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Sector: process engineering

Field: sustainable waste management and treatment processes

Waste statistical characterization and sustainable Management at the department of Process Engineering.

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Thanks

I begin by thanking God Almighty, who has given me the strength and courage to complete my studies and reach this stage.

I also extend my sincere thanks to my supervisor, Professor Sakri Asma, for agreeing to lead this project, and for her support, expertise, and valuable time.

I also thank all the staff of the Process Engineering Department for their cooperation.

Dedication

I dedicate this humble work:

To the soul of my beloved father

To my great mother

To my brothers in Gaza who are suffering the scourge of genocide, famine, bombing, and death

To my great, steadfast, and bereaved people in Gaza

To my relatives and friends who have supported me and stood by me in the most difficult circumstances

ملخص

تهدف هذه الدراسة إلى تحديد وفرز وتقدير كميات النفايات المختلفة، بالإضافة إلى مراقبة نظام الإدارة المستدامة على مستوى قسم هندسة الطرائق (كلية العلوم والتكنولوجيا جامعة البليدة -1-)، لمدة 15 يوم. أظهرت النتائج تحديد العديد من النفايات والتي منها القابلة لإعادة الاستخدام واعادة التدوير مثل: الزجاج، الالمنيوم، البلاستيك للنفايات مثل: الورق، الكرتون، توجد ايضا اشكال أخرى النفايات الالكترونية والنفايات الملوثة والكيميائية. كان مجمل الوزن للنفايات التي حصلت 114.547 كغم في 15 يوم.
الكلمات المفتاحية: أنواع النفايات، فرز النفايات، التحليل الإحصائي، قسم هندسة الطرائق، جامعة البليدة.

Summary

This current study aims to identify, sort, and quantify various types of waste, as well as monitor the sustainable waste management system at the Department of Process Engineering (Faculty of science and technology – University of Blida-1-) over a 15day period. The results revealed the identification of a wide variety of waste types, including reusable and recyclable items such as paper, cardboard, glass, aluminum, and plastic. Other forms of waste were also present, such as electronic waste, contaminated
waste, and chemical waste. The total weight of waste collected was 114.547 kg over the 15 days.

Key-words: waste types, waste sorting, statistical analysis, Department of process engineering, University of Blida.

Résumé

Cette étude vise à identifier, trier et quantifier différents types de déchets, ainsi qu'à surveiller le système de gestion durable des déchets du Département de génie des procédés (Faculté des sciences et techniques – Université de Blida-1-) sur une période de 15 jours. Les résultats ont révélé
l'identification d'une grande variété de déchets, notamment des articles réutilisables et recyclables tels que le papier, le carton, le verre, l'aluminium et le plastique. D'autres formes de déchets étaient également présentes, comme les déchets électroniques, les déchets contaminés et les déchets chimiques.
Le poids total des déchets collectés s'élevait à 114,547 kg sur ces 15 jours.

Mots clés: types de déchets, tri des déchets, analyse statistique, Département de génie des procédés, Université de Blida.

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Introduction

Introduction

Universities function as mini-communities that encompass academic, residential, research, and administrative functions. These institutions generate substantial amounts of waste daily, varying from general municipal waste to specialized waste like laboratory chemicals and electronic apparatus. Per the United Nations Environment Program (UNEP), higher education institutions can produce several tons of waste monthly, a lot of which remains poorly managed, especially in developing areas (UNEP, 2020). [1]

University waste management refers to the organized processes of collection, segregation, treatment, recycling, and disposal of different waste streams generated on campus. Effective waste treatment is crucial for lessening environmental impacts, including air pollution, water contamination, and soil degradation (World Bank, 2012). Treatment methods vary and encompass recycling, composting, incineration, anaerobic digestion, and hazardous waste neutralization, based on the type of waste. [2]

Improper or inadequate waste management in universities can result in severe environmental consequences. For example, food and organic waste disposed of in landfills contributes to methane emissions, while unsafe disposal of e-waste can release heavy metals into the soil and water (EPA, 2022). [3]

Moreover, burning waste in open spaces — a frequent practice in under-resourced institutions — leads to air pollution and presents health risks (ADB, 2019). [4] Adopting a comprehensive and sustainable waste management system helps universities decrease operational costs, adhere to environmental regulations, and foster environmental responsibility among students and staff. Moreover, such systems can serve as educational instruments and models for surrounding communities, reinforcing the university's role in progressing sustainable development (UNEP, 2020).

This study aims to shed light on the types and quantities of waste produced by the department of Process Engineering, (Science and Technology Faculty University of Blida-1-). It also examines waste management procedures in laboratories, both doctoral research and teaching laboratories. To achieve this goal, this thesis began with an introduction. In the first chapter, an overview was provided of waste and some general information about waste in management in the Process Engineering Department. The second chapter addresses the materials and the methods used to accomplish this work at the Department of process Engineering. Subsequently, the third chapter presents the results reached and discusses them. Finally, the analysis is concluded with a conclusion and discussion.

Chapter 1. General information about waste

Chapter 1. General information about waste

1.1. Definition of the term "waste"

Waste are unwanted or unusable materials. Waste is any substance discarded after primary use, or is worthless, defective and of no use. A by-product, by contrast is a joint product of relatively minor economic value. A waste product may become a by-product, joint product or resource through an invention that raises a waste product's value above zero.

