastrophic obstacles by enacting laws such as the "Act of 2001 on land management and its sustainable development" (Aliouche, 2017), which clarifies the role of participants and the various devices for preserving the urban environment.

Among the Algerian national objectives are the reduction of the quantities of waste produced and the mitigation of the impact of their disposal on the environment. The Algerian government has envisioned a national environmental strategy that will permit to present the first foundations of sustainable development. Through this work, we decided to take an example of urban pollution in the city of El-Khroub, which is considered an Algerian city of historical and administrative importance, located in the province of Constantine. The aim was to assimilate the subject and attempt to identify the

reality of urban waste management in the city, in order to better understand what systems are used for management and elimination and what control bodies are effective.

In order to study the problems, we conducted a field survey in the region and we probed the areas that suffer from household solid waste pollution, attempting to find out how it is managed by visiting the landfills and disposal areas.

Theory and methodology

Review of literature

One of the environmental challenges currently facing urban societies, particularly third world countries, is solid waste. It is an essential factor which leads to the deterioration of the urban environment resulting problems that threaten the safety of society (Chandrappa & Das, 2012) and distorts the urban landscape. The increase of this problem in such countries is due to the growing population, which makes the per capita share of it is increasing annually. In Asia and Pacific regions, for instance, the capita per is estimated 0.5 to 1.4 kg daily according to the United Nations report that examines the increase in waste until 2025.

In developing countries, the amount of waste produced varies from one city to another, depending on several factors, the most essential is population growth. According to statistics, the average annual production of waste is between 180 and 240kg. This is about 1.5 to 2.5 times less than in industrialized countries (Hiligsmann et al., 2006).

Other studies highlight the same point in the third world scrutinizing what makes life conditions poor (Troschinetz & Mihelcic, 2009) including air and water pollution, in addition to the spread of diseases and epidemics in cities such as malaria and asthma (Koné-Bodou Possilétya et al., 2019), particularly in poor and fragile neighborhoods (Hardoy & Satterthwaite, 1991). Thus in some major African cities like Abidjan, the capital of Côte d'Ivoire, we find large accumulations of household solid waste where the accumulated waste reach 53.65% (N'guettia, 2010). According to a study on India (Pappu, Saxena, & Asolekar, 2007), the amount of solid waste accumulated is 960 million tons annually varies from domestic, and industrial to agricultural solid waste. However, many countries have now realized the concept of waste recycling; therefore it is becoming a source of making profits and generating energy under the framework of sustainable waste management (Chandrappa & Das, 2012). For Algeria, the problem of waste persists since the population continues to rise. According to the recent reports of the National Waste Agency (Chandrappa & Das) for 2020, the amount of household solid waste was 13.5 million tons whereas it was just 11 million tons in 2016, and the report expects it to reach 20.5 million tons in 2035 (AND, 2020), while the estimated amount of waste per capita is 0.80 kg/day (AND, 2020).

Algeria has attempted to address this challenge through a series of actions enacting several laws on environmental protection and waste management to achieve sustainable development, including Act No. 01-19 of 12-12-2001 (Loi, 2001), established competent governing bodies such as the National Waste Agency, and set programs and guidelines such as the Municipal Waste Management Guidelines and the Province Waste Management Scheme (PWAGDES) for the safety of environment and the citizens' health.

Extensive investment has also been made in the area of its operation. Since 2002-2017, it has been estimated 88 billion DA (562 271 020,34 euro), of which 41 billion DA (261967199.93) are for collection and transport tools and 37 billion DA (236409406.28 euro) are for waste management structures (waste, technical land-filling, waste dumps). (AND, 2020). But, despite these huge sums and structures distributed throughout the country, Algeria has not yet achieved the designed goals (Khelladi, 2011), given the magnitude of the obstacles it faces.

Research methodology

The present paper tries to capture the reality of third world societies in general, as well as that of Algeria in particular; this approach is carried out by analyzing the previous literature that tackled the issue of the present study, including some articles and books that highlight this reality as a global challenge, considering that the latter affects both first and third world countries.

However, each country has a certain degree of interest. Developed countries have found solutions to waste disposal once and for all, using it to produce energy in a profitable way. However, most underdeveloped countries still suffer from this worsening phenomenon and from their inability to manage it, falling eventually into a circle of dirt, unpleasant odors and disease. Others try to keep pace with technological advances to reduce the phenomenon.

Considering the lack of theoretical approaches and methods to monitor the situation, the field study is an essential step for carrying out this research. This has been conducted through field investigations. We have visited several Algerian bodies, such as the Ministry of Environment and the National Waste Agency, as well as the local municipalities (ElKhroub) and Constantine authorities, beside the technical land-filling centers belonging to the municipality of AlKhroub.

Situation analysis

El-Khroub city is located in the southeast of the province of Constantine and covers an area of 244.65 ha. It is considered as the second agglomeration after Constantine, and it is the best adapted pole to organize the southern part of the province (Benkouachi & Alatou, 2017). It is crossed by major roads at the citywide, CW 175 (ex RN03) and RN 20, which constitutes a connection towards the other states Guelma and Batna (Fig. 1).

