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PROMOTING SUSTAINABLE DEVELOPMENT THROUGH WASTE RECOVERY: THE CASE OF JIJEL IN ALGERIA

Abstract: The current article assesses existing functional modalities of waste management and valorization in Algeria, as well as their current roles in the dynamic of sustainable development, on the basis of state-of-the-art circular economy international best practices (Germany, Sweden, China and Japan.). The work was carried out based mainly on the data of the National Waste Agency (ANSD), from the year 2013 to 2022. Special interest was given to the Wilaya of Jijel. The analysis shows that municipal waste management has significant performance gaps, inadequate source separation of recyclables, and proportional poor logistical coverage (where logistics do exist) for successful waste valorization. Growth and cumulative change indicators provided valuable insights for measuring different components of waste generation dynamics, and observing general periods of rapid change in waste generation. International comparison showed that advanced countries have already strategically implemented strict regulations on sorting, recycling, and to a lesser extent, waste to energy, in waste management, with similar robust public and private sector disposal realities equally applied. By contrast, Algeria continues to struggle to find solutions for these issues, with valorization rates being consistently very low compared to international standards, despite legal and social instruments for action. In conclusion, recommendations were made on how to build enough necessary waste management infrastructure; stimulate, encourage and stimulate local government and community actions; support true opportunity for innovation and investment; and overcome the cultural barriers to awareness/action environmental and social, with full community concerted action and support action. Our ultimate goal is trigger genuine transition to a circular economy based on sound waste management principles where waste is considered as a value which contributes to better quality of life, and individual and societal well-being.

Keywords: waste management, municipal solid waste, circular economy, environmental regulations, Annual Growth Index, Jijel

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Introduction

The world increasingly recognizes that human activities with negative environmental impacts must be regulated and assessed for their effects on the climate (Wiesmeth, 2012). Numerous studies demonstrate a direct link between such activities and unprecedented natural disasters, as well as between climate change and population health issues, particularly respiratory diseases (McMichael & Lindgren, 2011). This situation contrasts sharply with our enjoyment of fundamental human rights, both individually and collectively.

Consequently, attention has shifted toward alternative models such as the circular economy, which aims to transform unsustainable production and consumption patterns through resource efficiency, recycling, ecological design, and industrial ecology (Geissdoerfer et al., 2017) . This model has emerged as a tool for sustainable development, guiding countries toward optimal resource use while protecting the environment (Daly & Farley, 2011).

The significance of the circular economy is becoming more obvious. It exemplifies product recycling and waste, sensible utilization of resources, ecological design, and industrial innovation giving it a credible alternative to prevailing consumption-based economic paradigms (Anwar et al., 2025). The major countries adopting cutting-edge waste management have been Germany, Sweden, China, and Japan where separate waste disposal systems embracing source separation, recycling, waste as energy, and involvement of the everyday citizens, as well as the private sector in waste disposal. Their results achieved high recycling rates, low landfill disposal, and socio-economic and environmental benefits (Liang, 2024).

Although Algeria has made significant progress - in waste management policy, the rise of designated technical platforms for landfilling, and national programs like the PROGDEM program and the SNGID 2035 strategy - overall performance on material recovery - recycling and reuse - is still poor. Other difficulties result from unsorted residue, poorly developed infrastructure, and little knowledge or awareness on waste management (Abbas & Lamri, 2025; Cheniti et al., 2024).

This study analyzes Algeria's waste management and recovery performance regarding sustainable development and the circular economy. It compares Algeria's practices with the models of international leaders and reviews the National Waste Agency data (2013-2022) and focused on Algeria's Wilaya of Jijel, to highlight public structural gaps and limitations and offer recommendations for an economy based on a circular economy that uses resources efficiently.

The main research question addressing this study is: How can Algeria use international experiences in waste management and the circular economy model for sustainable development by turning waste from a negative environmental and economic impact into a resource that adds to wealth and quality of life for the current and future generations?

Literature Review

The notion of sustainable development has shaped over time through global initiatives and conferences and has built into a foundation through various global initiatives and confer-

ences (Sachs, 2015). Initially attempts included the 1915 Canadian Commission for Environmental Conservation, identifying the importance of passing on "natural capital" to future generations (Harris & Roach, 2017), and the 1923 International Conference in Paris, when environmental conservation and reasonable use of resources were important themes (Jose, 2023).

The 1960 Rome Conference flagged the dangers of rampant economic and demographic growth, while the formally referred to "environmentally sustainable development" was presented at the Stockholm Conference in 1972 (Biswas & Biswas, 1982). The World Conservation Strategy, produced in 1980, went further in prompting the conservation of biodiversity and shared the stage with the International Conference in 1984 that promoted the argument to balance the economy and the environment (Redclift, 2005). It was not until 1987 that the term "sustainable development" was officially recognized by the World Commission on Environment and Development (WCED) in their report Our Common Future.

Afterward, the Rio Earth Summit (1992) defined sustainable development in public and policy debates (Drastichová, 2022); the Kyoto Protocol (1997) coordinated international efforts towards reducing greenhouse gases (Dessler & Parson, 2019); the Johannesburg Summit (2002) reaffirmed the importance of protecting natural resources and biodiversity (Dodds & Strauss, 2012); the Copenhagen Summit (2009) and the Paris Summit (2015) strengthened international commitments to address climate change (Falkner, 2016); and most recently the Glasgow Conference called for increased implementation activity under the Paris Agreement and a move towards sustainable, low-carbon development (Lennan & Morgera, 2022).

Sustainable development focuses on the quality and use of natural resources in such a manner that they do not deteriorate or become wasted (Daly, 2017) and has prompted Algeria to establish successive national policies and plans addressing responses to waste that have been developed around Law 01-19, which regulates the monitoring, disposal (waste management strategy for waste disposal), and valorization of waste (Hassaine & Abrika, 2024; Hemidat et al., 2022; Ismahan, 2022) . It lays down principles and instruments of waste management aimed at "reducing waste at source," waste sorting and collection, recycling and reuse and citizen awareness of waste management practices (Abbas & Lamri, 2025). Funding for these programs is from state and local governments.

At the local level, Algeria has also developed a total of 1,089 plans for household waste management, however, only 18% had received official approval by 2021 (Ministry, 2021b). At the regional (wilaya) level, plans were also formulated for specific waste types (e.g. medical, hazardous, industrial waste) that were catered to different environmental directorates and were not considered tourism programs. Regional plans did that made use of the national policies backed by technical support.

Recycling is one of the main pillars of waste valorization, which is defined as taking household, industry and agricultural wastes and remanufacturing them to less impactful environmental waste and economic value. Paper, plastics, glass, metal, textile, and waste water can be collected, sorted, treated, and re-manufactured into an eco-friendly product (Küfeoğlu, 2024) . Although recycling as a practice is older than my country, recycling has allowed my country to migrate away from being a colonial dumpster and bestow positive environmental and economic outcomes, such as less landfill space used, less raw materials

used, and green jobs and innovative job opportunities (a Waste, 2018) in health and environmental difficulties, less waste of resources, and job creation beyond landfilling (Wijkman & Skånberg, 2015). This model represents a viable, sustainable development option that encompasses economic, social, and environmental dimensions.

Materials and Methods

In order to conduct this study, a multi-method approach was employed, including a literature review, quantitative methods, GIS geographical analysis, and benchmarking. This interdisciplinary framework helped to understand the complex realities of waste management and sustainable development in Algeria.

a. The data and sources: Data were gathered from various secondary sources, including official reports from national and international organizations, environmental statistics, and research reports on sustainable development, waste management, and the circular economy. These described the quantitative and qualitative basis for the analysis.

b. Statistical Processing and Analysis of Indicators: Numerical data was statistical processe with Microsoft Excel whereby the data was arranged into tables with indicating calculations for annual growth and cumulative change and charts were produced that illustrated the evolution of waste generation over time and waste recovery over time and across different countries.

Two key indicators were used to analyze the evolution of waste quantities during the studied years:

Cumulative Change Indicator, calculated as:

$$\text{Cumulative Change} = \text{Value of the year} - \textit{Value of the base year (2008)} \quad (1)$$

This indicator is used to measure the total accumulated difference in waste production compared to a reference year, enabling long-term trend monitoring.

Annual Growth Indicator, calculated using the formula:

$$[(\textit{current year value} - \textit{previous year value}) \div \textit{previous year value}] \times 100 \quad (2)$$

This indicator is a key analytical tool to understand the year-over-year dynamics of waste generation. It precisely highlights annual changes and helps direct efforts to improve environmental management. The importance of this indicator lies in:

- Tracking temporal trends in waste production (increase, decrease, or stability);
- Evaluating the effectiveness of environmental policies and measures in reducing pollution;
- Future planning for infrastructure related to waste collection, transport, and treatment;
- Identifying periods of sharp change to understand underlying causes and take appropriate measures;

- Supporting decision-making processes among local stakeholders and environmental institutions within the framework of achieving sustainable development goals.

The indicators were calculated for the province of Jijel by using 2008 as the base year; 2008 was selected because it includes the onset of Algeria's national waste management strategy and has consolidated statistics. The data were processed for each year. Statistical analysis and presentation was done using Microsoft Excel, which was sufficient for a descriptive study and analysis of trends. There are, obviously, limits to Microsoft Excel in terms of processing solid large datasets and also statistical analysis.

Geographic Analysis:

Spatial patterns of waste generation and management were visualized using Geographic Information Systems (GIS). Spatial analysis was run in ArcGIS to identify the regional differences and priority areas where policy could intervene. Where possible, the analysis included spatial statistics and interpolation to add more robustness to the analysis. The spatial resolution of the study was at the municipal level, which allowed for sufficient representation of regional differences.

Benchmarking and Policy Analysis:

One benchmark assessment evaluated Algeria against international benchmarkers that are leaders in waste recovery, such as Germany, Sweden, Japan, and China. The transnational benchmarking assessment included both value gaps and best practices for waste valorization and processes rather than products associated with a circular economy. The findings from the benchmarking were adapted to the Algerian situation and included realistic policy recommendations.

Results and Discussion

Presentation of Leading International Models in Waste Management and Recover

Waste generation and its management are among the main contributors to the overall carbon footprint of an economy-one of the key areas that countries are increasingly striving to reduce in order to limit their impact on climate change (Change, 2013). Biodegradable waste, such as food waste, paper, cardboard, and garden/yard waste, all release methane gas-a powerful greenhouse gas that significantly contributes to global warming and climate change.

Waste Management and Recovery in Germany

Germany is a leader in this area, and has the highest recycling rate globally since 2016. In 2021, the country achieved a 71% recycling rate by using a variety of measures, probably the most important is a mandatory waste separation policy for manufacturers and consumers. Consequently, Berlin managed to cut their plastic waste exports to a 10-year low point of 745,100 tons in 2022 (Gelmez et al., 2025).