Examples include municipal solid waste (household trash/refuse), hazardous waste, wastewater (such as sewage, which contains bodily wastes (feces and urine) and surface runoff), radioactive waste, and others. [5]

1.1.1. Environmental definition of “waste”

Environmental waste is an unnecessary use of resources or a substance released to the air, water, or land that could harm human health or the environment. [6]

1.1.2. Economic definition of “waste”

Waste refers to the inefficient or unproductive use of resources, including time, effort, and materials, resulting in a loss or underutilization of their potential value. In the context of economics, waste is a critical concept that is closely tied to the analysis of price ceilings and price floors. [7]

1.2. Waste classification.

Algerian Law No. 01-19 of December 12, 2001 relating to the management, control and elimination of waste, gives the*Classification of waste.

Table 1:Examples of waste lists (J.O.R.A.annexeII)

Waste code	Waste designation	Waste class
15.1.1	Paper/cardboard packaging	Municipal waste
17.1.1	Concrete	Inert waste

20.1.3	Biodegradable kitchen and canteen waste	Municipal waste

Table 2: Examples of waste lists (J.O.R.A.annexeIII)

Waste code	Waste designation	Waste class
2.7.2	Chemical treatment waste	Hazardous waste
5.1.3	Acid alkyl sludge	Hazardous dangerous waste
8.4.9	Resin oil	Hazardous dangerous waste

1.3. Classification of waste according to its toxicity

1.3.1. Hazardous Waste

Hazardous waste contains, in varying quantities, toxic or hazardous elements that pose risks to human health and the environment due to their toxic, corrosive, explosive, combustible, etc. nature (SPE, 1997).

1.3.2. Inert Waste

This is waste that does not undergo any change during storage, does not decompose, does not burn, and does not produce any physical or chemical reaction, it's not biodegradable, and does not deteriorate other materials with which it comes into contact in a way that could harm human health
and cause environmental pollution.

1.3.3. Toxic Waste

This is hazardous waste produced in small quantities by households and businesses (garages, hairdressers, photo labs, printing shops, etc.). It may be ordinary waste.

1.3.4. Ultimate Waste

Final waste refers to the residual waste that remains after all possible treatment and recycling processes have been carried out. This is waste that cannot be reused, recycled, or recovered in any way. Final waste is generally intended for safe disposal, for example, by burying it in landfills or incinerating it in special facilities.

Final waste can be hazardous or non-hazardous, but its main characteristic is that it cannot be converted into useful resources or energy in a profitable or environmentally sustainable manner. Managing final waste is a significant challenge for local authorities and businesses, as it requires special measures to ensure proper and environmentally sound disposal.

1.3.5. Non-hazardous Waste

This is waste that is neither hazardous nor inert; it includes municipal waste (household waste, waste from the maintenance of green spaces, and waste from individual or collective sanitation).

1.4. Classification based on physical state

✞ According to Murat (1981), this classification includes:

- **Solid waste:** This includes household waste (HW), metal waste, inert waste (ash, slag, etc.), rubber waste, plastic waste, and wood waste.
- **Liquid or pasty waste:** Tar, used oils, various residual solutions, etc.
- **Gaseous waste:** Landfill biogas (methane), greenhouse gases (carbon dioxide, etc.).

1.5. Classification according to waste treatment method

1.5.1. Biodegradable or decomposable waste

Such as green waste, water treatment sludge, food scraps, etc., this waste is at least partially destroyed naturally, more or less rapidly, generally by bacteria, fungi, and other microorganisms and/or by chemical reactions.

1.5.2. Recyclable waste

Such as glass, metals, and plastics. This waste can be directly reused in other areas or recycled.

1.5.3. Special waste

This includes toxic waste, radioactive waste, and nuclear waste, which must be treated in a very specific manner due to their particular harmfulness related to radioactivity.

1.6. University waste treatment methods

Universities generate different waste streams, including food waste, recyclables, hazardous materials, and electronic waste. Effective waste treatment methods are essential for reducing environmental impact and promoting sustainability.

1.6.1. Source Reduction & Waste Minimization

Preventing waste generation through reusable products, digital items, and efficient resource use.

✞ Examints:

- Avoiding single-use plastics.
- Zero-waste system implementation.

1.6.2. Waste sorting and collection

Sorting waste into categories at the source ✞

Examples:

- Color-coded bins for plastic, paper, organics, and E-waste.
- Collection drives for batteries.

1.6.3. Recycling

Converting waste material into new products ✞

Examples:

- Paper, glass, and plastic recycling.
- Recycling toner cartridges and old electronics.

1.6.4. composting

Biological decomposition of organic materials (food waste and garden waste)

✞ Examples:

- Traditional composting.
- Vermicomposting.

- In-vessel (mechanical) composting.

1.6.5. Incineration (with energy recovery)

Controlled burning of waste, particularly for non-recyclables and contaminated materials. It's the most appropriate way to treat medical and hazardous waste.

✞ Examples:

- Burning hazardous pharmaceutical and medical waste.

1.6.6. Chemical waste treatment

Neutralization or stabilization of hazardous chemicals from labs

✞ Examples:

- pH neutralization.
- Solidification.
- Safe storage before disposal by certified handlers.