It is bounded as follows: (1) CW 175 bypass road to the East; (2) Railway and the national road RN20 to the South; (3) Railway and the national road RN 05 to the West. The study of local climate requires (Djebel-Ouahch and Chettaba) data area, then since the location of the reference station (Constantine) is at an altitude different from the study area, this led us to make corrections of temperature and rainfall. The climatic data were collected from the meteorological services for a period ranging from 1994 to 2004 which are represented in Figure 2.

The study area has a continental climate, hot in summer and cold in winter. Temperate and dry, rainfall is rare in summer but frequent in winter (Boularak, 2003). The rainy period extends from November to March, when the precipitation amount increases and reaches the highest value of 93 mm in January, while the temperature drops to 2.89°C. The dry period extends between March and November, when temperatures are high, reaching 35 C° in August, while rainfall decreases to 4.81 mm in July. As for the prevailing winds in the region, they are cold and dry northwest winds that blow in winter. The southwest wind (sirocco) is hot and often sand-laden in summer. On the other hand, snow is rare in the area.

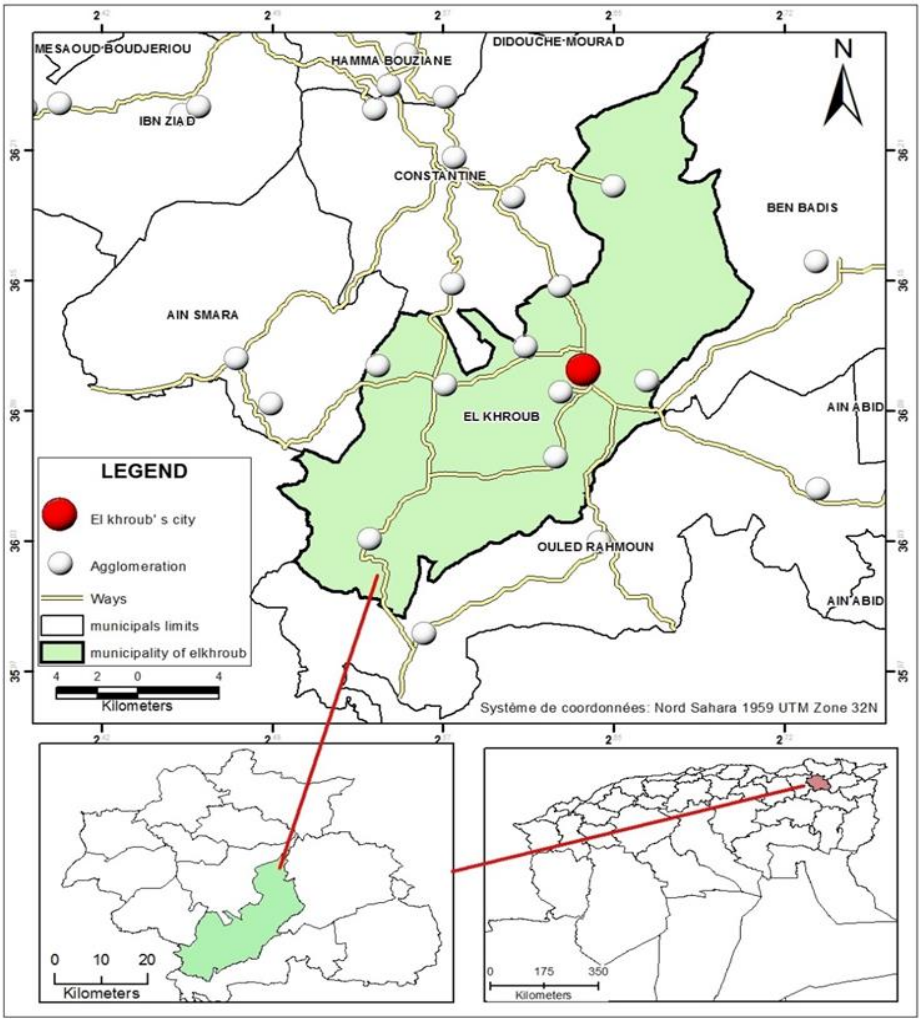

Figure 1: El Khroub city location (State of Constantine)

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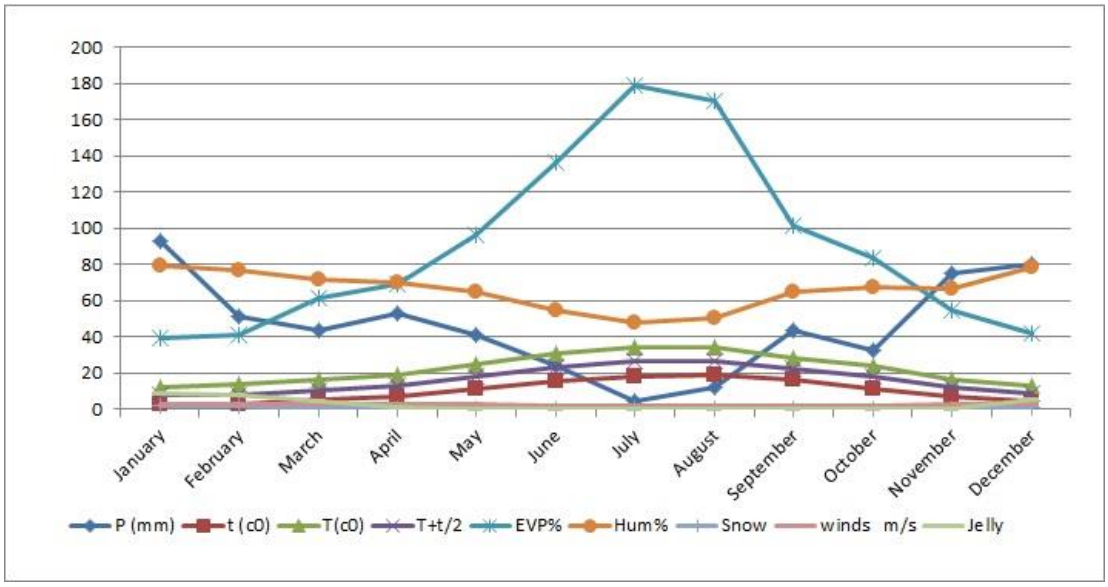