Table 1. Usage rates of packaging types in Germany for the years 2025 and 2035 (in percentage):

Type of Packaging	2025	2035
Plastic	50%	55%
Wood	25%	30%
Ferrous metals	70%	80%
Aluminum	50%	60%
Glass	70%	75%
Paper and cardboard	75%	85%

Source: (Schroeder & Jeonghyun, 2019)

The table on the use rates of packaging in Germany between 2025 and 2035 has a clear signal promoting the use of recyclable materials. We see a marked increase, in many cases, between the usage raises of the various packaging practices introduce as actions of one or many sustainably minded consumers, companies or cohorts. From this we can infer that there has been a change within the systematic design for a system trust maintained by government Accountability and/or reducing the malfunctioning of waste management altogether simply by improving upon the quality of the mattering sustainable packaging systems- fully in line with the goals of environmental protection and sustainable development.

In reference to my previous comments on plastic usage, I did take note of the increase from 50% to 55%, still likely to indicate some continued reliance on plastic but maybe with some increased reassurance of use of a derived product of sustainable design towards plastic that could be perceived to be more advanced to recycling whereas wood increased from 25% to 30% that might signal increasing assurance towards a natural product (Stuchtey et al., 2016).

And we can keep also note of the increases with metal and paper-based materials like ferrous metals went up from 70% to 80%, aluminum also increased usage from 50% to 60%, glass went from 70% to 75% and then paper and cardboard went from 75% to 85% usage - make these are significant increases and basically all tied in sustainably based systems (MacArthur, 2017).



Fig. 1. Waste Segregation Bins in Germany for Sustainable Waste Management
Source: https://www.umweltbundesamt.de

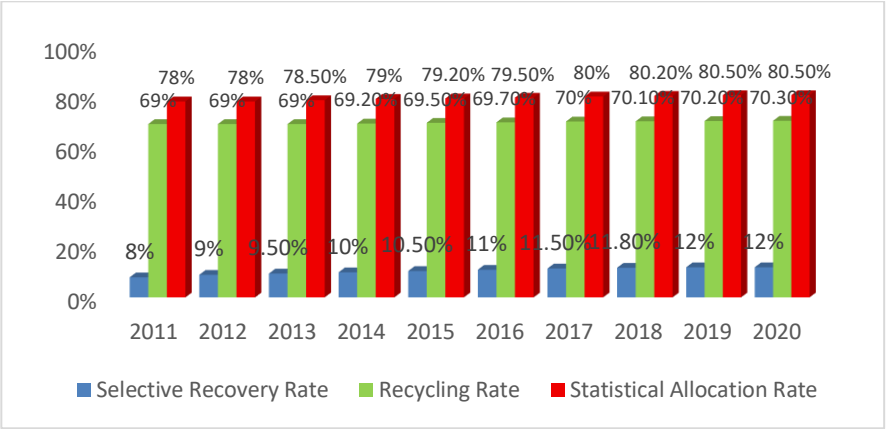


Fig. 2. Evolution of Recovery, Recycling, and Allocation Rates in Germany (2011–2020). Source: Data of (Weber, 2022)

The evolution of recovery, recycling, and allocation rates in Germany between 2011 and 2020 reflects ongoing efforts to improve the waste management system and indicates the effectiveness of the environmental policies adopted by the country over the past decade (Wielgosiński et al., 2021). The table highlights three key indicators: the rate of selective recovery, the recycling rate, and the statistical allocation rate—all of which show an upward trend, although at varying speeds.

The selective recovery rate increased from 8% in 2011 to 12% in 2020, reflecting a gradual improvement in the ability of citizens and local systems to sort waste at the source (DeBoe, 2020). This progress can be attributed to awareness campaigns, the expansion of separated waste collection networks, and the modernization of infrastructure related to containers and transportation. Although the growth rate has been relatively slow, it remains steady and ascending, indicating a gradual shift in consumer behavior.

The recycling rate grew slowly but gradually, from 69% in 2011 to 70.3% in 2020. Although it is only a modest increase of 1.3% over the last ten years, it is clear that the German recycling system is stable, performing at a better rate than a number of other countries (Vambol et al., 2023). As one of the highest rates, consistency like this is indicative of the operational status of industrial facilities, and technology that processes waste.

The third indicator, the statistical distribution rate increased during the same time period, from 78% to 80.5%. This suggests that a greater amount of waste, in both recovery and disposal wearing, was allocated to associated treatment processes, whether it be recycling, energy recovery, and safe disposal. This improvement illustrates growth in the consolidation of circumstances incorporating the various stages of waste management from collection to treatment (Spies et al., 2024).

Taken together, all of this substantiates Germany as committed to a good faith environmental policy that includes waste with emphasis on waste prevention, source separation, recycling and proper bin allocation. The inputs suggest the importance of source sorting as a means of establishing a culture and enhancing efficiencies related to recycling within an effective circular economy.

Waste-to-Energy Industry in China

The waste-to-energy marketplace in China is growing rapidly with an anticipated compound annual growth rate (CAGR) of greater than 4.75% over the next few years based on strong censuses of supportive government policies and positive investments in the time ahead. However, environmental issues including harmful gases emitted into the atmosphere and residual ashes that can leach into groundwater may adversely affect the market development.

Furthermore, the daily per capita amount of waste is expected to increase by roughly 40% by 2050, and this potential enables a naturally inherent ability to satisfy the rising energy demands. In spite of these risks to public health and the environment, incineration is still the most common treatment method for municipal solid waste (MSW).

China has initiated and carried out several state-of-the-art projects, not limited to the Shenzhen Waste-to-Energy Plant, which is the largest of its type in the world. Typically, this facility processes 2.7 million tons of waste each year and generates around 1.5 billion kilowatt-hours of electriSpecific Efficiency for plants utilizing can be expected to be around 80% for plants utilizing combined heat and power (CHP) generation.

As a result of environmental developments increasing, waste-to-energy plants are taking advantage of advanced flue gas purification operations that further reduce environmental sustainability and solvent the capacity for health implications associated with the technology.

Table 2. Top 10 E-Waste Producing Countries in the World

Rank	Country	E-Waste Generated (kilotons)	Recycling Rate (%)
1	China	10,129	16%
2	United States	6,918	15%
3	India	3,230	1%
4	Japan	2,569	22%
5	Brazil	2,143	0%
6	Russia	1,631	6%
7	Indonesia	1,618	Not available
8	Germany	1,607	52%
9	United Kingdom	1,598	57%
10	France	1,362	56%

Source: World Bank

The table.2 of the ten highest producing countries of e-waste in the world clearly indicates large differences not only in total waste generated but also in recycling rates, pointing to the issues and possibilities involved in managing an expanding waste stream. Most notably, China produces the most e-waste, 10,129 kilotons per year, followed by the United States with 6,918 kilotons, and India with 3,230 kilotons. These figures show a positive correlation between volumes of e-waste and demographic, industrial, and technological features typical of each country. However, it is important to emphasize that the recycling rates in these top three e-waste producers are all relatively low, particularly in the case of India, where it is only 1%. This fact illustrates some of the weaknesses of infrastructure and waste management policies in some of these developing economies.

In contrast, there is strong performance concerning e-waste recycling in some European countries, like Germany, the UK, and France which often achieves over 50 percent recycling, and all while generating less waste than the massive producers. They have been able to achieve this level of recycling for e-waste due to the overall success of their systems of waste management, regulations protecting the environment, and robust public awareness when engaged in sustainability in these nations. In contrast, countries like Brazil and Russia have been identified as having extremely low or virtually nil recycling of e-waste, despite the bump in e-waste production, and their observations clearly showed challenges implementing effective environmental policies. Additionally, the table does show gaps in data in Indonesia which highlights their ineffective environmental monitoring and tracking systems.

Overall, the table indicates a clear need to enhance capabilities in the world implementing electronic waste management strategies, particularly in countries that generate a lot of e-waste and recycle very little. Money will needed to either build up infrastructure to support better electronics recycling efforts and/or regulations/mandatory collection and treatment of waste policies; and/or assistance in support of current recycling technologies.

Household Waste Management in Sweden

As a benchmark, Sweden produces per capita roughly half and more in household waste per person than Algeria, Sweden recently reported around 460 kg per year-household waste and Algeria, around 250 kg (Kaza et al., 2018). The differences may be attributed among other matters, to economic activity, economic development, and levels of consumption.

The composition of household waste in Sweden reflects both consumption patterns and efforts to reduce waste generation, which is particularly noticeable in the plastic waste segment. Below is a detailed explanation of the composition of household waste in Sweden, which I will compare to the situation in Algeria.

Organic waste makes up 35% of waste in Sweden and 53% in Algeria. In Sweden, the organic component of waste is mostly collected separately and treated by composting or anaerobic digestion to make compost and biogas. In stark contrast, organic waste in Algeria is practically entirely landfilled (Linden & Brusselaers, 2020).

Paper and cardboard waste represents 25% in Sweden and 6.76% in Algeria (Silva Neira, 2024). In Sweden, it is widely sorted at the source and recycled. In contrast, in Algeria, household paper and cardboard waste is disposed of in public dumps along with other untreated waste.

Plastic waste makes up 15% of the waste and in Algeria it makes up 15.31% (Mounir, 2023). In Sweden, plastic is regularly sorted at source and recycled. Furthermore, Sweden utilized a deposit system for plastic bottles that made the recycling of plastic more accessible and led to the return of plastic bottles. In Algeria, about 80% of plastic waste is recovered by the informal sector, while the remaining portion is managed by formal activities in technical landfill centers. It is estimated that only around 15% of the plastic waste generated in Algeria is effectively recovered (Kaza et al., 2018).

Glass waste represents 10% in Sweden and only 1% in Algeria. In Sweden, glass is sorted by color (clear and colored) and recycled. Collection points are provided for households to facilitate glass waste recovery. In Algeria, glass waste generation is minimal, and

no dedicated collection system currently exists. This lack of infrastructure creates significant obstacles for recycling and waste management.



Fig. 3. Waste Sorting System in Sweden: Selective Collection Bins in a Public Space
Source: (Johansson & Lindahl, 2014)

Metal waste accounts for 5% in Sweden and 1.72% in Algeri (Petridou et al., 2024). In Sweden, metals are collected separately and recycled. Additionally, a deposit system is applied to aluminum cans. In contrast, in Algeria, metals are mainly recovered by the informal sector. The rest is managed through formal activities in technical landfill centers and specialized companies. It should also be noted that in Sweden, metal waste that escapes selective collection is recovered in incineration units.

Waste from textiles constitutes 5% in Sweden and 17% in Algeria (Ouigmane et al., 2021). In Sweden, the portion that cannot be reused or recycled is incinerated; in Algeria, this waste is typically disposed of in landfills. For the record, dealing with textile waste (and many other high-calorific-value wastes) in Algeria could kickstart the development of incineration technologies in that country (Ponnet, 2024).