1.6.7. landfilling (last resort)

Disposal of non-recyclable, non-compostable waste in engineered landfills

1.7. The nature of waste generated in faculties and university departments

Waste generated from universities, including their faculties and departments can be diverse due to the wide range of academic, research, and operational activities. Here's a breakdown of waste generated in specific departments and faculties within a university:

1.7.1. Faculty of Science

The Faculty of Science is a place for education and research on science. Science is a study that engages in a "dialogue with Nature" to understand the principles and laws working in the natural world. [8]

✞ **Types of waste:**

- **Laboratory waste:** test tubes, gloves, masks, and pipettes.
- **Chemical waste:** acids, solvents, reagents (some hazardous).
- **Glass waste:** broken lab equipment.
- **E-waste:** Electronic hardware, computers and sensors.
- **Paper waste:** lab reports and documentations.

1.7.2. Faculty of medicine/ health sciences

It's a tertiary educational institution, professional school, or forms a part of such an institution, that teaches medicine, and awards a professional degree for physicians. Such medical degrees include the Bachelor of Medicine, Bachelor of Surgery, Master of Medicine, and Doctor of
Medicine.

✞ **Types of Waste:**

- **Biomedical:** syringes, bandages, gloves.
- **Pathological:** biological samples, tissues.
- **Pharmaceutical:** expired drugs.
- **General waste from clinical spaces (masks, PPE).**

1.7.3. Faculty of Engineering and Technology

It's a department or school that focuses on the study of engineering principles and technological advancements. It encompasses various fields like civil, mechanical, chemical, electrical, and computer engineering.

✞ **Types of Waste:**

- **Packaging of materials and tools**
- **Electronic waste:** batteries, cables, and circuit boards.

- **Chemical waste:** acids, coolants, and solvents.

1.7.4. Faculty of Agriculture & Environmental Sciences

It's a faculty or school that deals with surveying, planning and designing of spaces within the Mother Nature. [9]

✞ **Types of Waste:**

- **Organic waste:** plant material, compostable biomass.
- **Soil, pesticides, fertilizers and some hazardous waste.**
- **Lab and greenhouse waste.**

1.7.5. Faculty of Architecture and design

It's a department or school dedicated to the study and practice of architecture and various design fields.

✞ **Types of waste:**

- Cardboard, foam boards, wood scraps
- Drafting paper, models, adhesives
- Paints, solvents (hazardous materials possible)

1.7.6. Business & Economics Faculty

It's a department that focuses on teaching and research in the fields of business administration, economics, and related areas.

✞ **Types of waste:**

- **Large quantities of paper.**
- **Discarded reports, and handouts.**
- **Office waste: cardboard, packaging.**

1.7.7. Canteen and restaurants waste

It's a room that sells food, drinks and personal items to personnel at school.

✞ **Types of waste:**

- **Organic waste:** food scraps, used cooking oil, fruits and vegetables peels, and expired food items.
- **Packaging waste:** Plastic, Paper, cardboard, and aluminum.
- **Liquid waste:** leftover drinks and Grease from dishwashing or grease traps.

1.8. Good waste management and sustainable development

This process focuses on meeting current needs without compromising the ability of future generations to meet their own, emphasizing the balance between economic growth, social equity, and environmental protection.

University waste is an important issue due to its type and large volume. Therefore, there must be good sustainable management and good treatment methods to reduce environmental and human risks. Here, some examples of methods and universities that treats university waste on the spot without the need for private companies to take care of this waste will be presented.

1.8.1. Waste segregation at source

Waste separation or segregation at source is the action whereby waste is sorted into different fractions at the point of generation, for example in the household kitchen, or on the property before the waste is put out for collection. [10]

1.8.1.1. Method

- Classify waste into categories: organic, recyclable, hazardous, electronic, biomedical, etc.
- Use color-coded bins with clear labels.

1.8.1.2. Example

University of Cape Town (South Africa) introduced a “three-bin system” for recyclables, organics, and general waste, improving recycling rates by over 40%. [11]

1.8.2. Recycling and Reuse

Reusing: This involves taking items that might otherwise be considered waste and finding new applications for them, without changing the original form or intent.

Recycling: Recycling is the process of taking waste materials and converting them back into raw materials to be used in creating new products. [12]

1.8.2.1. Method

- Partner with recycling companies for paper, plastics, metals, and e-waste.
- Reuse items like furniture, lab glassware, and office supplies.

1.8.2.2. Example

Harvard University (USA) recycles 50% of its waste and has an extensive reuse program for lab equipment and office furniture. [13]

1.8.3. Composting of organic waste

It is a biodegradation method in which organic matter such as food scraps and leaves decompose into soil. This soil could be used for your gardens and farms. Over the years, composting has been widely adopted as an environmentally friendly way to reduce food waste. [14]

1.8.3.1. Method

- Collect food scraps, garden waste, and biodegradable materials.
- Use on-site composting units or partner with composting facilities.

1.8.3.2. Example

University of British Columbia (Canada) runs an industrial-scale composting facility that processes 1,000+ tons of organic waste annually. [15]

1.8.4. Treatment of Laboratory and Hazardous Waste

Laboratory Hazardous Waste Management is more complex than ordinary waste management. The activity focuses on handling specific wastes generated from laboratory experiments and research. These wastes are usually complex, toxic, and potentially dangerous to human health
and the environment if not managed properly. [16]

1.8.4.1. Method

- Neutralize, dilute, or stabilize chemical waste before disposal.
- Use licensed hazardous waste disposal companies.

- Maintain Material Safety Data Sheets (MSDS) and waste logs.