Figure 2: Main climatic characteristics of Constantine during 1995-2004 period (Source: ONM)

The urban growth of the city of El-Khroub is defined through four phases:

- *Phase prior to 1962*: The center of El-Khroub was created by the settlers, who used it as a housing camp and watchtower. It was declared as a seat of the municipality with full disposal by a royal decree of March 28, 1863, extending over an area of 12.5 hectares. The cultural area during this period was 12.5 hectares.
- *Phase from 1962 to 1977*: This stage is characterized by the exodus of the rural populations to occupy the houses of the centenarians. Then, the city of El-Khroub began to expand to the north, east and south, therefore, new neighborhoods appeared, like the district of August 20 which was built in the middle of the city, with about 472 houses, which lacked most of the facilities necessary for life. In addition to The Military Quarter to house the frames of the National Popular Army, to move the city of El-Khroub out of its core on the outskirts in 1974, with 317 dwellings. The urban area at this stage reaches 28.25 hectares.
- *Phase from 1977 to 1987*: This stage witnessed a significant increase in the annual growth rate, reaching 9.45%. Thus, the northern residential urban area emerged in the form of residential neighborhoods such as the neighborhood of 450 apartments, and the 900 apartments, located in north of the old core.
- *Phase from 1987 to 2008*: It was distinguished by the completion of the remaining projects from the previous period: the neighborhood of 300-apartments belongs to 900-unit apartments sector, the neighborhood of 500 apartments belongs to 1600 apartments, and the 500 apartments belongs to 1200 apartments (Marouk, 2008). After 1998, the authorities reassessed the situation through the publication of the Directive for Development and Reconstruction for the Constantine's assembly before launching major projects towards the new town of Masinissa on an area of 235 Ha.
- *Phase from 2008 to 2016*: The establishment of various facilities varying between shops and real estate agencies of which the most important are: the financial center, the foreign bank, the commercial bank and the cultural center, furthermore the youth center and the construction of a new departmental headquarters with the continued completion of housing projects in addition to the creation of a new city Masinissa in the northeast and the city Ain-Nahas in the north-west of the municipal center and the new city in Ali Mendjeli in the west.

Results and discussion

Reality of urban waste management in the city of El-Khroub

Types of municipal waste

Waste is defined as "any residue of a production process of transformation, or use any substance, material, product or more generally, any movable property abandoned or which its holder intends to abandon" (Thürer et al., 2017). This definition to the

waste presents harmful effects on the ground, the flora and the fauna, degrading the sites or the landscapes, generating noises or odors and attacking human health and environment (Mwangi & Thuo, 2014). These definitions therefore include household waste as well as industrial residues and unused products from agriculture (Damien, 2004).