Residual waste, which cannot be recycled, represents 20% in Sweden. In Algeria, it's not possible to refer to residual waste due to the absence of source separation. In Sweden, these residuals are incinerated to produce energy, which helps reduce the volume of waste sent to landfill centers.

Waste management policy in Sweden exhibits an approach focused on source separation and recovery of valuable materials. Sweden has a dual authorization system of source separation and source separation combined with mechanical sorting operations, giving Sweden the potential to maximize recoverable recyclable materials while minimizing residual waste. Residual waste, which is landfilled or incinerated, includes all other waste types receiving recycling processing level at an additional facility, and the recycling facility removes most types of waste's recyclable materials for conversion into valuable materials. Sweden essentially has eliminated landfilling completely with only 1% of the total waste being landfilled.

Sweden has become a global benchmark in the waste management field, including a number of important factors, including legislation, infrastructure, citizen participation process, technologies, and awareness campaigns. These factors have helped build an impressive waste management system so much that Sweden is a model waste management process for many countries.

The role of legislation is crucial. The Waste Management Act and Extended Producer Responsibility (EPR) enforce standards for waste sorting, recycling and treatment and impose liabilities on local authorities and producers for environmentally responsible waste management.

Sweden has a sophisticated infrastructure of recycling and collection centers (Återvinningscentraler) in Sweden, where members of the public take the different types of waste. The volume of residual waste (the remaining, non-recyclable waste) goes to waste-to-energy plants where it is incinerated to produce electricity and heat, allowing it to treat approximately 49% of its household waste as well as avoiding sending these residuals to landfill. Furthermore, organic wastes are taken to composting operations or anaerobic digestion operations to develop compost or biogas, respectively.

The deposit refund system for plastic bottles and aluminum cans in Sweden has achieved impressive recovery rates over 85% (Johansson, 2024). The system encourages consumers to return empty packaging, thus enhancing recycling and minimizing waste.

The government and municipal governments frequently launch awareness campaigns to promote waste sorting and recycling, and utilize effective and various media types to raise public awareness (Bortoleto et al., 2012). Municipal governments also incorporated environmental education in school curriculums, which encourages students in the young generation to develop awareness of the environmental importance of recycling and sustainable waste management.

Citizen engagement is an important component of Sweden's waste management success. Citizens are typically well-informed of environmental issues and participate in waste sorting and recycling programs with organized collection systems, with easy to access infrastructure. Economic incentives in deposit refund schemes and tax exemptions for households that properly sort their waste issue also motivate engagement in Sweden (Berglund, 2006).

Ultimately, Sweden commit public funds to innovative technology to enhance waste sorting and recycling, including smart sorting machines and state-of-the-art recycling. Sweden also provides public subsidies for research and development of other area of waste management and waste technology.

Waste Management in Japan

Japan has earned the distinguished status of being a world leader in waste management. Their forward-thinking approaches and robust, sustainable planning have made Japan the benchmark for all other countries across the globe. Recycling in Japan averages 84%, which is well above the world's average of 20% (Ministry, 2021a). This places Japan at the leading-edge of recycling in the world.

The culture of waste recycling is entrenched within their citizens. Japan remains ambitious in their waste management systems. In envisioning a system that emphasizes waste management services that will be in compliance with the circular economy, Japan aims for (Singh et al., 2023):

- 100% Recycling of plastic waste, and
- 50% reduction of food waste.

These metrics are important and emphasize Japan's continuing intent to sustain a circular economy and lessen the long-term impact of waste.

The Extended Producer Responsibility (EPR) system is one of the pillars to Japan's success in waste management. The EPR framework emphasizes the accountability of producers as the entity responsible for collecting and recycling their products after consumer use. The EPR approach provides complete accountability for the environmental footprint of producer's products, while encouraging them to develop items for recycling purposes – thus advancing more sustainable production and consumption.

Table 3. Summary of Policies, Plans, and Regulations Regarding EPR for Containers and Packaging in Japan

Policies, Plans, and Regulations	Promulgation Date	Effective Date	Status
Act on the Promotion of Effective Utilization of Resources (Act No. 48 of 1991)	26 April 1991	Came into effect in April 2001	In effect
Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging (Act No. 112 of 1995)	16 June 1995	Came into effect in 1997	In effect
Basic Act on Establishing a Sound Material-Cycle Society (Act No. 110 of 2000)	2 June 2000	Came into effect in January 2001	In effect

Source: Containers and Packaging Recycling Act and JCPRA (https://www.jcpra.or.jp/english/profile.html

Illustrated below (Table 3), and indicative of Japan's clearly defined direction towards developing a single Extended Producer Responsibility (EPR) system for containers and packaging, is the detailed and gradual approaches to developing the legal frameworks over decades. Japan took a significant step in 1991 when it enacted the Act on the Promotion of Effective Utilization of Resources, which took full effect in 2001, and the important point here is that Japan had clearly done preparatory work and developed infrastructure in advance of this legislation.

This was followed by the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging in 1995, which now stands as the fundamental law regulating the relationship between producers and consumers regarding the recycling of waste. Then, in the year 2000, Japan added a third law of significance: the Basic Act for Establishing a Sound Material-Cycle Society which enshrined principles of circular economy.

All of this legislation is significant in the persistence and continuity with which it remains in place today, which demonstrates the success of Japan's environmental policy in establishing a culture of recycling and holding producers accountable for their products from cradle to grave, which together had formed a model which should be looked to as a model in the modern management of waste.

Moreover, the Japanese government also actively supports individuals in taking part of the role of waste management by developing the infrastructure and raising awareness of waste management issues. The Japanese government does this by providing structured systems for waste collection and sorting, providing recyclable products for use, and raising awareness by promoting good waste disposal practices.

The Practical Aspect of Waste Management in Algeria: An Analytical Study of Technical Landfill Centers and Public Dumps at the National Level

Urban and similar waste management represents one of the major environmental and economic challenges facing developing countries, particularly Algeria, in light of urban expansion, population growth, and increasing consumption rates (Kaza et al., 2018). With the evolution of modern concepts in the field of sustainable development, it has become necessary to reconsider waste disposal methods and to strengthen recovery and treatment mechanisms, in a way that ensures both environmental protection and public health (Wilson et al., 2015).

In this context, the public authorities of Algeria are progressively focusing on the establishment of technical landfill centers, and controlled public dumps as organized and efficient alternatives for the disposal of household waste (Lamri et al., 2022). The centers were established in the framework of the national environmental protection policy and managed by specialized institutions, and focus on integrating recovery and sorting into the processes of treatment.

However, the reality of the field provides contrasting operative levels regarding the readiness and continuity of these facilities across the provinces. Some centers operate with a large degree of efficiency, while others return to closed doors, poor operation, and ongoing hiccups which involve planning, environmental governance, and theoretically effective value use.

Distribution of CETs and Public Dumps in Algeria (2024)

CETs (technical landfill centers) are one of the main parts of the solid waste management system in Algeria (Hachemi et al., 2024; Peckl, 2022). These are such vital centers in reducing pollution and protecting the environment by receiving and processing waste in a controlled way. The figure below provides details of all the CETs by province in Algeria, which also includes total area, operating life span, and actual status (2024), from National Waste Agency (AND) records.

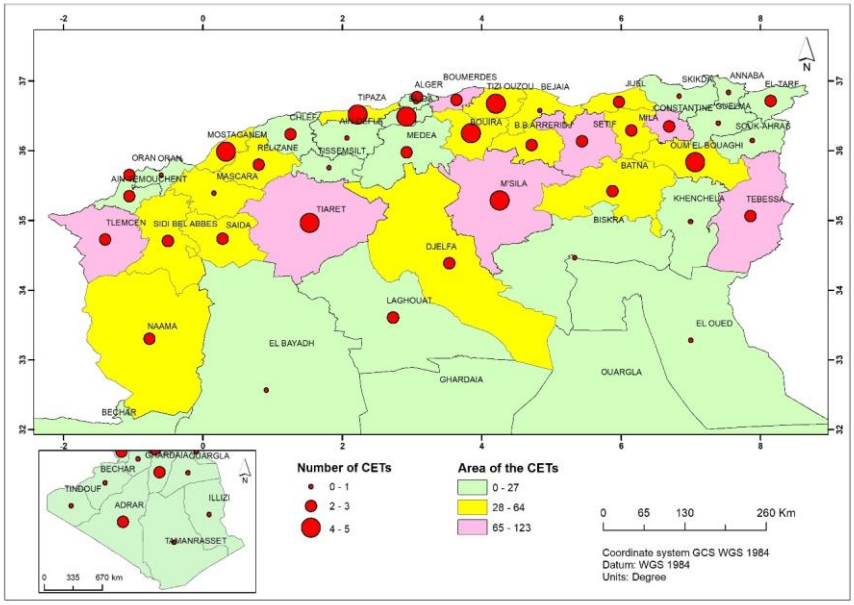


Fig. 4. Statistics of Technical Landfill Centers by Wilaya, Including Their Surface Area
Source: Author, based on data from AND (2024)

By the map, there is a major difference between the Algerian provinces (Wilaya) about the number of Centers of Technical Landfill (CET) and the whole area of them. These differences are presenting differentiated coverage levels and differentiated capacities about waste management by regions.

By number of centers, the provinces stand out with 4 to 5 centers which are Algiers, Oran, Tiaret, Médéa, and Blida provinces due to the higher population and their economic activities. Other provinces only have one center with many like Wilayas Timimoun, Relizane, Tissemsilt, El Oued, Guelma and others. These may pose geographic coverage of waste management and geographic coverage of waste transportation, and being able to process things in a good condition.

As for the total area of the landfill centers, the provinces are classified into three categories according to the map:

- The first category includes provinces with small areas ranging from 0 to 27 hectares, such as Béchar (10.5 ha), El Tarf (16 ha), and Souk Ahras (12.43 ha).
- The second category includes provinces classified as medium area and ranging from 28-64 hectares in size. As provinces classified as medium area, Djelfa (45 ha), Saïda (64 ha), and M'Sila (47 ha) fall into this category.
- The third category includes the provinces that are classified as large area in size, ranging from 65-123 hectares in size which includes Oran (123 ha), Constantine (108 ha), Sétif (104 ha), Algiers (95 ha), and Tiaret (73 ha).

Regardless, the number of centers does not properly correlate to the area size. There are provinces with a few centers which cover a larger area size, i.e., ORAN with 3 centers occupying 123 hectares. Whereas there are provinces with more centers that have a tidal

small area size; for instance, Blida with 4 centers occupying 17.5 hectares. This is a major inequality between the provinces, and shows the other provinces operate with differences of planning mechanisms, as well as additional provincial characteristics that spatially distribute those centers.