1.8.4.2. Example

Massachusetts Institute of Technology (MIT) uses the "Green Labs" program to manage lab waste through inventory control, substitution, and waste minimization. [17]

1.8.5. Energy recovery from waste (Waste-to- Energy)

Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion and landfill gas recovery. This process is often called waste to energy. [18]

1.8.5.1. Method

- Use anaerobic digesters to convert food and organic waste into biogas.
- Incinerate suitable waste in controlled environments to generate energy.

1.8.5.2. Example

University of California, Davis operates a biodigester that converts campus food waste into renewable energy and fertilizer. [19]

1.9. Bad University Waste Management Impact on Environment

Poorly managed waste in university institutions poses serious threats to the environment especially to water, soil, and air (atmosphere). These impacts are intensified when waste is improperly sorted, stored, or disposed of.

1.9.1. Impact on Water

A. Leachate contamination

- When solid waste is dumped in unlined landfills or open areas on campus, rainwater can percolate through the waste, creating a liquid called leachate.

- Impact: This leachate can seep into groundwater or surface water sources, carrying toxic substances like heavy metals, pathogens, and organic pollutants.

B. Runoff from Organic Waste

- Food waste and biodegradable materials dumped carelessly can rot and release nutrients (nitrogen, phosphorus).

- These nutrients enter water bodies, causing eutrophication, which leads to algal blooms, fish kills, and degraded water quality. [20]

1.9.2. Impact on Soil

A. Chemical and Heavy Metal Pollution

- Improper disposal of e-waste, batteries, lab chemicals, or paints on campus soil can introduce lead, cadmium, mercury, and arsenic into the soil.

These substances reduce soil fertility, harm microbial communities, and can be taken up by plants, entering the food chain.

B. Physical Contamination

- Non-biodegradable items like plastic, glass, and metal fragments degrade soil structure and water-holding capacity.

- Example: Plastic waste fragments in soil interfere with root growth and moisture absorption.

C. Acidification

- Waste incineration ash or acid-forming chemical spills can lower soil pH, harming plant life and beneficial organisms. [21]

1.9.3. Impact on Air

A. Air pollution from waste burning

- Some universities, especially in developing regions, burn waste in open areas due to lack of proper disposal systems.

- This emits carbon monoxide (CO), volatile organic compounds (VOCs), and dioxins.

Ps: These pollutants are known to cause respiratory diseases, cancer, and environmental haze.

B. Greenhouse Gas Emissions

- Methane (CH_4) is released from the anaerobic decomposition of organic waste in landfills.

- Improperly maintained compost pits or organic bins also produce methane if oxygen is limited.

- Impact: Methane is over 25 times more potent than CO_2 in trapping heat in the atmosphere.

C. Odor and Gaseous Emissions

- Poorly managed food waste and biological waste emit ammonia, hydrogen sulfide, and other foul-smelling gases, reducing campus air quality. [22]

Chapter 2. Materials and Methods

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2.1. Study area

2.1.1. The department of Process Engineering

The Department of Process Engineering is part of the faculty of technology. This department specializes in the optimization and management of industrial processes, focusing in some sectors like: chemical, mechanical, energy, and environmental engineering. It plays a pivotal role in addressing Algeria's industrial and environmental challenges.

2.1.2. The department

Figure 1:The department

2.1.3. overview of daily activities that may influence waste generation.

2.1.3.1. laboratories work.

More than 15 research and educational laboratories produce waste daily, including non-hazardous and hazardous waste. Laboratories from which waste was collected and which produced large waste:

- Laboratory of Solution Chemistry.
- Laboratory of Chemical Engineering.
- Laboratory of Instrumentation and Regulation.
- Laboratory of Unit Operations.

- Laboratory of Biochemistry and Microbiology.
- Laboratory of Heat Transfer.
- Laboratory of Chemical Reactors.
- Laboratory of Waste Analysis and Recovery.
- Laboratory of Materials Engineering.
- Laboratory of Physical Analysis Methods.
- Laboratory of Organic Chemistry.
- Laboratory of Electrochemistry and Corrosion.
- Laboratory of Atomic Absorption Spectrophotometry.
- Laboratory of Fluid Mechanics.
- Laboratory of Sustainable Waste Management and Treatment Processes.

2.1.3.1.1. Laboratory of Solution Chemistry. (N°211)

Laboratory of Solution Chemistry is a specialized lab that focuses on the manipulation and study of chemical solutions. It involves analyzing and preparing solutions for various chemical
experiments and research purposes.

Figure 2: Laboratory of solution chemistry

2.1.3.1.2. Laboratory of Chemical Engineering. (N°226)

Laboratory of Chemical Engineering is a specialized lab used to study and develop chemical processes, materials and products. This kind of lab plays a crucial role in both education and research within the field of chemical engineering.

Figure 3: Laboratory of Chemical Engineering

2.1.3.1.3. Laboratory of Instrumentation and Regulation. (N°231)

Laboratory of Instrumentation and Regulation is used for measurements, this lab ensures the safety, quality, and reliability of results.

Figure 4: Laboratory of Instrumentation and Regulation

2.1.3.1.4. Unit Operations. (N°252)

Laboratory of Unit Operations is a dedicated space where chemical engineering students gain practical experience with industrial equipment and processes. Some unit operations are performed such as: distillation, absorption, or filtration. This lab serves as a bridge between theoretical knowledge and real-world applications.

