

Environmental And Sustainability-Based Approach To Urban Solid Waste Landfill Site Selection: A Case Study Of Charef City, Djelfa Province

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Abstract

Urban solid waste control has become an important environmental and planning activity in Algeria, especially in rapidly expanding city areas where demographic growth, unplanned urbanization, and evolving consumption patterns have intensified waste technology. These dynamics have imposed increasing environmental, social and monetary pressures on general government. The city of Sharif embodies this mission, as its mixed urban, rural and pastoral characteristics influence the composition and volume of household waste produced. Patience with inadequate disposal practices and the proliferation of uncontrolled landfill sites has increased soil degradation and increased risk of groundwater contamination, threatening environmental sustainability and public health. In this context, this study examines advanced scientific methods for controlling urban waste settled in Al Sharif through the perspective of environmental sustainability. It evaluates the feasibility of organizing a technical landfill as a sustainable solution for waste disposal, while identifying and analyzing the spatial, environmental, social and economic criteria required to choose a technical site for proper burial, called technical waste backfilling. The study aims to assist in the informed selection process and contribute to the development of an integrated and environmentally sound approach to city waste management tailored to the city's unique regional context.

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1. Introduction

The environmental impacts associated with inadequate waste disposal practices are considerable. Poorly managed landfills and uncontrolled dumping sites contribute to soil degradation and pose a serious risk to groundwater resources, particularly through the infiltration of leachate generated by waste decomposition under rainfall. At the national scale, municipal solid waste generation is estimated at approximately 10 million tons per year, with more than 90% being disposed of through landfilling, often in uncontrolled conditions. The widespread presence of illegal dumpsites across the country constitutes a persistent threat to ecosystems, water resources, and public health.

In response to these challenges, many countries have adopted diversified and integrated waste management strategies based on environmental protection and sustainable development principles. However, the selection of appropriate waste treatment and disposal methods remains highly context-dependent, closely linked to local socio-economic, environmental, and spatial conditions. In Algeria, the Technical Landfill Centre (CET) represents a key component of the national waste management strategy. Unlike uncontrolled dumps, CETs are regulated facilities designed to ensure controlled disposal, minimize environmental pollution, and contribute to a more sustainable management of urban solid waste, alongside recovery and valorization processes.

Urban solid waste management is a collective responsibility involving multiple stakeholders, from public authorities to local communities. At the local level, the city of Al-Charef is characterized by significant shortcomings in the organization and efficiency of its waste management system, resulting in various environmental and sanitary dysfunctions.

Within this context, the present study aims to analyze the current urban solid waste management practices in the city of Al-Charef and to assess the mechanisms of waste disposal in place. The central research question guiding this work is as follows:

What is the feasibility of establishing a controlled technical landfill for the city of Al-Charef, and what would be the most suitable site for its implementation?

To address this main question, several secondary questions are examined, particularly those related to the urban, socio-environmental, and spatial specificities of Al-Charef, as well as the environmental impacts of waste on its immediate surroundings. The study ultimately seeks to contribute to the development of a sustainable and environmentally sound approach to urban solid waste management adapted to the local context.