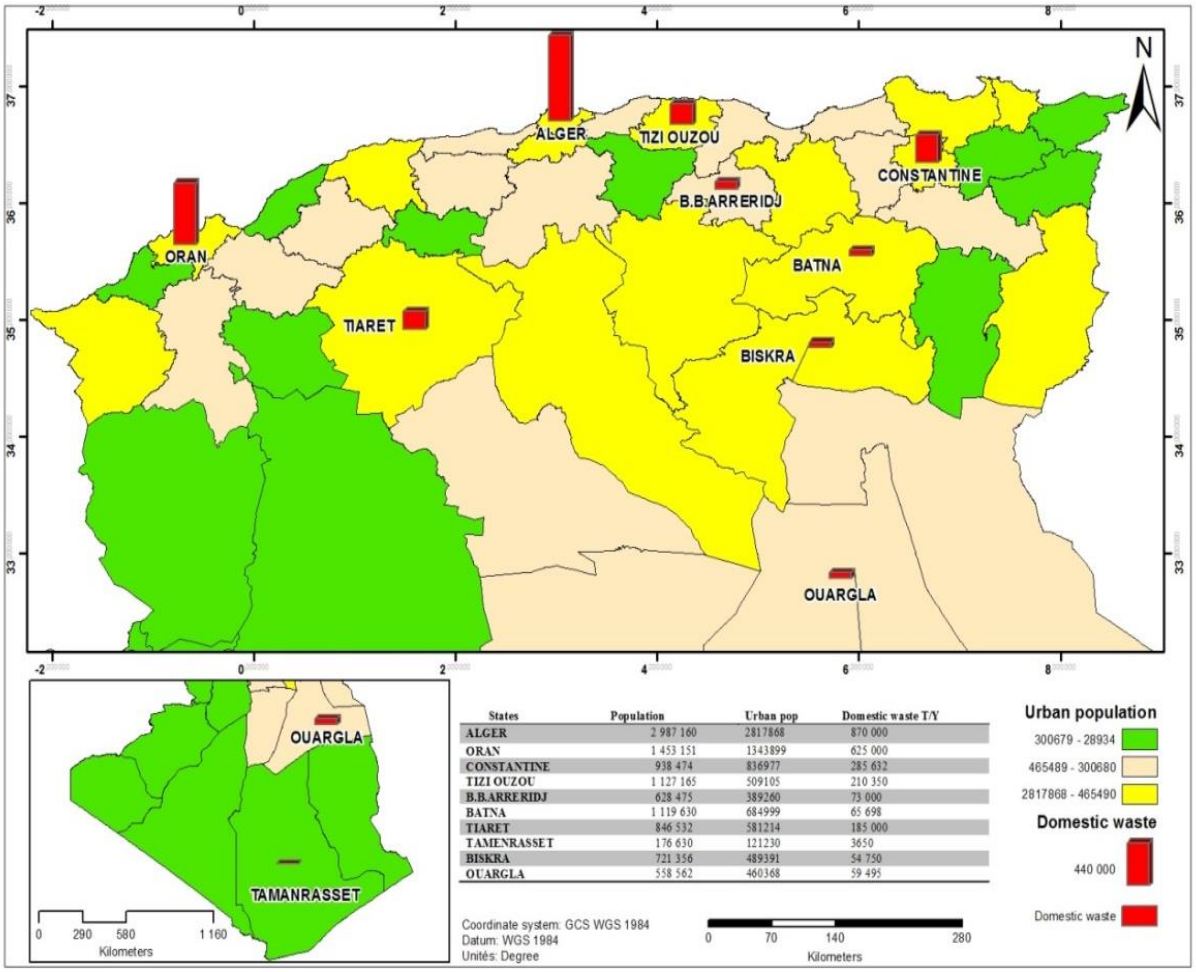
From the general definition of waste, we then decline their different categories by taking into account certain aspects of waste: hazardous or not, physical, chemical and biological characteristics (fermentable,

flammable, etc.) producing sector (industries, private community), composition, use (packaging, household appliances, vehicle) (Balet, 2016).

Household and similar waste

The term "Household and Assimilated Waste" includes the Household Waste, which comes from the domestic activity of the households as well as the waste coming from the industries, craftsmen, tradesmen, schools, public services and hospitals (Lebersorger & Schneider, 2011).

It usually consists of materials left over from the family's daily use, which includes organic materials from vegetable and fruit scraps, bread and others, in addition to plastics, glass, paper, cardboard, leather, metals, etc. These components differ in weight of the total waste product from one area to another within the same city. Indeed, in Algeria, the problem persists. In 2020, according to AND, the quantity of treated household waste was evaluated at 6 million tons, that is to say, a treatment rate of 45% compared to the total quantity generated, estimated at 13.5 million T (AND, 2021). As a result, the installed capacity for waste treatment is not sufficient. The following figure gives a picture of the quantity of waste produced in some provinces of Algeria.



States	Population	Urban pop	Domestic waste T/Y
ALGER	2 987 160	2817868	870 000
ORAN	1 453 151	1343899	625 000
CONSTANTINE	938 474	836977	285 632
TIZI OUZOU	1 127 165	509105	210 350
B.B.ARRERIDJ	628 475	389260	73 000
BATNA	1 119 630	684999	65 698
TIARET	846 532	581214	185 000
TAMENRASSET	176 630	121230	3650
BISKRA	721 356	489391	54 750
OUARGLA	558 562	460368	59 495

Figure 3: Production of domestic waste in relation to population in Algeria (Source: RGPH 2008 and AND 2017)

It should be noted that the cities on the Algerian coast, which are more densely populated, generate much higher quantities of waste than those in the highlands and the South (Abdelli, 2017). The province of Algiers produced more than 870000 tons in 2017, followed by the province of Oran, with a production of 625000 tons per year. The average city emits between 200 and 300000 tons of waste per year. particularly this is the case of Constantine in the East and Tizi-Ouzou in the Center. Indeed, some cities produce amounts of less than 50000 tons of waste per year, which are generally concentrated in the South; this is the case of Biskra and Ouargla, which are characterized by a low population density. As for the South, the province of Tamanrasset emits 3650 tons of waste per year (Eddine, 2012).

Following the AND report, 89 CET were installed in the northern region, and highlands and 81 controlled dumps, or 90% of the total national park. The rest is located in the South region with 12 CET and 09 controlled landfills, that is 10% of the total number (AND, 2021).