Figure 5: Laboratory of Unit Operations

2.1.3.1.5. Laboratory of Biochemistry and Microbiology. (N°251)

Laboratory of Biochemistry and Microbiology is a research and teaching facility. It includes specialized equipment, instruments, and procedures to study microorganisms and biochemical processes.

Figure 6: Laboratory of Biochemistry and Microbiology

2.1.3.1.6. Laboratory of Heat Transfer. (N°256)

A heat transfer laboratory is a specialized place designed for experimenting with the principles and applications of heat transfer, like: conduction, convection, and radiation.

Figure 7: Laboratory of Heat Transfer

2.1.3.1.7. Laboratory of Chemical Reactors. (N°166)

Laboratory of Chemical Reactors is a lab dedicated to studying and optimizing chemical reactions in a controlled environment. These reactors are designed to be adaptable, allowing for a wide range

of reactions and conditions to be explored.

Figure 8: Laboratory of Chemical Reactors

2.1.3.1.8.Laboratory of Waste Analysis and Recovery. (N°151)

Waste analysis and recovery lab is the place where we studied the waste evaluation at and the processes of waste management. We conducted many workshops that we greatly benefited from,

which aimed to properly dispose of hazardous waste such as batteries.

Figure 9: Laboratory of Waste Analysis and Recovery

2.1.3.1.9. Laboratory of Materials Engineering. (N°152)

Laboratory of Materials Engineering is specialized lab designed for the study and characterization of various materials, including polymers, metals, ceramics, and composites.

This lab is equipped with advanced instruments for material characterization, and micro-examination.

Figure 10: Laboratory of Materials Engineering

2.1.3.1.10. Laboratory of Organic Chemistry. (N°131)

Organic chemistry lab is specialized lab focuses on the separation, purification, and synthesis of organic compounds using distillation, recrystallization, melting point analysis, chromatography, and other techniques.

Figure 11: Laboratory of Organic Chemistry

2.1.3.1.11. Laboratory of Electrochemistry and Corrosion. (N°311)

It's a lab where you can study the interactions between electricity and chemical reactions, particularly those involving the degradation of materials such as metals, through corrosion.

Figure 12: Laboratory of Electrochemistry and Corrosion

2.1.3.1.12. Laboratory Atomic Absorption Spectrophotometry (AAS). (N°113)

Atomic absorption spectrophotometry lab is a specialized facility used for analyzing the elemental composition of a sample by measuring the of light absorbed by it's constituent atoms,

it's also used to determine how much of certain elements are in a sample.

Figure 13: Laboratory of Atomic Absorption Spectrophotometry (AAS).

2.1.3.1.13. Laboratory of Fluid Mechanics. (N°106)

Fluid mechanics lab is place dedicated to having experiments and researches on the properties and behavior of fluids both liquids and gases.

Figure 14: Laboratory of Fluid Mechanics

2.1.3.2. Administrative and office activities

Administrative work relies heavily on paper, such as exams, printouts, documents, and forms.

2.1.3.3. Teaching and student activities

Students are the main source of waste, and therefore education and its activities cause the formation of this waste in several forms, including: paper, food, food packaging, aluminum, and plastic.

2.2. Overview of the methodology

2.2.1. Brief description of the approach used to conduct the waste survey

The waste scanning process was done by collecting waste from each source separately (laboratories, classrooms, administration) in the traditional way using LDPE plastic bags. This type of bag was specifically chosen for its durability and ability to withstand heavy loads without tearing. Administration waste is collected first, followed by laboratory waste, and then classroom waste, all separated. This is done at the end of the last shift each day, to ensure the appropriate amount of waste produced for the day is collected.

2.2.2. Time frame of the survey

The study lasted for 15 days, with daily work to collect waste produced from laboratories, classrooms, offices and administration, then analyze it, separate each type and then calculate their weight to determine the quantity of each type so that in the future we can develop solutions
and methods for recycling and valuing this waste.

2.3. Waste characterization:

2.3.1. Glass

Glass is clearly and extensively used in laboratories and mistakes are bound to occur indirectly which may lead to the breakage of these glass tools. This is what was concluded after collecting laboratory waste, you can see the broken glass collected as shown in the picture below.

Figure 15: broken glass equipment

2.3.2. Paper

As we know, paper in all its forms is widely used in bureaus, laboratories and classrooms. In terms of the amount collected in 15 days, paper was the heaviest type of waste.

Figure 16: paper

2.3.3. Carton

Cartons were produced in large quantities in laboratories and administration, so that in laboratories they use toilet paper significantly, which has a cardboard lining inside. There are also food cartons such as (juices, tea, chemical yeast) in addition to cardboard boxes to store certain samples in the laboratory. As for administration bureaus, the entire carton collected were carton containing paper

packages.

Figure 17: carton

2.3.4. plastic

Plastic was significantly produced in administration bureaus, classrooms, and laboratories, but the largest production occurred in laboratories. The plastic collected came in a variety of forms, including bags, water bottles, gloves, and sample containers used in the biochemistry and microbiology lab.

Figure 18: plastic

2.3.5. E-waste

Electronic waste was almost non-existent, the only thing collected in 15 days was this piece of a printer, as shown in the picture below.

Figure 19: Part of a printer

2.3.6. Aluminum

Aluminum was most prominently found in laboratory bins and classrooms. Students and engineers brought their own foil-wrapped food and soda cans to the labs, and aluminum foil was also used in
the labs to wrap samples and contaminated waste that could be infectious.