1– Study of the natural environment of the city of Charef

1.1 Geographical and administrative situation

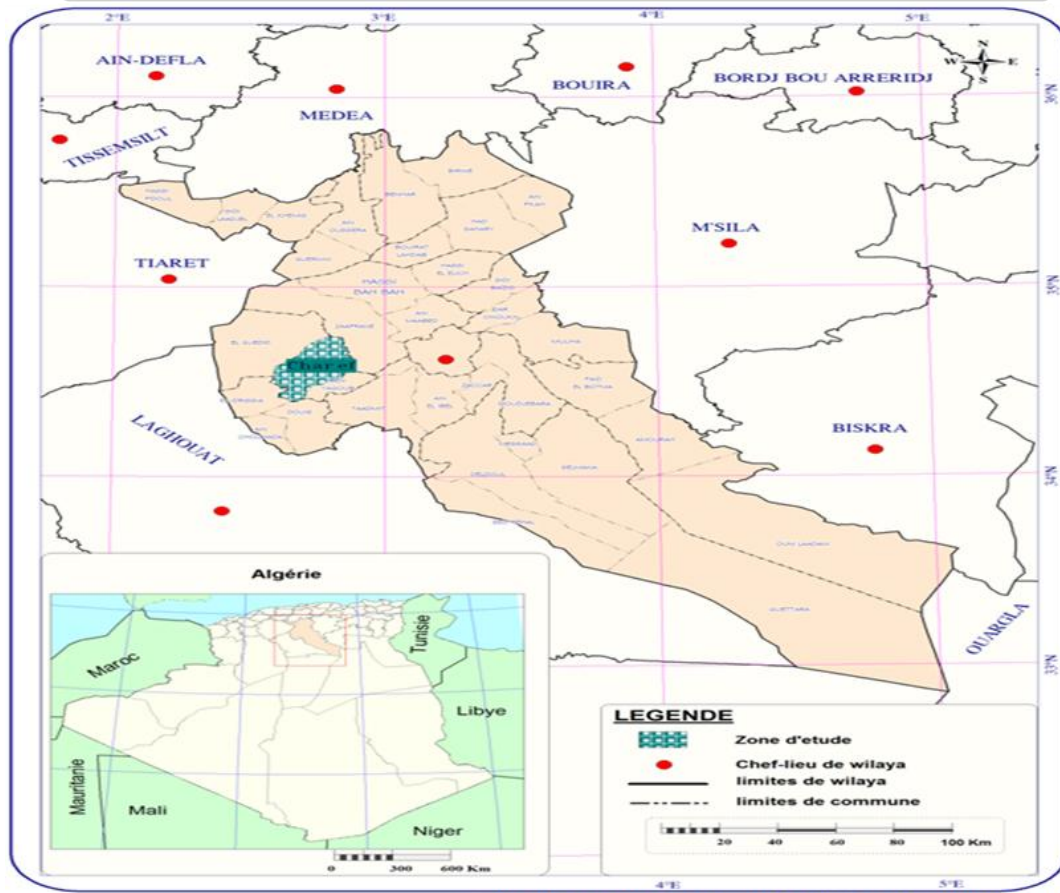
The commune of Charef is administratively part of the wilaya of Djelfa, and is located about 46 km west of the capital of the wilaya. It covers an area of approximately 59,055 hectares, which gives it a relatively large territorial extension on a municipal scale.

It is limited to:

- To the north-east by the commune of Zaafrane,
- To the west by the communes of Guedid and Idrissia,

- To the south by the commune of Beni Yaagoub.

Map N°01: Administrative situation of the municipality of



On the cartographic level, the commune is part of the Lambert North Algeria coordinate system, while the capital is located at 2°48' east longitude and 34°37' north latitude. This position places Charef in a transition zone between the High Steppe Plains and the first reliefs of the Saharan Atlas, which strongly influences its natural characteristics.

1.2 Environmental Analysis

1.2.1 Climate

In the absence of a local meteorological station, the climatic analysis of the commune of Charef is based on data from the Djelfa station, corrected according to local conditions. The climate of the region belongs to the semi-arid domain with an arid tendency, typical of the Algerian steppe regions, characterized by hot and dry summers and cold and relatively wet winters.

(a) Temperatures

Temperatures are a determining factor both for the development of vegetation and for human activities, particularly agricultural and tourism. The average annual temperature has strong seasonal variations, with winter averages of around 5 °C and summer averages reaching nearly 27 °C. Summer maximum temperatures can exceed 38 °C, while winter minimums can drop below –10 °C during cold waves, reflecting a marked continental climate.

(b) Evaporation and humidity

Evaporation is high, especially in summer, due to the combined effect of high temperatures and dry winds. Relative humidity varies considerably according to the seasons: it reaches high values in winter (up to more than 80%) and very low values in summer, especially during sirocco episodes, when it can fall below 35%. These conditions accentuate aridity and water stress.