Overall, our result show that the current distribution of area and number of landfill centers is not uniform, and these would be based on a variety of factors some of which would include population density, industrial activity, and geographical characteristics of the provinces. This means that a detailed analysis of the current provision of the distribution of environmental infrastructure was required for equitable provision across each province as well as for effective waste management.

It is also important to highlight the issue of the spread of illegal dumpsites in provinces that lack operational Technical Landfill Centers (CETs) or where such centers are no longer functional. This situation has a negative impact on both the environment and public health. The coastal province of Béjaïa is a clear example of this problem (as shown in the image), where no fewer than 36 illegal dumpsites have been recorded across various parts of the province, particularly on the outskirts of cities, along main roads, and in mountainous areas near forests, such as along the Tifra road (Douici, 2024).

This situation reflects the absence of effective and sustainable waste management solutions and poses a threat to local ecosystems, especially in environmentally sensitive and tourist areas. It underscores the urgent need to reactivate non-operational landfill centers or establish new, well-structured ones that take into account the geographical and demographic characteristics of each region. Additionally, it calls for stronger monitoring mechanisms and encourages municipalities to improve their waste management through technical and financial support, while also involving civil society in environmental protection efforts.



Fig. 5. Illegal Dumpsites in the Tourist Province of Béjaïa Due to the Absence of Technical Landfill Centers (June 2025)

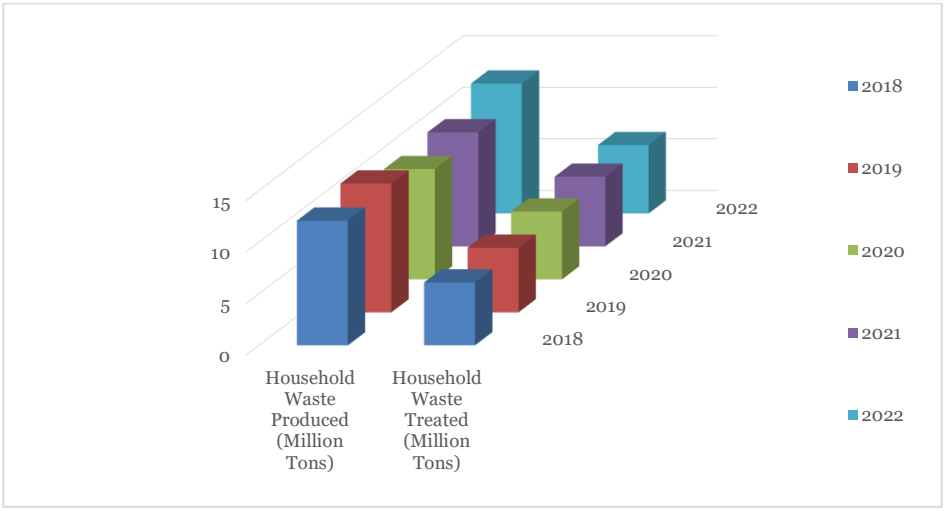


Fig. 6. Progress in Household Waste Production and Treatment (Million Tons, 2018–2022)

By analyzing the data presented in Table 2, which illustrates the evolution of waste quantities in Algeria between 2018 and 2022, it becomes clear that the development of household waste production went through three main phases. In the first phase, from 2018 to 2019, there was a slight increase in the amount of waste produced estimated at around 0.4 million tons-reflecting the continued gradual rise in waste generation due to demographic factors such as population growth and economic factors like the expansion of consumption activities.

The second phase (2019-2020) experienced a dramatic decline of waste production by 1.8 million tons. The impact of COVID-19 during this phase played a key role in the decline because it halted virtually all areas of economic and social activity that potentially generated waste.

In the third phase, from 2020 to 2022, waste quantities began to rise again, increasing by approximately 1.9 million tons. This growth is the result of the resumption of economic and social activity and a return to normal life, indicating that production levels had returned to, if not exceeded, pre-pandemic figures.

As for household waste treatment, its development can be divided into two main phases. The first phase, from 2018 to 2021, saw a clear improvement in treatment operations, with the quantity of treated waste increasing by about 0.66 million tons. This reflects the efforts made by public authorities to develop treatment facilities and expand their capacity. However, the second phase, from 2021 to 2022, witnessed a slight decline in treated waste, estimated at 0.13 million tons. This could be due to management difficulties or the temporary closure of some treatment or technical landfill centers.

In terms of waste recovery, the National Waste Agency cites figures from 2020 showing that the recovery rate from households and similar wastes only reached 9.83% of the total generated - well below expectations. The recovery rates at sorting centers also remain very low, not exceeding 0.1%, which reflects the poor performance of the selective sorting system. There is an urgent need for structural reforms in the waste sector, for investment in

recover and recycling projects to be promoted, and for the need to press the importance of better awareness of environment for stakeholders, civil society and local authorities.

Analysis of Waste Management Models: Between Local Reality and Modern Approaches to Sustainable Management (The Case of Jijel Province)

Jijel Province is geographically located in the northeast of Algeria, the geographical coordinates of the province are located between latitudes 37° and 30° North of the Equator and longitudes 30° and 31° East of Greenwich. The area of the province is approximately 2,396.63 km², with its northern border to the western Mediterranean coastline about 120 km long. Jijel does not have any landlocked borders with Béjaïa Province to its west, Skikda Province to its east, as well as Mila and Sétif Provinces to the south (Kerroud & Lamri, 2024; Kholkhal et al., 2023).

Jijel is approximately 357 kilometers from its capital Algiers (Kerroud & Lamri, 2024) , only a thirty-minute flight away. For the eastern High Plateaus, the province is an important water outlet for some of its Africa neighbours. Also, it is on an air flight path to some of the more major Mediterranean cities; it takes approximately 60 minute flight to both Marseille and Barcelona.

On an administrative note, there are 11 district units (called dairas) within Jijel Province encompassing 28 municipalities that illustrate its territorial density and administrative capacity.

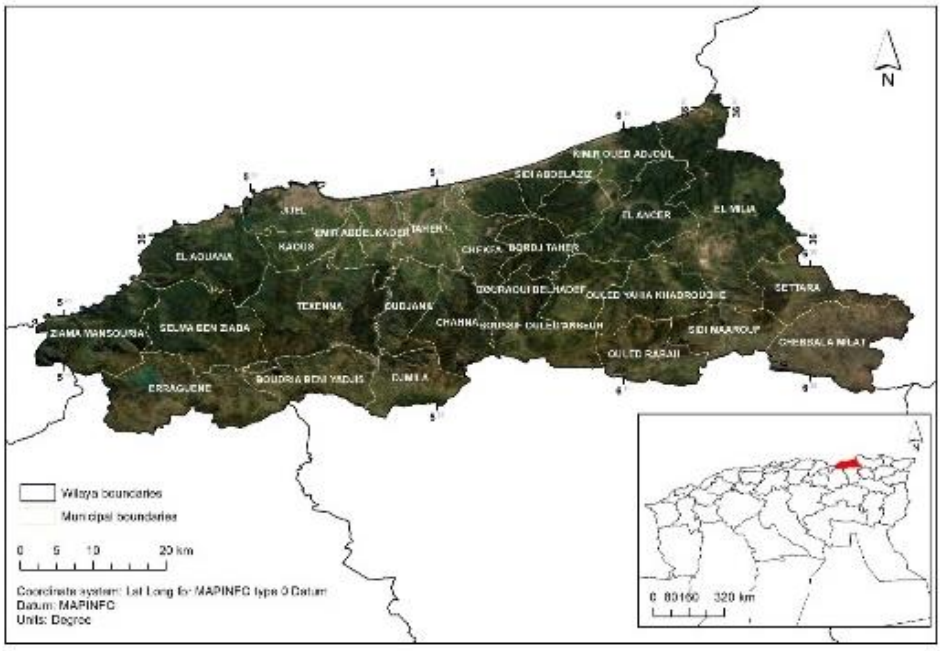


Fig. 7. Location of Jijel Province (Source: Author)

Jijel Province continued to evolve the operational management of household waste directed to technical landfill centers from 2008 until April 2023. In 2008 when the project started, it made a good beginning, using a small quantity (2,543 ton), the quantity of waste to be collected for its gradual extension to other locations accross the province over the next few years. In a few years, the municipality of Jijel became the provincial leader, when they recorded over 42,000 tons in 2019 smaller amount. Since then, new locations - Kaous (in 2011) El Kennar N'sir (in 2018) Texenna (2019) and the amounts also provided insight into the direction of a waste collection system that was developing (Table 4).

Table 4. Evolution of Collected Household Waste Quantities Directed to Technical Landfill Centers in Jijel Province (2008–2023)

Year	Jijel Municipality	Kaous Municipality	El Kennar Municipality	Texenna Municipality	Annual Total (tons)	Cumulative Change (tons)
2008	2,543.04	/	/	/	2,543.04	0.00
2009	25,728.40	/	/	/	25,728.40	23,185.36
2010	29,137.50	/	/	/	29,137.50	26,594.46
2011	31,666.60	2,472.72	/	/	34,139.32	31,596.28
2012	30,836.90	3,697.90	/	/	34,534.80	31,991.76
2013	33,130.30	4,042.24	/	/	37,172.54	34,629.50
2014	34,316.10	4,399.52	/	/	38,715.62	36,172.58
2015	35,884.70	4,743.53	/	/	40,628.23	38,085.19
2016	38,583.70	5,058.18	/	/	43,641.88	41,098.84
2017	38,197.80	5,249.45	/	/	43,447.25	40,904.21
2018	41,921.40	5,832.26	119.53	/	47,873.19	45,330.15
2019	42,653.40	5,960.88	3,433.31	1,898.87	53,946.46	51,403.42
2020	40,814.60	5,961.56	3,252.62	2,097.59	52,126.37	49,583.33
2021	41,605.10	5,961.34	3,069.86	1,977.24	52,613.54	50,070.50
2022	42,035.00	3,041.00	3,041.00	2,002.00	50,119.00	47,575.96
Total	—	—	—	—	**596,358.34**	

Source: Technical Landfill Management Company – Jijel

In total the amount of waste collected can't did didget over 3 million tons, with the highest in 2019 with around 54,000 tons. Since then, on numeric representation, has plateaued for when the numbers were primarily converted to tons after first starting, and has not surpassed 52,000 tons. It is assumed that the lesser used figures, COVID-19 pandemic, and the municipal government and increasing responsibility in focusing on waste recovery could likely reference a more stable or decrease of waste collected (probably due to would be all contingent on collection coverage and operational capacity). By April 2023, reached probably a projected 10,000 tons.