Figure 20: Aluminum

2.3.7. Contaminated waste

The contaminated waste was minimal and originated from the biochemistry and microbiology laboratory. It consisted of IV injector and standard syringes, needles, and samples containing ear swabs used for specific testing.

Figure 21: Contaminated waste

2.3.8. Organic waste

Organic waste was present in varying proportions in laboratories, classrooms, and administration areas. However, the largest source was the laboratories, due to the large number of students and engineers who spend significant amounts of time working. This organic waste were food scraps, fruit, vegetables, and eggs peels, and juice. Therefore, the presence of food and organic waste was likely to be higher, as was the case in classrooms.

Figure 22: Organic waste

2.4. Materials used

2.4.1. Scales for weighing

two types of scales were used to weigh the waste. The first was an electronic portable scale, which was relied on mainly to weigh heavy waste. As for the second scale, it was a home electronic scale that can weigh anything up to 5 kg. This is for weighing small wastes that do not constitute large quantities to obtain an accurate result.

Figure 23: home digital electronic scale

2.4.2. Waste bins and sorting

Waste collection containers were handled in the traditional way (collecting waste in bags), and there were no sorting containers in the Process Engineering Department. A waste collection point is nonexistent and has not yet been implemented. Plastic waste containers are distributed throughout all offices, classrooms, and laboratories. After being collected by the janitors, waste is not placed in a single waste collection point within the department building, but rather is disposed of in a large metal waste container.

2.4.3. Personal protective equipment (PPE) for safety

Protection is critical when handling laboratory waste, as it can be highly contaminated and hazardous. As a precaution and to ensure safety, thick leather gloves were used to collect, sort, and
identify the waste. A lab coat was also used.

Figure 26: safety lab gloves

Figure 25: lab coat

2.5. waste from source to final destination

As mentioned earlier, waste sources vary, from student activities in classrooms and laboratories to administrative and office activities, for which department professors and staff are responsible.

Nearly all waste is destined for the technical landfill center, where a waste collection truck passes by when they are informed that the container is full. Liquid and solid chemical waste from laboratories are collected by a specialized company called **GREEN SKY** based on an agreement with the department management.

2.6. Waste management in the Process Engineering Department

2.6.1. Waste disposal

Waste disposal is easy and occurs in the traditional way in classrooms, administration offices, and laboratories. Waste is disposed of in trash cans and then collected in a large container outside the department building. However, there is an exception regarding the handling of hazardous solid waste in laboratories. Based on a survey distributed to laboratories, it concludes that 90% of engineers and students had not received prior training on hazardous waste disposal and how to handle it after disposal. As a result, hazardous and special waste is thrown into trash cans, which in turn are mixed with general department waste. This leads to an increase in the proportion of hazardous waste due to its regular mixing with hazardous and special waste.

2.6.2. Waste recycling and valuation in the department

There is no form of recycling, whether at the level of laboratories, administration, or classrooms, nor even waste valuation. This is considered bad because there are all forms of waste that we can benefit from, whether through recycling, reusing, or disposing of in more appropriate ways that do not negatively affect the environment and the population.

Chapter 3. Results and discussion

Chapter 3. Results and discussion

3.1. Results

3.1.1. Breakdown of waste disposed in the Department of Process Engineering

The percentage of waste collected varies, with laboratory waste coming first, then classroom waste, then administration waste, in order from largest fraction to smallest. As shown below in Figure (27).

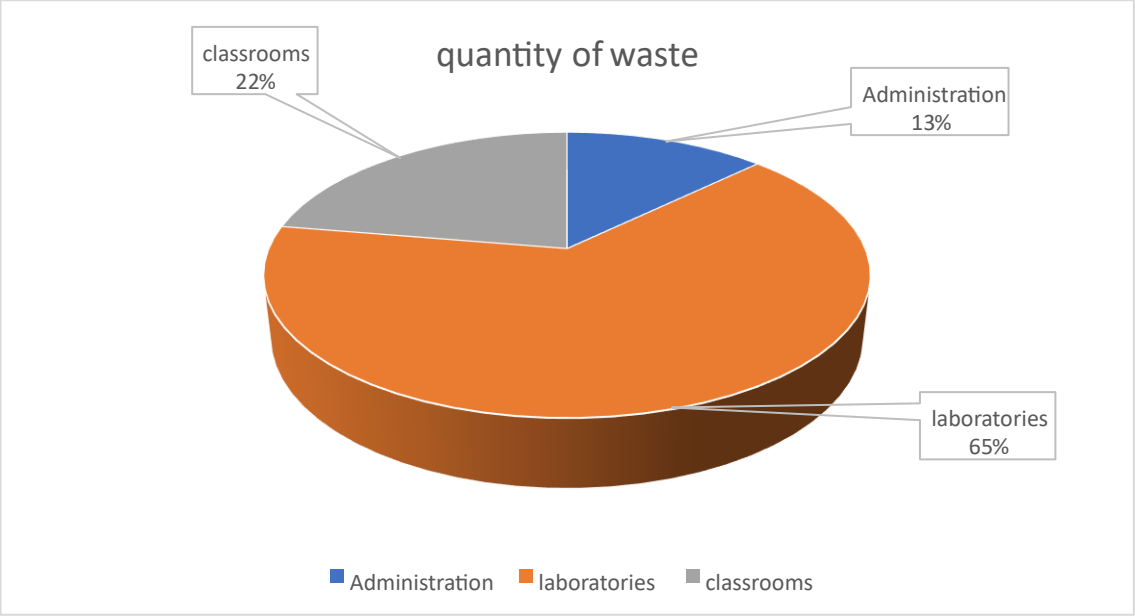

Figure 27: Breakdown of waste disposed in the Department of Process Engineering

Waste of administration

- The amount of waste collected from the administration and offices in 15 days was 14.675 kg, which was the least heavy of the waste collected from the department building.