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The quantity of domestic waste deposited in El-Khroub city, in 2017 is estimated at 20453.28 tons (source: EPCA 2017). It is noted the rapid increase in the amount of household waste in 2014, as it increased in one year by about half of the first amount in 2013, which was estimated at 20500.00 tons. The year 2016 reached 44000,00 tons at the maximum. Then it recorded a decline in 2017, which was estimated at 20453,28 tons. This decline can be attributed to the strategy implemented by the State and local authorities to manage and reduce this waste. The situation becomes unmanageable when cleaning staff strike for more than 10 days (Ter, 2020) to demand their social and professional needs. This leads to the accumulation of piles of waste on the streets, especially as local authorities procrastinate in solving this often recurrent problem that threaten public health

Figure 4: Domestic waste in El Khroub city (1600 housing district) (Source: the authors)

Inert waste

Inert waste is not subject to any significant physical, chemical or biological modification. It consists mainly of construction waste: excavations and debris; demolition waste with treated wood, free asbestos, tar paints, pyralene (Kourmpanis et al., 2008). The city of El-Khroub suffers from the problem of inert wastes, which has deformed its urban environment and resulted from construction and restoration work such as bricks, ceramics, bricks, earth and statistics, concrete, ... etc. In addition to the cutting branches of trees, the amount of inert wastes produced is now estimated at 9 tons per year. The presence of various types of waste in the vicinity of the population often leads to many health and social pathologies.

Municipal Abattoir of El-Khroub city

The workers of the municipal abattoir unload the amount of waste, including the remains of entrails and their contents, into a trailer with a capacity of 10 tons, where they are collected by the public institution of cleaning and disinfection, which has an agreement with the abattoir, two times a week**.** On the day of Eid al-Adha (the feast of Muslims), the amount of solid household waste can reach 500 tons in the city of Al-Khroub alone.

Figure 5: The inert waste at El Khroub city (Source: the authors)

Waste management actors

Waste management in Algeria is carried out by two sectors: the public sector (the municipality) and the private sector (Sakri et al., 2021).

The public sector (the municipality)

The Algerian legislator has recognized that responsibility for the management of household and similar waste lies with the municipality, which must organize on its territory a public service to meet the collective needs of its citizens in terms of collection of household and similar waste, its transport and its treatment.

It is also possible for two or more municipalities to join to participate in the management of part of the household waste, this was confirmed by article 03 of decree n°84-378 of December 15, 1984: "The municipal People's Assembly organizes, under the conditions provided for in this chapter, on its own territory, or in common, or through common municipal bodies, or in an appropriate manner the collection service of waste requiring a particular organization: industrial waste, radioactive waste, fecal matter" (official journal, 1984)

The local public establishment of cleaning and disinfection of the town of El-Khroub

The municipality of El-Khroub signed an agreement with the local public institution of cleaning and disinfection in 1989, renewable annually, to ensure the maintenance of cleanliness and sanitation of the entire soil of the municipality. It is an establishment of an industrial and commercial nature, with legal personality and financial independence, created by the community (Municipal Council) on March 07, 1988. The legal status or capacity of the establishment has been changed from a public economic establishment (EPE) to an industrial and commercial

establishment (EPCA), in accordance with State Decree n°130 of 08/09/2011.

This establishment is located in Ben Boulaid district in El-Khroub, on an area of about one hectare. It enjoys financial autonomy for the management of household waste. It also works hard to collect, sweep and transport household waste and similar on almost the entire municipal territory. It is responsible for:

(1) collection of household and similar waste; (2) Sweeping of streets, roads, and highways; (3) Cleaning of public places and parks; (4) Lifting of rubble; (5) Collection of hospital waste; (6) Mosquito control by burying the carcasses of dead animals, according to Article 19 of Decree No. 88 corresponding to 15 December 1984 (official journal, 1984)

(2) *Urban solid waste disposal centers in the city of El-Khroub*: The first official regulation of this style of *waste* management dates back to the 5th century B.C, when the authorities of the city of Athens, Greece, decreed that all waste must be transported more than one mile (1.6 km) from the city limits. The city of El-Khroub has known several public waste disposal facilities to get rid of its urban solid waste, which are:

(3) *El-Haria Landfill*: The landfill of El-Haria is located on the national road n°111 leading to Constantine in an area called "Al-Qashqash". The landfill is 5 km from the town of Ben Badis and 20 km from the headquarters of the town of El-KhroubThe dump is located on a slope surrounded by agricultural land, 5 km north of the dump (Mansouri et al., 2018). The waste has been dumped there since 2001. The area allocated to the farm is 5 hectares.

(4) *public waste disposal centre "Ain Smara"*: It is located at the top of a private quarry - Hodna Ibrahim - in Djebel Awlad Salam, 4 km from the municipality of Ain Smara, and 5 km from the national road 101 (Fig.8). The use of the public waste disposal site started in 1992, it receives waste from the municipality of Ain Smara, El-Khroub, the public fruit and vegetable markets of Constantine and the production unit of Saïdal (AMRI, 2007).

(5) The dumping of garbage in the city of El-Khroub began in 2005. The waste is emptied without any regulation and directly on the roadside. Furthermore, the surface area of the landfill is estimated to be 4 hectares, the area operated is 2 hectares and the amount of waste dumped in the landfill is estimated to be 60 tons/day. The dump reached its saturation point within 5 years, when it was closed in 1997, in May 2004, the dump was reopened with an area of 7 hectares.