Overall, the analysis shows that the cumulative quantity of household waste collected and directed to landfill centers in Jijel Province during the period from 2008 to April 2023 reached 596,358 tons. This significant amount requires the new policy of source separation, recovery of wastes, and waste reduction at the source as per SNGID 2035 on national waste management policy statement which support full commitment to the circular economy and ensuring our resources for future generations.

To calculate the Cumulative Change Index for each year relative to the base year (2008), the following formula is used:

$$\textbf{Cumulative Change} = \textbf{Value of the year} - \textbf{Value of the base year (2008)} \quad (3)$$

Notes:

- The values are in tons (or in kilograms × 1,000 depending on the context), and the difference is calculated for each year in comparison to the base year 2008.
- This calculation is applied only to the "Annual Total" column, since data for the other municipalities is partially incomplete.

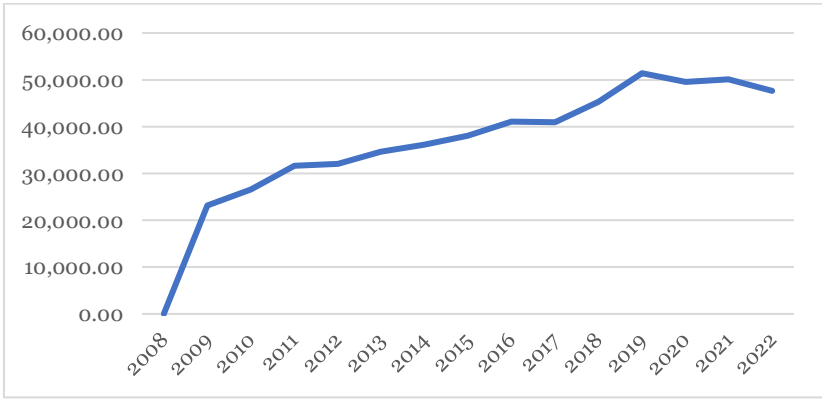


Fig. 8. Cumulative Change Curve of Collected Household Waste in Jijel Province

The cumulative change curve of household waste collected in Jijel province from 2008 to 2023 shows a considerable increase in the volume of processed waste. The base year was 2008 and from approximately 2,543 tons, the quantities rose, gradually and steadily, peaking cumulatively in 2019 at approximately 51,403 tons. The growth over time is a direct reflection of urban expansion, population density, and the improvement in waste collection systems.

On the other hand, this upward curvilinear growth exhibited a relative slowdown after 2019, as the quantities show a gradual decrease from 2020 to 2022. One of the main aspects which drove this decrease has been the COVID 19 pandemic, which disrupted municipal services and radically altered consumption behaviours.

In 2023, we noted a significant drop in our recorded values attributable to the data only covering four months during that year.

Overall, this indicator reflects consistent growth in waste volumes over the period of 15 years, which reflects alternatives in environmental planning and improvement in waste treatment and recycling systems.

Like other provinces across the country, the Wilaya has benefited from the establishment of four technical landfill centers for household waste since 2003. This initiative aimed to eliminate illegal dumping and to implement a monitoring system for waste in terms of both quantity and type. These centers are strictly limited to processing only household waste or similar types, unlike the previous uncontrolled dumpsites where all types of waste, hazardous and non-hazardous, were discarded indiscriminately. The distribution of these technical landfill centers is as follows:

Jijel Technical Landfill Center

The technical landfill facility of the municipality of Jijel counts among the largest environmental projects that aim to cope with and treat household waste under a sustainable development approach and the preservation of the environment. The site was handed over for expert management on October 28, 2008, with the National Company for Water and Environment (Nationale Eau et Environnement - NEE) having done the technical and environmental studies and a series of degree study documents. The project belongs to the Directorate of Environment of the Jijel Province.

As for the construction work, cells 01 and 02 were built by the company AMENHYD, while cell 03 was executed by the company EGR REKIMA. The construction of cell 03 was completed in 2016, and it officially entered into operation on January 15, 2018.

The site covers a total area of approximately 7 hectares, of which 4 hectares are allocated for the operational zone, which includes the technical cells designated for waste containment. The total available landfill volume is estimated at 942,736 cubic meters, distributed across four cells that vary in surface area, volume, landfill level, and number of operational days.

A total of 5,999 days of cumulative operation has been recorded, which corresponds to approximately 17 years of continuous activity, according to estimates provided by the consulting firm NEE (design office) (https://www.nee-spa.dz/).

The cell data is distributed as follows:

- The **first cell** covers an area of **14,047.12 m²** with a capacity of **170,780 m³**.
- The **second cell** spans **13,325.13 m²** with a volume of **122,980 m³**.
- The **third cell** has an area of **12,400.77 m²** and a volume of **91,797 m³**.
- The **fourth cell**, which is the largest, extends over **24,241.50 m²** with a total capacity of **557,179 m³**.

It is worth noting that three of these cells have been fully utilized using the dome method.

In terms of buried waste quantities, the total quantity of household waste delivered to the center by the municipality of Jijel, from October 28, 2008 to November 30, 2020, was approximately 391,366.41 tons. The municipality of Kaous delivered a total of 46,955.91 tons from May 2011 to November 30, 2020. The municipality of Kennar N'Shefi delivered a total of 6,525.8 tons from December 2018 to November 2020. While the municipality of Texenna delivered a total of 3,840.12 tons from February 2019 to the end of November 2020.

As a result, the total amount of waste buried during this period estimated at 448,688.24 tons at an estimated burial density of approximately 500 kg/m³, which indicates a good degree of compaction and good use of volume.

At the human resource level, the centre has a group of 50 workers with diverse skills working on a range of technical and administrative tasks. The workers include a centre manager, heads of departments - maintenance, procurement and billing, weighbridge operators, drivers, maintenance agents, cleaners, security guards, and a field monitor officer.

The creative personnel demonstrates that there is an organizational structure in place to, not only get the right expertise and skills, but to ensure that center is operated by an arrangement of regular monitoring on a continual basis of all cellphone activity.

Regarding the equipment, the site has a complete and varied set of technical equipment to ensure they are highly efficient in their operations. This complete set must include a 38-ton VANDEL compactor, a 28-ton bulldozer, a loader, a tracked excavator, a digital weigh-bridge, a high-pressure cleaning truck, a 10 m^3 water tanker, a 3-ton waste truck, and a 60 KVA electric generator. These equipment pieces and a complete set of equipment are vital to ensure that operations will continue and to minimize the environmental impacts of land-filling activities.

Inter-Municipal Technical Landfill Center – Dimina – Taher

As part of the national policy for the technical and sustainable management of house-hold waste, an inter-municipal technical landfill center was established in the Dimina area, located in the municipality of Taher, in the Wilaya (province) of Jijel. The center began operations on November 12, 2011. The project aimed to improve waste treatment condi-tions while reducing environmental impacts.

The Directorate of Environment of Jijel Province acted as project owner, while the con-sulting company Territoire – Aménagement – Développement (T.A.D) conducted technical studies and project monitoring. Construction was executed by EGR REKIMA.

Significant quantities of household waste were deposited for landfilling starting from six municipalities: Taher, Emir Abdelkader, Chahna (in May 2012), Ouadjana (in January 2012), Sidi Abdelaziz (in September 2018) and El Chekfa (in December 2018). Waste landfilled be-tween 12 November 2011 and 30 November 2020 is estimated at 178,588.410 tons, and waste density during compaction is estimated at 1,313 kg/m^3, higher than the national average, in-dicating excellent technical performance and exceptional utilization of available landfill.

Inter-Municipal Technical Landfill Center – Zarzour – El Milia

The technical landfill site located in the Zarzour area, under the jurisdiction of the munici-pality of El Milia, was inaugurated on October 23, 2011, as part of the national strategy to manage household waste using technical approaches that adhered to environmental stand-ards and sustainable development principles. The project was under the authority of the Directorate of Environment of Jijel Province, French consulting firm Territoire – Amé-nagement – Développement (T.A.D) managed the technical supervision of the project, and the company EGR REKIMA was responsible for construction works.

From a technical perspective, the site covers a total area estimated at 15.58 hectares, of which 44,722 square meters are allocated for landfill cells, offering a total available land-fill volume of 447,720 cubic meters. The center contains a single Class 02 cell, which is operated using a traditional method in accordance with approved technical standards—specifically, by compacting waste in layered form. The current saturation rate has reached 80%, reflecting an intensive use of the available space.

Between October 23, 2011, and November 30, 2020, the center received solid house-hold waste from ten (10) municipalities, including two belonging to the Wilaya of Skikda. The municipalities served include: El Milia, Settara (since January 2012), Ain Kechra (since October 2013), Boualeghlouat (since September 2013), El Ancer (since March 2015), Khiri Oued Adjoul (since April 2016), Djemâa Beni Habibi (since February 2017), Ouled Yahia

Khadrouch (since July 2017), Bouraoui Belhadef (since March 2018), and Sidi Marouf (since September 2018). During this time, the total amount of waste sent to landfill was approximately 167,331.430 tons, assuming a compaction factor of 467 kg/m³. This indicator helps to define an important technical performance measurement and demonstrates a high level of efficiency with regards to the operating and well-used capacity of the site.

The center has a team of 13 designated workers that carry out various roles as required for the successful operation of the day-to-day operations of the center. The worker types include: center manager, weighbridge operator, heavy truck driver, machine operator (Enginiste), two multi-skilled workers, a daytime security guard, and 6 nighttime security agents.

With respect to the technical means, the center is equipped with the tools to carry out landfilling works according to the standards approved, which are: a 28-ton sheep's foot roller compactor (VANDEL type), tracked excavator, electronic weighbridge with digital station, and 3-ton waste truck. These assets encapsulate the commitments that were made toward efficient and sustainable expendable household waste.

Inter-Municipal Technical Landfill Center for Household Waste in Chekfa

As part of the 2012 sectoral development program, the environment sector of Jijel Province benefited from a project to establish a fourth inter-municipal technical landfill center for household waste, intended to serve the municipalities of Chekfa, Sidi Abdelaziz, and El Kennar Nouchfi.

The project was officially registered under the title: “Construction and Equipment of an Inter-Municipal Technical Landfill Center (Chekfa – Sidi Abdelaziz – El Kennar Nouchfi),” with a financial allocation of 250,000,000 Algerian Dinars.

Despite the importance of the project, construction work did not commence due to an issue related to the land selected for the center, located in the Faza area, at the site known as Ras Arsa in the municipality of El Kennar Nouchfi.

It is worth noting that the land in question is owned by the Forestry Sector and did not receive approval from the inter-ministerial committee that visited the province at the end of the previous year.

Evolution of Landfilled Waste Quantities at the Taher and El Milia Centers (2011–2023)

Monitoring the evolution of landfilled waste quantities is an important indicator for evaluating the effectiveness of the municipal waste management system. In this context, the roles of the Technical Landfill Centers of Taher and El Milia stand out, as they represent the two main structures for waste treatment in the Jijel province.