Waste of laboratories

- The amount of waste collected from both educational and research laboratories reached 74.251 kg in 15 days, which was the highest in weight among the waste collected from the department building.

29 **Waste of classrooms**

- The amount of waste collected from classrooms in 15 days was 25.621 kg, despite the fact that there are only 6 classrooms.

3.1.2. Daily waste disposal report for 15 days

3.1.2.1. Waste disposal evaluation during the first week

The table below shows the amount of administrative, laboratories and classrooms waste (unit kg) produced by the Process Engineering Department daily during the first week:

Table 3: The amount of waste collected in the first week

Day\ services	Administrative	laboratories	classrooms
Day 1	0.55	12.145	4.125
Day 2	1.39	8.335	1.735
Day 3	1.35	6.195	1.845
Day 4	0.3	4.57	1.255
Day 5	0.835	4.1	1.175
Day 6	1.051	2.977	0.385
Day 7	0.58	2.455	0.985
Total	6.056	40.777	11.507

1. The amount of administrative waste was small, as the largest weight produced was 1.39 kg/day;

2. The amount of laboratory waste was the largest of all, but it was decreasing day after day, so that the largest mass collected was 12.145 kg/day on the first day, and we note that on the last day of the week it was 2.455 kg/day;
3. The amount of classroom waste varied, with the maximum mass on the first day being 4.125 kg and the minimum being 385 kg/day;

3.1.2.2. Waste disposal evaluation during the second week

The table below shows the amount of administrative, laboratories and classrooms waste (unit kg) produced by the Process Engineering Department daily during the second week:

Day\ services	Administrative	laboratories	classrooms
Day 8	1.34	4.118	2.95
Day 9	2.217	6.201	1.802
Day 10	1.355	5.38	3.107
Day 11	0.89	3.875	1.12
Day 12	0.56	4.166	1.635
Day 13	0.7	4.783	0.925
Day 14	0.725	3.15	1.753
Day 15	0.7	1.921	0.822
Total	8.487	33.594	14.114

Table 4: The amount of waste collected in the second week

1. In the second week, most days, administrative waste did not exceed 1kg, except on three days, and the maximum weight collected from the administration was 2.217 kg/day;

2. The amount of waste collected from laboratories ranged between 3 and 6 kg, except for

   the last day, which had the lowest weight of 1.921 kg;

3. The amount of waste collected from classrooms ranged between 1 and 3 kg, with the smallest weight being on the last day, weighing 0.822 kg;

3.1.3. Composition of waste collected from the administration

The administration consists of several service rooms and offices that produce different wastes as shown in the table below:

Table 5: Composition of waste collected from the administration

Waste type	cardboard	organic	plastic	aluminum	paper	Total
weight	4.55	0.402	3.035	0.25	6.438	14.675

- The quantity of paper and cardboard produced was the largest due to the administration's work related mainly to paper and cardboard, with the total weight of paper being 6.438 kg and cardboard 4.55 kg
- The amount of plastic was also close to that of paper and cardboard, with a total weight of

  3.035 kg.

- The amount of aluminum and organic waste was very small, as the total weight of aluminum was 0.25 kg and organic waste was 0.402 kg.

3.1.3.1. Percentage of total waste composition collected from the administration

Waste in administration is diverse and of varying proportions, as shown in Figure (28)below.

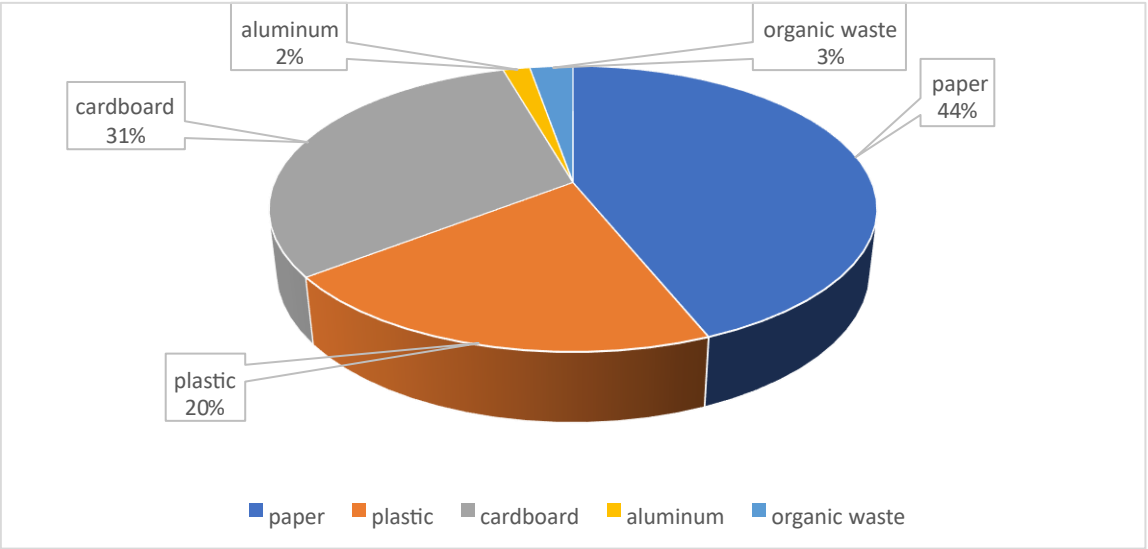

Figure 28:Percentage of total waste composition collected from the administration

3.1.4. Composition of waste collected from the classrooms

There are six classrooms in the department. Waste collected from these classrooms was no different from the administration's waste, as the same compositions were present in varying quantities, as shown in the table below.