(c) Precipitation

Rainfall is low and erratic, with an annual average of between 200 and 300 mm. The majority of the rainfall is concentrated between September and March, accounting for nearly 70% of the annual total. The summer months were a period of marked drought, with minimum rainfall in June and July. This seasonal distribution reinforces the semi-arid character of the commune.

(d) Snow, hail and frost

Snowfall is rare but not negligible, with an average of about 3 days per year, some exceptional years having recorded a greater snow cover. Hail is a very occasional phenomenon, mainly limited to the month of December. Frost is more frequent, with about 18 days a year, mainly in January, February and March, which can have negative effects on crops and natural vegetation.

(e) Weather and wind diagram

According to the diagram of Bagnouls and Gaussen, the commune experiences a dry period of five months (June to October) and a wet period spread over the rest of the year. The prevailing winds are mainly from the north and northwest, especially in winter, bringing cold and sometimes humid air masses. In summer, southerly winds (sirocco) predominate, accentuating dryness, evapotranspiration and thermal discomfort.

1.2.2 Reliefs

The relief of the commune of Charef is generally moderate, with slopes varying from 0 to 25%. Steep to medium slopes dominate, particularly on the plateaus to the south, east and north-east. The steeper slopes (over 25%) are concentrated along the mountain ridges of the Senalba, which are characterized by a relatively dense vegetation cover.

The altitude varies between 920 m at the level of the Hadjia wadi and 1,557 m at the Taouzara djebel, offering a notable topographical diversity.

1.2.3 Morphological units

The commune is located on the northern slope of the Saharan Atlas, straddling the following areas:

- the Ouled Nail mountains, characterized by mountainous reliefs,
- and the High Plains of Zahrez El Gharbi, with a flatter relief.

The morphological units are divided into two main groups:

- the mountains, formed by south-west/north-east oriented ranges, with steep ridges made up of resistant limestone rocks, largely wooded (Senalba Gharbi forest);
- the plains, located to the north of the commune, presenting a monotonous relief and thick Quaternary deposits.

1.2.4 Geological and geomorphological aspect

The geology of Charef is part of the general framework of the atlases domain and the northern margin of the Saharan platform. It is marked by an alternation of formations ranging from the Triassic to the Quaternary.

Lithological level, the region is dominated by sandstone, limestone and marl soils, to which are added important Quaternary surface deposits. The most representative formations are the Cenomanian and the Turonian, which are very resistant and structuring for the relief, as well as the Tertiary and Quaternary formations occupying nearly half of the municipal area.

The tectonics are of the atlases type, characterized by simple folds-oriented SW–NE, alternating anticlines and synclines. The region is considered to be low seismic, although the presence of faults requires precautions in construction techniques.

1.2.5 Hydrogeological Aspect

From a hydrogeological point of view, the commune of Charef is part of the closed basin of the Zahrez, a vast intra-mountainous depression favorable to the accumulation of groundwater. The aquifers encountered range from the Early Cretaceous to the Quaternary, organized mainly within the Charef syncline.

Among the aquifer formations:

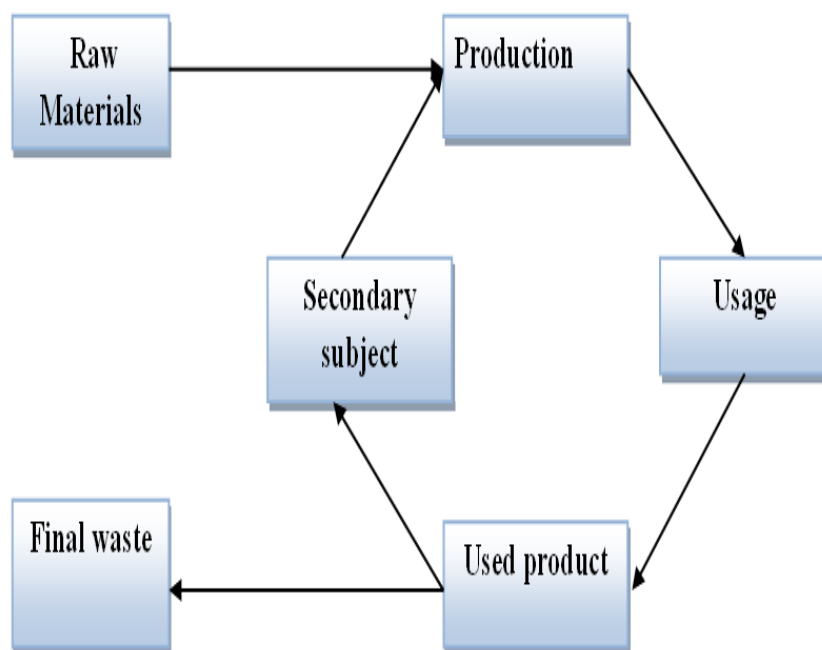
- the Barremian and Albian aquifers constitute important aquifers thanks to their fracturing,
- the Turonian contains an abundant but highly mineralized aquifer, unfit for consumption,
- The Mio-Pliocene formations are of little hydrogeological interest.

2. Typology and characteristics of waste

Waste can be classified according to several criteria, including its origin, nature and degree of danger. A distinction is made between:

- Household waste, from daily domestic activities, composed mainly of organic matter, plastics, paper, cardboard and various residues;
- Industrial waste, generated by production activities, the composition of which varies according to the sector of activity;
- Agricultural waste, from farms and livestock;
- Hospital and medical waste, characterized by its infectious potential and requiring specific treatment methods.

Physic-chemically, waste has variable characteristics such as density, humidity, calorific value and biodegradability. These parameters have a direct influence on technological choices in terms of treatment and recovery.



Source: Urban Solid Waste Management Information Manual 2001

3. Environmental and health impacts of waste

Poor waste management is a major source of environmental degradation. Uncontrolled storage or uncontrolled disposal promote soil pollution by leachate infiltration, groundwater contamination, and the emission of greenhouse gases, including methane, which contribute to climate change.

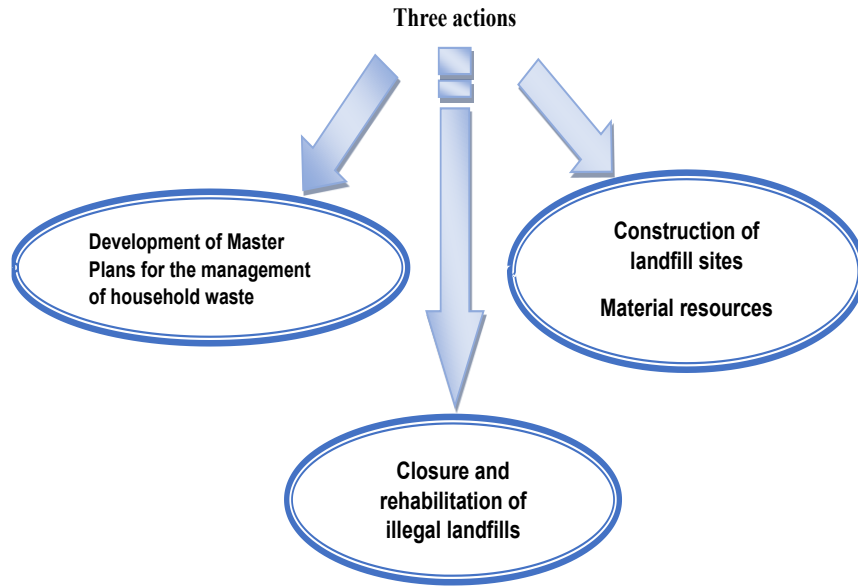
In terms of health, the accumulation of waste encourages the proliferation of disease vectors (insects, rodents), thus increasing the epidemiological risks for the local populations. It also causes odor and visual nuisances, affecting the quality of life and well-being of the inhabitants.