This section presents the development of the quantities of waste landfilled at these two centers during the period from 2011 to April 2023. It allows for identifying general trends, analyzing disparities between the benefiting municipalities, and anticipating strengths and weaknesses in the currently adopted system.

Table 5. Quantity of Waste Landfilled at the Technical Landfill Center in Taher (Taher Municipality) During the Period 2011 – April 2023

Year	Taher Municipality	Emir Abdelkader Municipality	El Chahna	Ouadjana	Sidi Abdelaziz	El Aouana	Total
2011	2,150.70	383.26	/	/	/	/	2,533.96
2012	13,616.66	3,243.68	210.20	613.00	/	/	17,683.54
2013	15,258.78	4,585.16	625.00	691.00	/	/	21,159.94
2014	12,155.86	2,472.32	684.50	634.00	/	/	15,946.68
2015	12,957.30	5,622.30	459.00	933.00	/	/	19,971.60
2016	12,850.68	5,369.60	652.00	1,006.98	/	/	19,879.26
2017	15,070.02	5,507.78	589.50	1,032.84	/	/	22,200.14
2018	16,980.12	6,276.74	661.30	1,036.50	673.94	229.74	25,858.34
2019	14,660.65	6,570.72	357.46	687.74	2,366.96	1,295.62	25,939.15
2020	15,202.34	7,586.20	0.00	693.16	2,178.87	1,974.60	27,635.17
2021	13,323.83	7,290.86	0.00	655.86	1,944.23	150.32	23,365.10
2022	14,083.00	6,733.00	/	799.00	1,921.00	/	23,536.00
Total	—	—	—	—	—	—	**251,001**

Source: Technical Landfill Management Company – Jijel

The summarized table shows the development of household waste volumes collected in some municipalities of Jijel province during the period extending from 2011 to April 2023. This table shows differences in volumes of waste between municipalities and the rate of increase and/or decreases corresponding to their respective local situations such as increase in population, economic activity, and the development of waste collection services.

With regards to the municipality of Taher, one of the most well-featured examples in the table, there is a clear upward progression of waste, increasing from around 2,150 tons in 2011 to over 14,000 in recent years, peaking at over 17,000 tons in 2018. The reasons for this is apparent, significant urban growth, an increase in population density, and improvements in the waste collection system, also with an upgraded geographical coverage.

As for Emir Abdelkader, waste amounts lift in a similar fashion, although still below Taher's levels. It began at 383 tons in 2011 and approached 7,500 tons in 2020, although it has reflected some fluctuations in the last two years. This growth clearly indicates greater economic activities and household consumption.

The two other municipalities of El-Chaouna and Ouadjana also began to participate in the waste collection process after 2012 and still show quantities that are significantly lower than the previous municipalities' records. This could represent a service area that is mostly rural with low population density or with limited coverage of the collection service. The data also has several blank years, which suggests interrupted or non-existent collection in these years.

The municipalities of Sidi Abdelaziz and Chekfa follow a similar trend with data starting only in 2018. Despite the late start to the data, Sidi Abdelaziz had an impressive capture for 2019, at over 2,300 tons, signifying to integration into collection and transportation of MSW.

In general, the table demonstrates an overall upward trend of waste disposal capacity in the years measured touching on important spatial context depicting geographic and financial disparities among the different municipalities and while there is movement towards modernizing the waste management system, covering more area, and improving

transport efficiency among other related aspects, many municipalities have low or irregular waste quantities.

Annual Growth Indicator

This indicator assists us in understanding trends in the annual generation of waste, while also aiding in tying the indicator to the efforts made to improve waste management and mitigate environmental impacts.

- Monitoring temporal trends in the generation of waste (increasing, decreasing, or stable).
- Evaluating the success of social and environmental policies and action taken to help reduce waste generation.
- Planning future infrastructure in waste collection and treatment.
- Recognizing periods of sudden change (either positively or negatively) for understanding what caused the change and possible influencing factors.
- Supporting decision-making related to environmental and sustainable development from the key decision-making audiences.

$$[(\boldsymbol{Waste\ quantity\ in\ the\ current\ year} - \boldsymbol{Waste\ quantity\ in\ the\ previous\ year}) \div \boldsymbol{Waste\ quantity\ in\ the\ previous\ year}] \times 100 \quad (4)$$

Table 6. Annual Growth Rate (%) of Waste Quantities Landfilled at the Technical Landfill Center of Taher (2011–2023)

Year	Taher Municipality	Emir Abdelkader	Chekna	Ouled Yahia	Sidi Abdelaziz	Chekfa	Total
2013	+12.06%	+41.36%	—	+12.72%	—	—	+19.66%
2014	−20.34 %	−46.08%	+9.52%	−8.25%	—	—	−24.64 %
2015	+6.59%	+127.41 %	−32.94%	+47.16%	—	—	+25.24%
2016	−0.82%	−4.49%	+42.05 %	+7.93%	—	—	−0.46%
2017	+17.27%	+2.57%	−9.59%	+2.57%	—	—	+11.67%
2018	+12.67%	+13.96%	+12.18%	+0.35%	—	—	+16.48%
2019	−13.66%	+4.68%	−45.95%	−33.65 %	—	—	+0.31%
2020	+3.69%	+15.45%	−100%	+0.79%	−7.95%	+52.41%	+6.54%
2021	−12.36%	−3.89%	—	−5.38%	−10.77 %	−92.39 %	−15.45%
2022	+5.70%	−7.65%	—	+21.82%	−1.19%	—	+0.73%

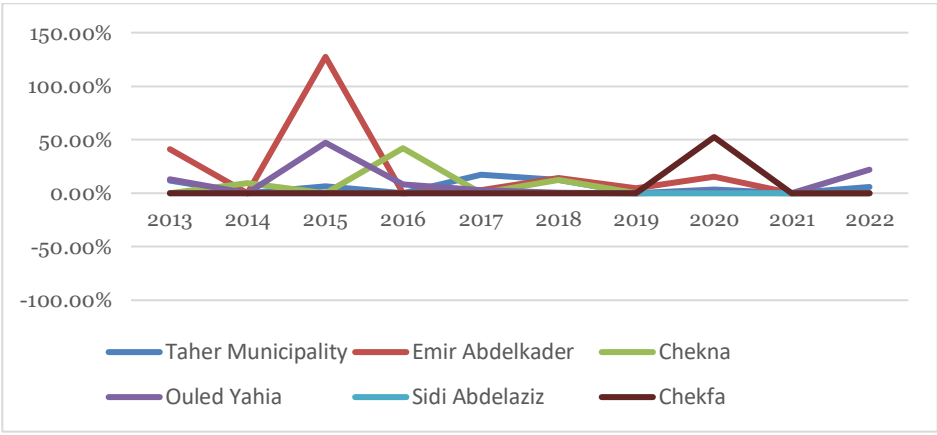


Fig. 9. Annual Growth Rate of Waste Landfilled at the Technical Landfill Center of Taher by Municipality (2011–2023)

The annual growth rate of landfilled waste quantities at the Technical Landfill Center of Taher during the period 2013–2022 reflects significant fluctuations across the different municipalities. This variation indicates disparities in waste collection and transport services, as well as local changes in population structure and economic activity.

The municipality of Taher, which generally generates the most waste in absolute terms, showed significant growth in most years, particularly in 2017 (+17.27%) and 2018 (+12.67%), while also showing declines in certain years, particularly in 2014 and 2021. The Emir Abdelkader municipality grew at an especially high rate in 2015 (+127.41%), suggesting a sudden service expansion, followed by declines in some years again in 2014, and again in 2022.

The documented "Chekna" municipality, which was recently added to the municipal index system, showed the highest variability, growing to over +197% in 2013, but then dropping to -100% in 2020, suggesting a complete halt to transport and/or collection activities of the municipality. The Oued Yahia municipality shows a steadier rate of growth with moderate growth when it occurs, suggesting that it is likely a more consistent operation.

The municipalities of Sidi Abdelaziz and Chekfa, which were only recently documented in the last few years, show very erratic growth, particularly Chekfa which shows +52.41% then -92.39% in the next year reflecting very erratic and possibly unstable service coverage.

From the total growth index data, it is clear there is very significant growth in some years (2015 and 2018) are offset by clear declines in other years (2014 and 2021), which shows an overall improvement trending over the years, but issues remain in achieving regularity for some municipalities, and better integration across all municipalities in the system.

For all these indicators, conclusions can be drawn that systematic monitoring of waste management in these municipalities should be done continuously to pinpoint any shortfalls. In addition, local policy should be reinforced to lessen varying swings, in order to stabilize and develop a sustainable waste collection strategy and management. Municipalities that have shown a continuous increase need to improve their technical and logistical abilities, while those that seem to have substantial decrease need to examined and/or improved, to avert disruption of service, and/or miscalculation.

Table 7. Amount of Waste Buried at the Technical Landfill Center in El Milia (El Milia Municipality) from 2011 to 2022

Year	El Milia	Sa-tara	El An-cer	Khiri Oued Ad-joul	Djema a Beni Habib i	Oule d Ya-hia	Boua roui Bel-hade f	Sidi Maro uf	Total
2011	2237.16	/	/	/	/	/	/	/	2237.16
2012	11189.74	1393.80	/	/	/	/	/	/	12583.54
2013	11605.70	1449.65	/	/	/	/	/	/	13055.35
2014	7890.70	1882.00	/	/	/	/	/	/	9772.70
2015	6129.22	1035.82	1064.34	/	/	/	/	/	8229.38
2016	11510.76	1886.24	1679.42	69.64	/	/	/	/	15146.06
2017	11833.56	1945.48	935.14	145.02	160.96	80.20	/	/	15100.36
2018	11620.94	2114.32	2263.38	664.94	1278.40	192.82	250.40	493.58	18878.78
2019	12752.40	2349.96	2423.14	937.18	2179.58	197.44	540.16	2125.38	23505.24
2020	12369.68	2343.00	3308.96	937.98	2230.12	288.34	619.14	2127.32	24224.54
2021	12191.18	2343.12	2432.34	854.20	2096.42	293.54	626.84	2019.60	22857.24
2022	8109.00	2199.00	1954.00	1000.00	2243.00	319.00	648.80	2062.00	18534.80
Total	—	—	—	—	—	—	—		

Souce: Technical Landfill Management Company – Jijel

The analysis of the data presented in the table shows the evolution of the amount of household waste collected in several municipalities of Jijel Province during the period from 2011 to April 2023. It highlights varying quantities between municipalities and notable differences between years, reflecting demographic, economic, and organizational changes in waste management.