(6) *the "Bougherb" Technical Landfill Center (CET)*: in accordance with the law 01-19 of December 12, 2001 (Official journal. 2001), relating to the management, control, and elimination of waste. The technical landfill center is an alternative to the common public dumpsters in order to prevent and preserve the environment, taking into account the exact operating conditions of the technical landfill center.

(7) *The first CET in Algeria was built in 2000 in Ouled Fayet* (Djadia et al., 2008), in the periphery of Algiers, five watertight pits were built, as well as a drainage system. Indeed, the realization of the CET is a main axis, then the Algerian State devoted considerable investments to realize them. Nowadays, 221 treatment installations have been built, 191 of which are in progress (AND, 2021).

(8) According to environmental specialists, the construction of a CET requires an area of not less than 40 ha, fenced, and landscaped. The first of the constraints facing the realization of the national program of CET is the problem of expropriations and opposition from residents, according to the government (Ahoussi et al., 2011).

(9) *The CET Bougherb is located in Ben Badis municipality* (Fig.7), which is located at east of the city of Constantine, 40 km (Ayat et al., 2021). The area contains sandy rocks, to the west of the site of Al-Qashqash consisting of gravel and clay, to the south, limestone massif of Mount Amestas, to the east and south-west, caritas limestone, to the extreme north-west we find formations consisting of marl and conglomerate.

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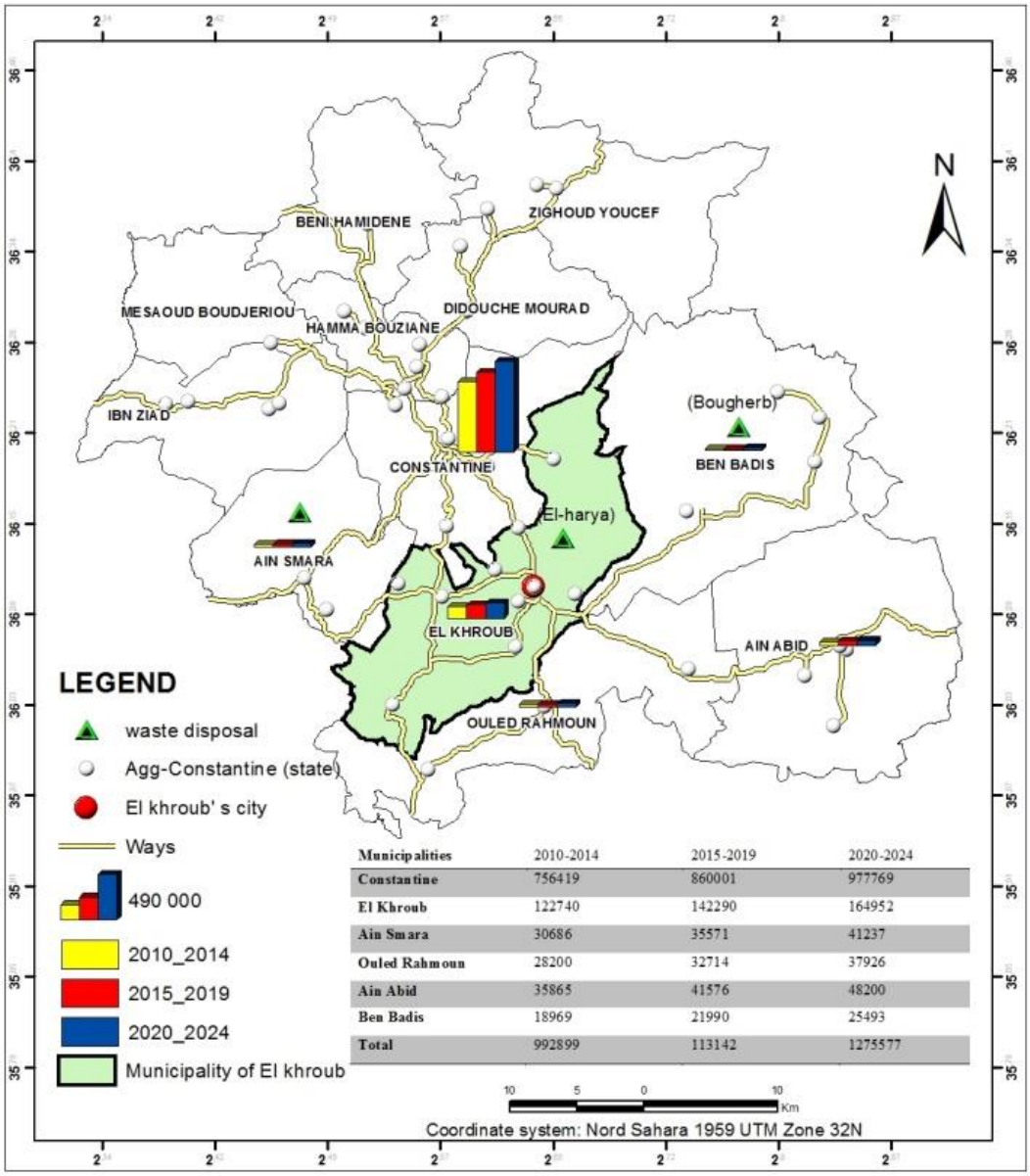
Figure 6: Part of the garbage collection process in El-Khroub city

Figure 7: CET Bougherb at Ben Badis from 2004 to 2021 (36°18'22.7N 6°51'15.0E) (Google Earth)

This figure (Fig.7) shows the construction stages of the landfill site since 2004, it also shows the different components of the landfill (Sorting place; Maintenance workshop; Retention Basins; Landfill Site). In 2021 it seems that it is functional and effective to managing waste.