4. Challenges and prospects for waste management

Waste management is based on a set of integrated processes, including prevention, collection, transport, treatment and final disposal. Modern approaches increasingly favor the principles of integrated waste management, based on source reduction, selective sorting, recycling and energy recovery.

In developing countries, the implementation of effective waste management systems faces institutional, financial and technical constraints. However, the adoption of strategies adapted to local contexts, combined with raising awareness among populations and building the capacities of local actors, is an essential lever for improving environmental and urban sustainability.

Diagram N°02: Components of the RPOGDEM



Source: Ministry of Spatial Planning, Environment and Tourism

I. Landfills

The management of urban and industrial solid waste is a major environmental and health issue. Despite the development of many treatment techniques such as composting, incineration, pyrolysis, material or energy recovery, no method has yet been used to completely eliminate residues. A fraction of the waste is still untreatable or untreated, especially in the event of a malfunction of the facilities. In this context, landfilling remains a universal and essential solution for the final disposal of waste.

However, landfilling cannot be done in an uncontrolled manner. The uncontrolled discharge of waste generates multiple types of pollution: contamination of surface and groundwater, air pollution by smoke and bad Oduors, as well as serious health risks linked to the proliferation of disease vectors such as insects, rodents and stray animals. These nuisances justify the need to eliminate illegal landfills and replace them with regulated and monitored facilities, called controlled landfills or landfill sites.

I.1. Typology of landfills

There are several types of landfills depending on how they are located and operated. The illegal landfill is created without any regulation. Waste is deposited illegally, without control or development, which makes it a major source of environmental and health nuisances. The raw landfill, although located on a previously chosen site, does not benefit from any protection measures. The waste is simply grouped together at one point, without compaction or covering. Controlled landfill is the most successful form of landfilling. The waste is deposited there according to a precise operating plan, spread, compacted and covered regularly in order to limit pollution and to respect the principles of hygiene, safety and aesthetics. It is located on an appropriate site, taking

into account geological, hydrogeological and regulatory constraints, and provides for the rehabilitation of the site at the end of its operation.

I.2. Principle of controlled landfilling

Landfilling is based on a set of rigorous technical practices. The waste is spread out in successive layers, levelled using mechanical machinery, and then limited by embankments forming the landfill front. Every day, they are covered with a layer of inert material 10 to 20 cm thick to reduce nuisance. Within the mass of waste, complex biochemical processes develop, the nature of which depends on the degree of compaction. Low compaction promotes aerobic fermentation, while high compaction leads to dominant anaerobic fermentations, which are responsible for the production of biogas.

I.3. Evolution of the volume of waste

The volume occupied by landfill waste gradually decreases under the effect of mechanical settlement exerted by machinery and natural settlement linked to the degradation of organic matter. This reduction is particularly marked in the early years and generally stabilizes after four to five years.

I.4. Controlled landfill operation methods

Depending on the level of preparation and compaction of the waste, several types of controlled landfills can be distinguished. The traditional type of landfill consists of depositing the waste in thick layers, compacted and then covered daily. It is suitable for rural areas with large areas. The compacted landfill, developed mainly in urban areas, is based on intensive compaction allowing a significant gain in space. It promotes anaerobic fermentation and the production of methane, the recovery of which can be considered. Crushed type discharge involves the prior crushing of waste, ensuring better homogenization and rapid aerobic fermentation. This process optimizes the use of space, but its cost remains high. Finally, baling or cubing is based on a very strong compression of the waste, producing dense, stable and easily manipulated elements.

I.5. Necessary equipment

The proper functioning of a controlled landfill requires mechanical equipment adapted to its daily tonnage, such as track loaders, bulldozers or compactors, as well as fixed equipment (control rooms, garages, workshops). Additional equipment can also be mobilized for safety and ease of operation.