In El Milia, the quantity of waste produced surpassed the other municipalities throughout the whole period, accumulating to be over 12,000 tons in only a few years (2012, 2013, 2019, and 2020), which reinforced that it was the largest waste producer in the studied municipalities, which possibly reflects the population density or levels of commerce and services. However, since 2021 there has been a clear decreasing trend. The other municipalities, like, Settara and El Ancer, began recording starting from 2012 and 2015 respectively, and showed a gradual upward trend—especially for El Ancer which peaked in 2020 with 3,308.96 tons. The increase may indicate an expansion of waste collection service area, or increases in the number of residents using waste collection services.

In terms of municipalities, similar registration pattern and registration process happened for municipalities like Khiri Oued Adjoul, El Aouana Beni Hbibi, and Sidi Maarouf, which have had large increases in recorded quantities over just a few years - specifically in the years of 2018 to 2022 - may reflect potential growth in the waste collection network or growth in the enforcement and improvement of monitoring and data gathering processes.

The total annual data has also reflected an upward trajectory starting from 2,237 from 2011 and to somewhere near 24,000 tons, with a recorded peak in tonnage in 2020 and then gradually declining in 2021 and 2022.

So to summarize and conclude, the data above represents the excessive growth of waste collection capacity in the province of Jijel, while also indicating the differences between municipalities. The differences represent the opportunity to consider how the current local waste management policies and practices are functioning as used to design accountability, efficiency, inclusiveness and sustainability systems.

Table 8. Annual Growth Rate Index (%) of Landfilled Waste at the Technical Landfill Center of El Milia (El Milia Municipality) from 2011 to 2022

Year	El Milia	Settara	El Ancer	Khiri Oued Adjoul	El Aouana Beni Hbibi	Ouled Yahia	Bouraoui Belhadef	Sidi Maarouf	Total
2013	3.72%	4.01%	—	—	—	—	—	—	3.75%
2014	−32.01%	29.82%	—	—	—	—	—	—	−25.14%
2015	−22.32%	−44.96%	—	—	—	—	—	—	−15.79%
2016	87.80%	82.10%	57.79%	—	—	—	—	—	84.05%
2017	2.80%	3.14%	−44.32%	—	—	—	—	—	−0.30%
2018	−1.80%	8.68%	142.04%	358.52%	—	—	—	—	25.02%
2019	9.74%	11.14%	7.06%	40.94%	70.49%	2.40%	115.72%	—	24.51%
2020	−3.00%	−0.30%	36.56%	0.09%	2.32%	46.04%	14.62%	0.09%	3.06%
2021	−1.44%	0.01%	−26.49%	−8.93%	−6.00%	1.80%	1.24%	−5.06%	−5.64%
2022	−33.48%	−6.15%	−19.67%	17.07%	+6.99%	8.67%	3.50%		

From 2013 to 2022, the yearly growth index of posted waste at the El Milia Technical Landfill Center in El Milia Municipality demonstrated clear variability of both increases and decreases which reflected irregular movements of waste materials being received from the various municipalities. The years began with small positive growth rates in 2013 and sudden declines in 2014 and 2015, especially for the municipalities of El Milia and Settara with total national decreases of –25.14% and –15.79% respectively.However, the year 2016 marked a major turning point, with a significant increase in waste quantities and a total growth of +84.05%, thanks to the strong performance of the three participating municipalities at the time (El Milia, Settara, and El Ancer).

As of 2017, the index was once again at –0.30% due to lower contributions from El Ancer, although El Milia and Settara remained positive. Starting in 2018 new municipalities began to join the center, and notably Khiri Oued Adjoul recorded exceptional growth of +358.52% alongside large gains in El Ancer contributing to a general growth of +25.02%. This increase continued in 2019, the other new municipalities included Bouraoui Belhadef and El Aouana Beni Hbibi, resulting in an overall growth of +24.51%.

The period between 2020 and 2022 showed gradual decline. Although growth of +3.06% was recorded in 2020, the index went negative in 2021 (–5.64%) and 2022 (–18.91%) due to an apparent drop in contributions from several municipalities including El

Milia, El Ancer, and Settara, while municipalities of Khiri Oued Adjoul and Ouled Yahia remained positive.

These changes highlight the instability in waste inflows and demonstrate the need for a broad overview of the management system, as well as the inter-municipal cooperation needed to ensure the efficient use of the center, in striving toward the goals of environmental sustainability.

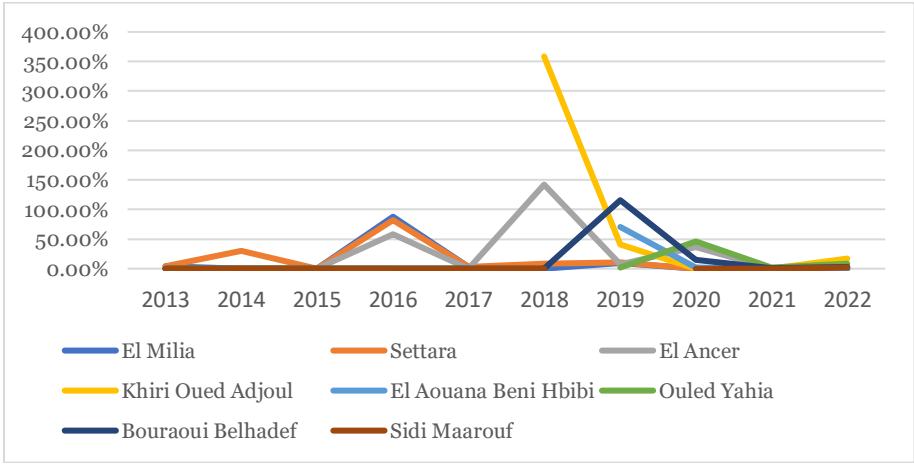


Fig. 8. Annual Growth Rate (%) of Landfilled Waste at the El Milia Technical Landfill Center by Municipality (2013–2022)

The evaluation of the annual increase indicator concerning the landfill waste at the technical landfill centers of Taher and El Milia has provided valuable insights into the waste management situation in the Jijel province, and indicated that there are important points about service regularity, service expansion, and structural and organizational mismatches at the municipal level. The analysis leads to the following conclusions:

- The indicators showed a definite variance among municipalities, with some municipalities (Taher, Emir Abdelkader, El Milia, and Khiri Oued Adjoul) showing significant growth rates over certain periods, and other municipalities (Chekfa, El Ancer, and El Chouna) exhibiting declines, or in some cases, stagnation, suggesting untoward performance without balance in coverage and general performance.
- The index helped track periods of sudden expansion or unexplained decline, prompting questions about the causes of these changes, whether they are related to organizational factors (weak monitoring or contract management), logistical issues (lack of resources and equipment), or even human factors (disengagement from the service or shifts in population behavior).
- The index highlighted the importance of certain municipalities in maintaining stable waste flows. Municipalities like Taher and El Milia contributed to supporting overall indicators due to their relative regularity, whereas others caused fluctuations due to instability or late integration.
- From a planning perspective, this index enables local decision-makers to identify gaps in the system, whether in the stages of collection, transfer, or coordination between municipalities and landfill centers and encourages the development of data-driven solutions.

To further improve the management of household waste, and to make sure that technical landfill centers can provide an effective service to the province of Jijel, a public provincial institution was created to manage the technical landfill centers, by virtue of the joint ministerial decree dated November 8, 2008, in order to resolve the delay that existed at the time and achieve the planned objectives under the National Environmental Program.

In the process of advancing the National Household Waste Management Program (PROGDEM) implementation and as derived from Law 01/19 and National Environmental and Sustainable Development Action Plan (PNAEDD), the environmental sector has experienced significant progress at the level of alarming management of technical landfill centers and potentially recovering recyclable materials, thanks to all the stakeholders they contracted and the role served by the provincial institution towards supporting and coordinating everyone's contributions.

The PROGDEM program (National Household Waste Management Program) is one of the ambitious initiatives launched by the state with the goal of bringing about fundamental changes in the waste management sector. This program aims to improve citizens' living conditions and quality of life by enhancing the efficiency of waste collection and transportation services and supporting municipalities through the provision of essential equipment and tools. It also seeks to reorganize local waste management administration and open the door to private investment in public management, thereby diversifying partnerships and improving performance.

The program also includes the implementation of training and technical support initiatives for sector stakeholders, while promoting selective sorting and recovery within the framework of a circular economy vision. The "polluter pays" principle is also being used as a tool for environmental justice.

Nevertheless, some indicators suggest that there are still remaining challenges - the estimated volume of 13 million tons of household and similar waste generated annually, and the national recycling rate of less than 7%.

In terms of infrastructural presence, Algeria has:

- 95 technical landfill sites (sites d'enfouissement sanitaire) for waste
- 30 landfills for non-treatable waste (déchets interdits)
- 9 sorting centers (centres de tri)
- 9 selective collection sites (déchetteries)
- 3 transfer stations (stations de transfert)

as well as other ongoing projects to extend facilities and structurally across the national territory.

In 2018, the Ministry of Environment and Renewable Energies started the National Integrated Waste Management Strategy (SNGID 2035) which is a long-term strategic vision to reinforce and promote the constitutional right to a healthy environment and basic social need through applying principles of green and circular economy, and support economic diversification away from hydrocarbons.

This strategy is based on a comprehensive and participatory approach to shaping environmental policies and is founded on a set of major objectives, the most important of which are:

- Preventing waste generation
- Promoting source separation and recovery
- Reducing health and environmental risks
- Applying the "polluter pays" principle
- Enhancing the role of the private sector as an active partner in sustainable management

These strategic orientations form the foundation for building an effective waste management system in Algeria that responds to future environmental and economic challenges.

Conclusion

The findings and analysis provided in this study clearly show that waste management and recovery are not just environmental options, but strategic priorities supporting the realization of sustainable development and natural resource protection for future generations. Experiences from around the world - especially in Germany, Sweden and China - show how a circular economy model; with source separation, recycling, and waste-to-energy, can provide an approach that moves waste from being an economic and environmental liability to being an economic resource; providing jobs and driving competitiveness.

The empirical results of this study demonstrate similar challenges in Algeria. For example, between 2011 and 2020, inter-municipal landfill centers in Taher and El Milia received over 345,000 tons of household waste, which can differ quality of the solid waste that is compacted at each site with compaction density ranging from 467 kg/m³ in El Milia to more than 1,300 kg/m³ in Taher. Those differences are reflective of structural inefficiencies, uneven performance, and insufficient infrastructure and operational practices. Despite the presence of legislative frameworks and planning models in the country, Algeria continues to struggle with structural and traditional barriers, including poor infrastructure, low levels of environmental awareness, and limited participation from the private sector and civil society.