We note that the amount of waste is constantly increasing, reaching the largest amount in the municipality of Constantine 860001T/year in 2019, followed by the municipality of El-Khroub of 142,290 tons/year, this is due to the expansion of the area of the municipality and the high number of residential areas, as well as the various organizations.

The quantity of municipal waste in Constantine is constantly increasing, according to the statistics of the waste disposal centers, as they confirm the continuation of the increase until 2024 (Fig. 8).



Municipalities	2010-2014	2015-2019	2020-2024
Constantine	756419	860001	977769
El Khroub	122740	142290	164952
Ain Smara	30686	35571	41237
Ouled Rahmoun	28200	32714	37926
Ain Abid	35865	41576	48200
Ben Badis	18969	21990	25493
Total	992899	113142	1275577

Figure 8: Location of public waste disposable Centers of El-Khroub city and Amount of waste landfilled since 2010 and planned for 2020-2024 (Source: The Public Organization for the Management of Technical Landfills and Waste Treatment Centers, 2019)

Household waste treatment methods

The city of El Khroub has suffered a lot from illegal dumps in the roadside, as they represented in the long term a public danger.

Landfill

The bottom of the cells is lined with layers of compacted clay and high-density plastic films, which provide a watertight seal to prevent liquid effluents from seeping into the soil. Furthermore, the waste is compacted in huge pits called lockers and then buried under layers of soil. The preparation process of the funeral center is based mainly on the creation of a watertight cell that allows its progressive filling.

Figure 9: Garbage storage in the CET Bougherb (Ben Badis)

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The cell is filled according to a scheme that determines its operation, as well as compensatory measures to preserve the environment. Before starting to fill the cell, the bottom is cleaned of all weeds, then a layer of clay is well placed compacted to a thickness of 75 cm, then covered with a non-permeable membrane called (the geomenbrane), which are membranes usually made of Polyethylene of high density or low density PVC, VFPE, HDPE, the geomenbrane is fixed with a mound of soil, which is then spread (Albright et al., 2006).

A second layer called Geotextil is added to avoid holes when the waste and machinery pass through. As a third layer, the Geodrain has the particularity of placing the evacuation tubes (drain pipe) of the LIXIVIAT (leachate) resulting from the residual liquid formed by the water running through the waste (Fleming & Rowe, 2004). This water is collected in a filtration storage tank and then transferred to a water filtration plant, where the treatment is carried out by the Lagunage technology due to its simplicity and low cost. Besides, the waste placed in the form of slicks in the deepest compartment of the cell is exposed to anaerobic fermentation, which is accompanied by the emission of biogas (Hashimoto, 1982), these gases are concentrated deep in the cell in the form of methane, which leads to serious accidents in the event of leakage into nature, can lead to the death of many animal and plant organisms.

The BIOGAS is eliminated by discharging it using several flares where they are placed inside a perforated cement tube, the distance between one flare and another is between 40-50m. It is also necessary to monitor the emission of methane gas above the CET because it causes accidents and explosions if its level exceeds 5% in the air (Zamorano et al., 2007). For the design of CET, certain conditions are taken into consideration such as site topography, geology and hydrogeology (Badjenna et al., 2016). According to the land use maps of the municipality of Ben Badis, the CET is placed in a bare land surrounded by a large agricultural area (Gana et al., 2018), a water lake is far from the landfill by a distance of 3 Km as the crow flies (Google earth). Thus, it is necessary to put very serious measures to avoid the filtration of water, especially as the region can experience a rather important wet period according to the analysis of Figure 2.

Waste incineration (or thermal treatment)

Incineration is one of the simplest techniques of disposal of urban waste. It is the process of being destroyed by fire, however due to their different components; they contain elements that are difficult to burn (Rand, 2000).

This operation allows us to: (1) Reduction of waste volume by 70-90%; (2)Valorization of the heat produced by combustion into district heating or electricity; (03)Incineration of municipal solid waste eliminates pathogenic organisms ; (4)It may be the only method that can be followed when there is no space required for a sanitary landfill or when groundwater is close to the surface; (05)To be operated as an optimal means of disposing of special and hazardous municipal solid waste such as hospital waste and abattoir waste. Incineration leads to the formation of thousands of molecules of only a fraction which is systematically searched in the fumes that cause some diseases (Council, 2000), such as liver, digestive tract and blood cancer due to dioxin exposure (Wissing, 2005).

In Algeria, currently, the solution of incineration is applied only for hospital waste within hospitals. For the following disadvantages: (1) very high humidity rate, (2) higher treatment cost due to equipment and operation costs, (3) the predominance of organic waste in the household waste (Wissing, 2005).

Recycling (or material recovery)

According to the services of the Ministry of Environment and Water Resources, Algeria has the capacity to recover a quantity of waste estimated at 760000,00 tons per year, which represents 3.5 billion Da (22304149,98 euro), of which paper represents an essential part in the possibility of recovery and recycling with a quantity of 385000,00 tons per year (the system of recovery of unsold newspapers). Out of more than 2 million tons of plastic packaging produced in Algeria by 192 units, only 4,000 tons are recovered (i.e. 0.0002%) (AND, 2021).