Mechanical equipment



Photo N°01: Sheep's foot compactor



Photo N°02: D6 suitable for grading waste

I.6. Advantages of Controlled Landfill

Landfill control the environmental impacts of waste by choosing suitable sites, keeping waste away from urban areas, treating leachate and biogas, and ensuring strict regulatory monitoring. It is based on a multi-criteria analysis integrating geological, hydrogeological, urban planning and environmental data, and is the subject of a technical file assessing the impacts, risks and management methods.



Photo N°3: End of activity (after rehabilitation)

I.7. Leachate

Leachates are polluted liquids resulting from the percolation of water through the mass of waste. Their production is linked to the biological degradation of organic matter in four main phases: hydrolysis, acidogenesis, acetogenesis and methanogenesis. These processes, which are mostly anaerobic, generate methane-rich biogas and leachate that is highly loaded with organic, saline and metal pollution. Their composition varies according to the nature of the waste, the age of the landfill and the climatic conditions.

I.8. Risks associated with poor operation

A poorly operated controlled landfill can generate significant risks: groundwater pollution, uncontrolled biogas emissions, odor and landscape nuisances, as well as the risk of fire or explosion. Preventive measures, including permanent surveillance, the installation of lockers and the installation of fire-fighting devices, are essential.

I.9. End of operation and rehabilitation

At the end of the activity, the landfill is contained by multi-layer waterproofing systems, ensuring the protection of the environment against infiltration. The leachate is recovered and treated, while the biogas is recovered or burned. Environmental monitoring is maintained for several decades after the site is closed. The gradual rehabilitation of the traps, their final cover and revegetation allow the site to be integrated into the landscape. Post-operation monitoring, spread over several phases, guarantees the stability of the structure and the sustainable control of environmental impacts.

I. Location and quantity of waste

The problem of solid waste in the city of Charef is closely linked to population growth, urban sprawl and the lack of sustainable and efficient management of storage sites. The analysis of the location of illegal dumping, the amount of waste produced and its environmental impacts is a fundamental step in assessing the feasibility of a controlled landfill.

I.1. Geographical location of illegal dumping

The illegal dumps in the municipality of Charef are spread over three main sites, located in the north-eastern part of the capital and in the south-western part near the existing controlled landfill. These deposits occupy a total area estimated at 7,701 m² and are located on virgin land characterized by low floristic diversity, dominated by sparse vegetation of the *Ziziphus lotus* type. The anarchic location of these deposits in undeveloped areas accentuates their environmental vulnerability and promotes the degradation of the surrounding natural environments.

I.2. Population projection

The capacity of a landfill is directly related to the evolution of the population and the amount of waste generated. A demographic projection over the next twenty years has been carried out in order to estimate future landfill needs. This projection is based on an exponential growth model that takes into account the base year population and a constant annual growth rate. The results show a continuous increase in the population of the city of Charef, from about 16,000 in 2008 to more than 34,000 in 2027. This demographic dynamic implies a significant increase in the production of household waste and puts increased pressure on existing management infrastructures.

I.3. Quantity and tonnage of waste

The estimate of waste generation is based on an average ratio of 0.50 kg per capita per day, a value commonly used for medium-sized cities. From this ratio, the daily and annual tonnage of waste produced by the municipality of Charef was calculated. The results indicate a gradual increase in

daily tonnage, from around 8 tones per day in 2008 to more than 17 tones per day in 2027. This evolution is directly correlated with population growth and confirms the need for a landfill infrastructure sized according to future needs.



Photo N° 04: Illegal dump in the town of Charef

I.4. Illegal dumping

Illegal dumps are uncontrolled storage sites, usually located near inhabited areas. Their uncontrolled exploitation is the source of many environmental and health nuisances, such as bad odors, the proliferation of insects and rodents, recurrent fires and the contamination of surface and groundwater. These sites also have negative socio-economic impacts, including reduced agricultural productivity of neighboring land, degradation of the landscape and inconvenience to local populations. It should be stressed that these nuisances are not inherent to landfilling itself, but are mainly the result of the lack of control, the lack of suitable equipment and the non-existence of waste recovery and recovery channels.