To move from diagnosis to effective action, policy recommendations must be both specific and prioritized. Based on the observed gaps, the immediate priority should be strengthening municipal-level collection and separation systems, coupled with targeted awareness campaigns in underperforming regions. In parallel, establishing fiscal and investment incentives can encourage greater private-sector involvement in recycling and resource recovery initiatives. These measures, if implemented consistently, would lay the groundwork for a circular economy adapted to Algeria's realities rather than imported in abstract form.

One must consider some limitations of this research. The analysis was largely based on secondary data sources. While secondary data is appropriate for this research, it does not account for behavioral change at the household level or a longitudinal study that demonstrates changes in waste actions. Future research could build on this study by including primary field surveys, modeling the economic feasibility of circular economy applications, and examining the long-term social acceptance of waste separation and recycling practices.

The shift towards a circular economy marks a critical opportunity for Algeria to balance environmental protection and economic development, manage natural resources sustainably, and enhance the quality of life for current and future generations. Realizing this vision will require a strong commitment from public authorities and private sector organizations and their collaboration with civil society organizations to convert waste into the foundation of sustainable development.

Conflicts of Interest: The authors declare no conflict of interest.

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References

Abbas, F., & Lamri, N. (2025). Optimization of Solid Waste Valorization in Algeria: Challenges and Sustainable Solutions. *Bulletin of the Serbian geographical society*, *105*(1), 287-304. https://doi.org/10.2298/GSGD2501287A

Anwar, M., Konnova, M. E., & Dastgir, S. (2025). Circular plastic economy for sustainable development: current advances and future perspectives. *RSC Sustainability*, 9, 3724-3840.

Berglund, C. (2006). The assessment of households' recycling costs: The role of personal motives. *Ecological Economics*, *56*(4), 560-569.

Biswas, M. R., & Biswas, A. K. (1982). Environment and sustained development in the Third World: A review of the past decade. *Third World Quarterly*, *4*(3), 479-491.

Bortoleto, A. P., Kurisu, K. H., & Hanaki, K. (2012). Model development for household waste prevention behaviour. *Waste Management*, *32*(12), 2195-2207.

Cheniti, H., Kerboua, K., Sekiou, O., Aouissi, H. A., Benselhoub, A., Mansouri, R., Zeriri, I., Barbari, K., Gilev, J. B., & Bouslama, Z. (2024). Life Cycle Assessment of Municipal Solid Waste Management within Open Dumping and Landfilling Contexts: A Strategic Analysis and Planning Responses Applicable to Algeria. *Sustainability*, *16*(16), Article 6930. https://doi.org/10.3390/su16166930

Daly, H. E. (1990). Toward some operational principles of sustainable development. *Ecological Economics, 2*, 1-6.

Daly, H. E., & Farley, J. (2011). *Ecological economics: principles and applications*. Island press.

DeBoe, G. (2020). *Economic and environmental sustainability performance of environmental policies in agriculture*. OECD.

Dessler, A. E., & Parson, E. A. (2019). *The science and politics of global climate change: A guide to the debate*. Cambridge University Press.

Dodds, F., & Strauss, M. (2012). *Only one Earth: The long road via Rio to sustainable development*. Routledge.

Douici, N. (2024). *Pas moins de 36 décharges sauvages recensées*. El Watan. https://www.elwatan-dz.com/bejaia-pas-moins-de-36-decharges-sauvages-recensees

Drastichová, M. (2022). Sustainable development and sustainable science. Where we came from, where we are now and where we are heading? Part I: The history of the concept. *Problemy Ekorozwoju*, *17*(2), 7-18.

Falkner, R. (2016). The Paris Agreement and the new logic of international climate politics. *International Affairs*, *92*(5), 1107-1125.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy - A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757-768.

Gelmez, E., Eren, H., & Özceylan, E. (2025). Evaluation of Environmental Performance of OECD Countries Using SD-Based ARAS and WASPAS Methods. *Gazi University Journal of Science*, *38*(2), 808-831. https://doi.org/10.35378/gujs.1458807

Hachemi, H., Seladji, C., Negadi, L., Bhandari, R., & Aryal, S. (2024). Improving municipal solid waste management in Algeria and exploring energy recovery options. *Renewable Energy*, *230*, Article 120861.

Harris, J. M., & Roach, B. (2017). *Environmental and natural resource economics: A contemporary approach*. Routledge.

Hassaine, M., & Abrika, B. (2024). Challenges and prospects for activating a circular economy in the context of sustainable waste management in Algeria. *Revista Galega de Economía*, *33*(2), 1-21.

Hemidat, S., Achouri, O., El Fels, L., Elagroudy, S., Hafidi, M., Chaouki, B., Ahmed, M., Hodgkinson, I., & Guo, J. (2022). Solid waste management in the context of a circular economy in the MENA region. *Sustainability*, *14*(1), Article 480. https://doi.org/10.3390/su14010480

IPCC (2013). *Climate Change 2013: The physical science basis*. IPCC.

Ismahan, H. (2022). *Gestion des déchets ménagers et assimilées*. Faculté des sciences et de la technologie univ bba.

Johansson, A., & Lindahl, A. (2014). *Sorting out waste - The development of a recycling station for public indoor environments* [Master Thesis, Sustainable Development, Innovation & Entrepreneurship, Other Engineering and Technologies].

Johansson, N. (2024). Deposit pickers in the Nordic: The role of deposit-refund systems for waste pickers in Stockholm. *Waste Management & Research*, 43(7). https://doi.org/10.1177/0734242X241297574

Jose, R. (2023). *The Joint Initiative on Investment Facilitation for Development*. International Institute for Sustainable Development.

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: a global snapshot of solid waste management to 2050*. World Bank Publications.

Kerroud, I., & Lamri, N. (2024). Potentials and development prospects of ecotourism in algeria: the case of Jijel Province. ZAOULI, 8(1), 206-232.

Kholkhal, D., Bendellaa, H., Benkhedda, H., Bouamer, S., & Benmahioul, B. (2023). Study of the morphological characteristics of acorns and growth parameters of cork oak seedlings of two provenances: from the North-East (Jijel) and the North-West (Tlemcen) of Algeria. *Agriculture and Forestry Journal, 7*(1), 35-41.

Küfeoğlu, S. (2024). Waste Management Emissions. In S. Küfeoğlu (Ed.), *Net Zero: Decarbonizing the Global Economies* (pp. 555-611). Springer Nature.

Lamri, N., Belayadi, A., & Abbas, F. (2022). Solid waste management as an urban area regulation in Algeria. Case of El-Khroub city. *Forum Geografic, 21*(2), 158-171. https://doi.org/10.5775/fg.2022.039.d

Lennan, M., & Morgera, E. (2022). The glasgow climate conference (COP26). *The International Journal of Marine and Coastal Law*, *37*(1), 137-151.

Liang, K. (2024). Energy Utilization of Agricultural Waste: From Waste Management to Energy Production. *Journal of Energy Bioscience*, *15*(3). https://doi.org/10.5376/jeb.2024.15.0015

Linden, A., & Brusselaers, J. (2020). *European Environment Agency, 2020 Bio-Waste in Europe - Turning Challenges into Opportunities*. Publications Office of the European Union: Amsterdam, The Netherland.

MacArthur, E. (2017). Foundation a new textiles economy: Redesigning fashion's future. London, UK.

McMichael, A. J., & Lindgren, E. (2011). Climate change: present and future risks to health, and necessary responses. *Journal of internal medicine*, *270*(5), 401-413.

Ministry of the Environment Government of Japan (2021a). *Annual Report on the Environment in Japan*. Ministry of the Environment Government of Japan.

Ministry of the Environment Government of Japan (2021b). *National Report on the State of the Environment 2020*. Ministry of the Environment Government of Japan.

Mounir, R. (2023). Solution to plastic waste in Algeria. *Economic studies Journal, 17*(2), 12-33.

Ouigmane, A., Boudouch, O., Hasib, A., Elkacmi, R., Aadraoui, M., & Berkani, M. (2021). Characterization of dry fractions contained in municipal solid waste in developing countries: a case study of a region in Morocco. *Journal of Material Cycles and Waste Management*, *23*(3), 1227-1238.

Peckl, K. (2022). *Waste-to-Energy: Decentralised thermal waste treatment plants as solution for the water and electricity scarcity in the MENA region - Case Study Tunisia* [Master Thesis, Technische Universität Wien].

Petridou, E., Sparf, J., Onn, B., Jochem, S., & Schøyen, M. A. (2024). *Sweden Report: Sustainable Governance Indicators 2024*. Verlag Bertelsmann Stiftung.

Ponnet, H. (2024). *Mapping textile waste flows towards its potential for recycling* [Master Thesis, Ghent University].

Redclift, M. (2005). Sustainable development (1987–2005): an oxymoron comes of age. *Sustainable development*, *13*(4), 212-227.

Sachs, J. D. (2015). *The age of sustainable development*. Columbia University Press.

Schroeder, L., & Jeonghyun, K. (2019). Germany's waste management policy development: A focus on municipal solid waste. *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Beijing, PR China, p24*.

Silva Neira, M. J. (2024). *Food waste in Swedish households. Trends, challenges, and opportunities towards achieving the global reduction target*. SLU, Department of Energy and Technology.

Singh, R., Lamba, S., Goodwin, L., Dhar, M., Hari, D., Sharma, N., & Jayahari, K. (2023). *Reducing food loss and waste: Enabling action through the target-measure-act approach*. T20 Brief May.

Spies, A. M., Kroell, N., Ludes, A., Küppers, B., Raulf, K., & Greiff, K. (2024). Assessing the resource potential of paper and board in lightweight packaging waste sorting plants through manual analysis and sensor-based material flow monitoring. *Waste Management*, *189*, 196-210. https://doi.org/10.1016/j.wasman.2024.07.034

Stuchtey, M., MacArthur, D., & Dominic, W. (2016). *The New Plastics Economy Rethinking the Future of Plastics*. World Economic Forum.

Vambol, V., Kowalczyk-Juśko, A., Vambol, S., Khan, N. A., Mazur, A., Goroneskul, M., & Kruzhilko, O. (2023). Multi criteria analysis of municipal solid waste management and resource recovery in Poland compared to other EU countries. *Scientific Reports*, *13*(1), Article 22053. https://doi.org/10.1038/s41598-023-48026-3

Weber, H. (2022). Nazi German waste recovery and the vision of a circular economy: The case of waste paper and rags. *Business History*, *64*(5), 882-903. https://doi.org/10.1080/00076791.2021.1918105

Wielgosiński, G., Czerwińska, J., & Szufa, S. (2021). Municipal solid waste mass balance as a tool for calculation of the possibility of implementing the circular economy concept. *Energies*, *14*(7), Article 1811.

Wiesmeth, H. (2012). *Environmental economics*. Springer.

Wijkman, A., & Skånberg, K. (2015). *The circular economy and benefits for society*. Club of Rome.

Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., Iyer, M., & Simonett, O. (2015). *Global waste management outlook*. Unep.