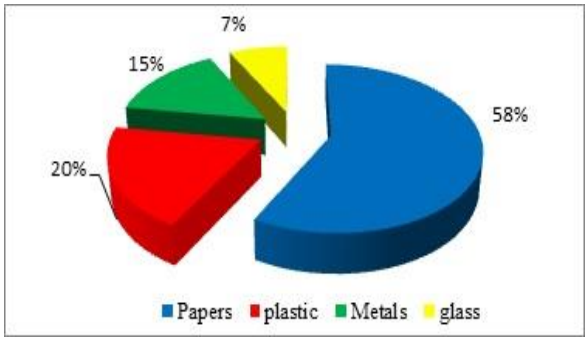

Figure 10: Types of recyclable waste in Algeria in 2017 (source: AND)

According to a publication by Tonic Emballage, a company specializing in the production of packaging in Algeria, the recycling capacity of the Algerian paper industry does not exceed 10% of all waste generated annually, while national consumption of paper and cardboard is estimated at 600000,00 tons / year Nearly 335000,00 tons of waste are dumped annually (Djemaci & Zaïd-Chertouk, 2011).

Recycling is possible for cardboard, paper, glass, plastic, metals, and dangerous household waste (batteries, paint, oil, etc.). The economic and environmental benefits of recycling are considerable (Pimentel, 1997), it helps to: (1) protect natural

resources; (2) reduce waste; (3) create jobs, (4) protect nature and save raw materials (Oke & Kruijsen, 2016). Algeria has 39 sorting sheds and 11 operational sorting centers (AND, 2021).

Figure 11: Storage of recoverable waste in El Khroub

During the meeting with the director of the environment of the province of Constantine, he said that the city of El-Khroub has an urban management establishment in the new city Ali-Mendjeli (EGUVAM) which has realized a selective sorting centre since April 2017. Its objective is the collection and recycling of dry household waste. This amount is part of a total of 30 tons of this type of waste, collected during this period through 19 neighborhood units in city of Ali-Mendjli, with an average collection of 580 kg/day, As the average recycling per day of waste of various types including bottles and plastic bags, is estimated at 150 kg.

Composting (biological recovery)

Composting is a biological process of transformation of organic waste (kitchen, green and wood wastes) by microscopic fungi and bacteria into a product comparable to soil (Insam et al., 2007).

The environmental benefits are multiple: (1) decrease the use of chemical fertilizers from mining resources (potash, phosphorus) by replacing them with natural composts; (2)reduce the amount of waste disposed of in landfills or incineration;(3) contribute to the reduction of greenhouse gases generated by waste treatment (incineration for example) (Wei et al., 2017).

Impact of municipal solid waste

Despite the laws in force within the city of El-Khroub for the disposal of waste, we notice huge amounts of waste scattered everywhere (Fig.12), causing a number of effects of which the most important are:

(1) Leaving waste, especially organic materials, in the streets or chaotic dumps under external influences, which makes it vulnerable to rotting and causes the escape of unpleasant odors. It is also a breeding ground for insects, which transmit many diseases to humans.

(2) Distorting the aesthetic view of the city.

(3) The volume of waste exceeds the containers, and in many and most cases, the waste is dumped in an unorganized and irrational manner, leading to the pollution of the city's external environment.

(4) Unpleasant odors emitted from waste inside open containers, or dispersed in random locations.

Figure 12: Neglected waste in the districts of El Khroub city

Conclusion

Through our field study and the analysis of various data and statistics related to the reality of waste in the city of El-Khroub, we conclude that the city suffers from the spread of waste of all kinds, especially household waste, which is associated with an increase in the size of the population of the region.

In spite of the presence of organisms charged by the elimination of the diverse types of wastes, but, the definitive elimination of this dirt has become almost impossible, considering the disinterest experienced by the citizen, and the little importance given to the necessity of preserving the environment by controlling all those responsible for the chaos in the urban space.

However, the following steps should be taken:

(1) Place large containers to accommodate the amount of household waste;

(2) Use good bags to pick up litter so that it does not tear easily due to the spread of stray cats and dogs in the litter box;

(3) Enact strict laws and penalties against anyone who pollutes urban areas;

(4) Perform road washing at night to get rid of volatile waste and unpleasant odors;

(5) Conduct awareness-raising operations among citizens and encourage them to dispose of their garbage in a legal and clean manner, by disposing of it in designated places and not randomly;

(6) Educate children in schools and the love of cleanliness;

(7) Hold contests for the best neighborhood award. These incentives work well and encourage citizens to keep their neighborhoods clean;

(8) The State shall ensure waste separation by placing specialized containers for materials, such as glass, plastic, paper, and other waste, to recover what can be recycled.

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Author contribution

This work was a joint work, each researcher put his trace. naziha LAMRI and Amna BELAYADI thought on the subject treated, faiza ABBAS carried out the methodology as she collected statistics from different directions, we shared the plan of work between us and each author took his share of drafting to finish as early as possible and after we made revision sessions together. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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