I.5. Environmental impacts of illegal dumping

An uncontrolled raw landfill is characterized by the accumulation of waste of various kinds, without a management plan or protective measures. Biological and chemical reactions between waste, in the presence of air, generate multiple nuisances: the emanation of odors perceptible over a radius of more than five kilometers, the flight of dust and light elements, the proliferation of disease-carrying agents, respiratory disorders and the risk of fire linked to the production of biogas. These impacts pose a direct threat to public health and the environment.

II. Environmental site analysis

II.1. General description of the site

The Charef landfill is located north-east of the capital of the commune, about 1.7 km from the exit of the town. It is considered to be a site with a medium environmental impact due to the anarchic dumping of waste on several illegal dumps, the semi-permeable nature of the soil favoring the risk

of underground pollution, the atmospheric pollution linked to the burning of waste and the total absence of control or mitigation measures for nuisances.

II.2. State of the existing landfill site

The town of Charef has a controlled landfill that is currently closed and unexploitable, located in the south-western part of the municipality. Analysis of its condition reveals significant deterioration of several critical pieces of equipment, such as the gate, fence, monitoring lodge, drainage system and gas wells. However, some structural elements, such as the traps, dikes, waterproofing and leachate pond, remain in good condition. This situation shows that the controlled landfill could be rehabilitated provided that the necessary developments and repairs are carried out.

II.3. Description of illegal dumping

Most of the waste is dumped in a disorderly manner along a ravine, by trucks and collection machines. The site is frequented by ragpickers, stray animals and birds, which accentuates the health risks. The strong smells released by the fermentation of waste testify to a total lack of management and monitoring.

II.4. Age and nature of deposits

The age of the landfill is over ten years old and no control measures were put in place during this period. Waste is mainly of household origin, but it also includes green waste, agricultural waste, rubble and, worryingly, special waste such as hospital waste. Some of the waste is burned in the open air or collected informally.

II.5. Waste height and water behavior

The height of the waste directly influences water retention, internal flows and evaporation potential. The increase in the thickness of the waste layers promotes the storage of rainwater, which can accentuate the production of leachate and modify the internal hydrological balances of the landfill.

Waste height



II.6. Effects on the environment

The environmental sensitivity analysis shows that the risks to groundwater and surface water remain limited due to the remoteness of the catchment structures and the significant depth of the water table. However, the impact on the population remains significant, particularly through the odor nuisances felt despite the relative distance of the site from residential areas.

III. Characteristics and feasibility of the controlled landfill

III.1. Lifetime of the locker

The studied locker has a surface area of approximately 10,276 m² and a depth of 5 m, offering a total volume of more than 51,000 m³. The life of the locker was estimated on the basis of the evolution of waste production and a ratio of 0.50 kg/inhabitant/day. Calculations show that, without compaction, the trap would be saturated quickly, while compaction would extend its life by several years, highlighting the importance of harvesting techniques.

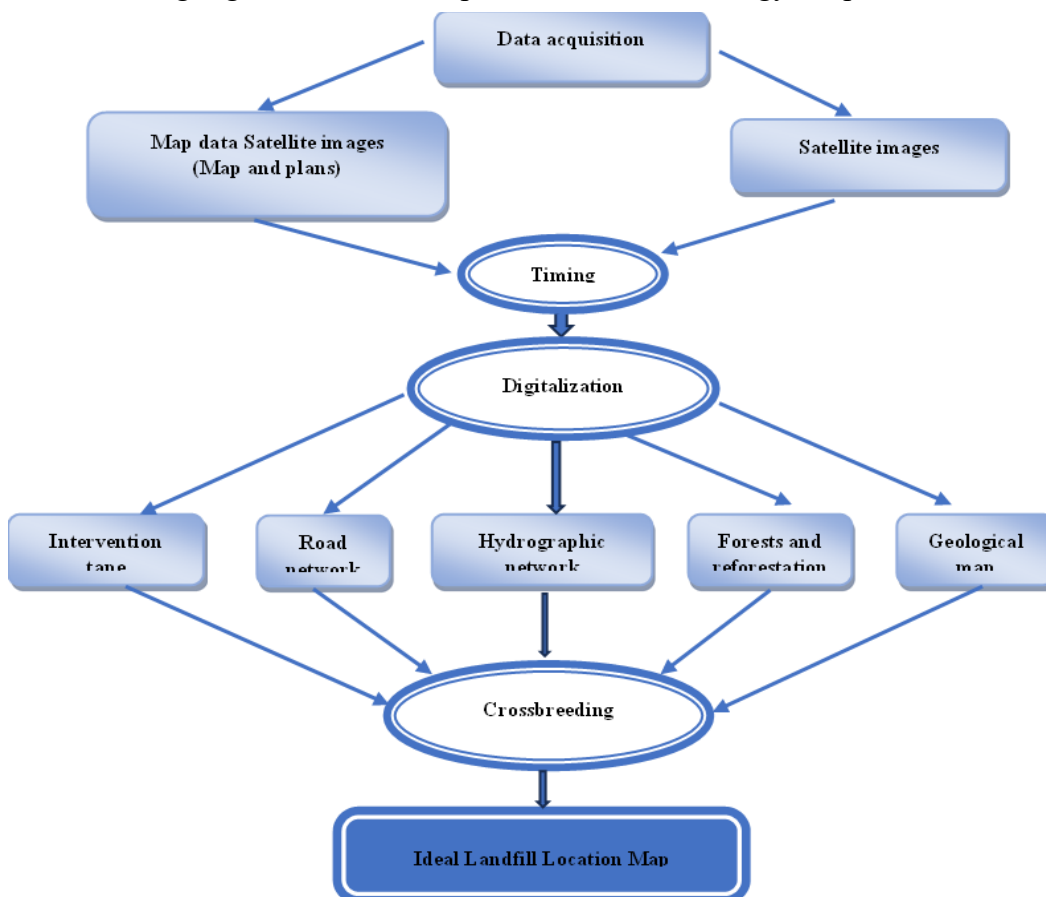
III.2. Landfill volumes

Two scenarios were considered: a pessimistic scenario without compaction and an optimistic scenario with compaction. The results indicate that compaction significantly increases the landfill capacity and delays the saturation of the bin, making the operation more sustainable.

III.3. Methodology and analytical tools

The study aims to demonstrate the feasibility of a controlled landfill for the city of Charef through the use of geographic information systems (GIS), combined with cartographic, environmental and regulatory data. The data were collected from several local agencies and broken down into map data and satellite images. Their intersection made it possible to identify the areas to be avoided and to propose an optimal location for the establishment of a future controlled landfill.

The following organizational chart presents the methodology adopted in this work:



Conclusion

The release into the environment or the discharge of leachate constitutes a major risk to all components of the natural environment, i.e. the environment in general. This is due to the polluting organic load and the excessive heavy metal content.

Knowing that all the studies that were done converge on the same point; the harmfulness of leachate on the entire environmental environment.

We are therefore invited to take great care in the serious and effective study whose main objective is to avoid pollution generated in a surrounding environment by having the certainty of an adequate and reassuring protection.

This protection will only be obtained by a judicious choice and a technical and scientifically preventive construction of a landfill site for waste that produces harmful leachate.

In this work, we have designed a study that allows us to make a choice of these landfill sites, in particular the controlled landfills, presenting the solution to the problems of seeing the germination of illegal landfills threatening the surrounding environment.

This was done through the use of GIS features.

A cross-referencing of the different layers of geographical information required has effectively enabled us to find and locate an ideal site for the construction of a controlled landfill that is the subject of our feasibility study.

The site in question, which adequately meets the conditions required by the MATE, both on the socio-economic and environmental plants, is located on the eastern side of the town of Charef.

Thus, this controlled landfill will offer the city the opportunity to protect and safeguard a surrounding environment that has only been favorably hospitable to this forest region and of a population that still tends as it was to be a friend of nature and to be part of it.

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