Table 6: Composition of waste collected from the classrooms

Waste type	cardboard	organic	plastic	aluminum	paper	Total
weight	3.729	1.983	6.669	0.587	12.653	25.621

- The quantity of paper and plastic produced was the largest Because of the students' activity, they use a lot of water bottles, juice bottles, and plastic bags. Students attend classes and study using paper, and also in tests, draft paper is consumed in large quantities. The total weight of paper was 12.653 kg and plastic's 6.669 kg.
- The quantity of cardboard produced was made up of cardboard juice boxes, which were available in abundance, and also cardboard cups, which had a total weight of 3.729 kg.
- The amount of aluminum and organic waste is small compared to the types we talked about previously, where the total weight of aluminum was 0.587 kg and the total weight of organic waste was 1.983 kg.

3.1.4.1. Percentage of total waste composition collected from the classrooms

Waste in classrooms is diverse and of varying proportions, as shown in Figure (29)below.

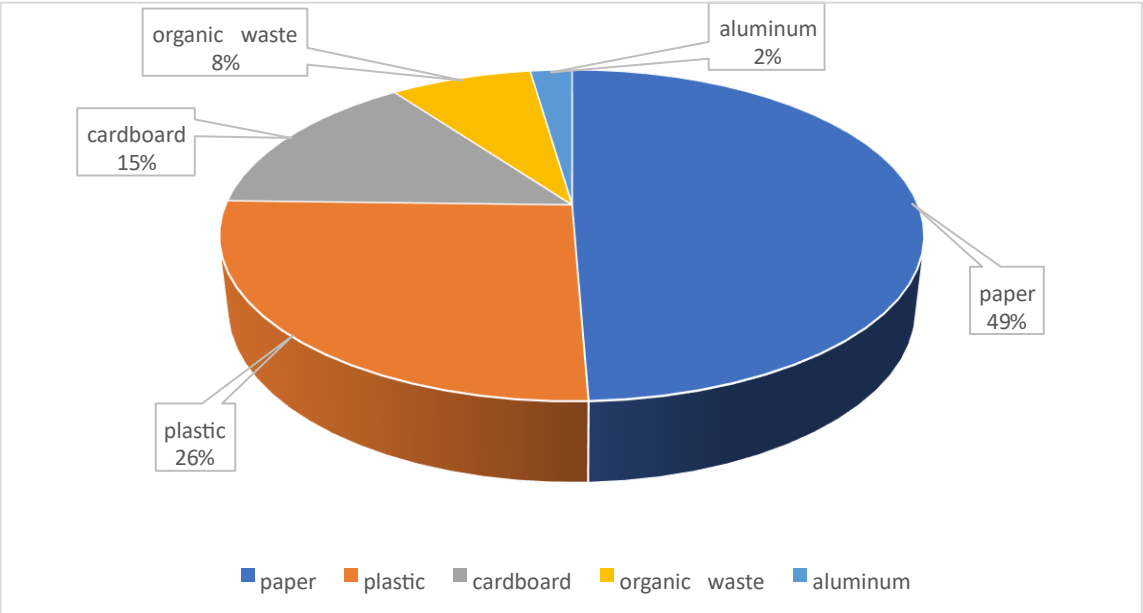

Figure 29: Percentage of total waste composition collected from the classrooms

3.1.5. Composition of waste collected from the laboratories

The waste collected from laboratories has varied due to the variety of chemical research, processes, and various studies conducted by students and engineers, as shown in the table below.

Table 7: Composition of waste collected from the laboratories

Waste type	cardboard	organic	plastic	Aluminum	paper	algae	glass	E-waste	Contaminated waste	total
weight	11.335	7.025	14.586	3.474	27.673	0.457	8.619	0.465	0.617	74.251

- The amount of paper waste in its various forms was the largest among the other types due to its frequent use in laboratories, and it weighed 27.673 kg.
- The amount of plastic and cardboard was also significant, as the weight of the plastic was 14.586 kg and the weight of the cardboard was 11.335 kg.
- Significant amounts of glass and organic waste were present. Broken laboratory glassware and glass samples weighed 14.586 kg, as for the organic waste, it was the leftover food of
  students and engineers who work for hours in the laboratories, which weighed 7.025 kg.
- Aluminum was so abundant that it was used as a packaging for food, some contaminated waste, and bacterial samples, which weighed 3.474 kg.
- The amount of algae, contaminated waste, and electronic waste was the least. The weight of algae was 0.457 kg, the weight of contaminated waste was 0.617 kg, and the weight of electronic waste was 0.465 kg.

3.1.5.1. Percentage of total waste composition collected from the laboratories

Waste in labs is diverse and of varying proportions, as shown in Figure (30) below.

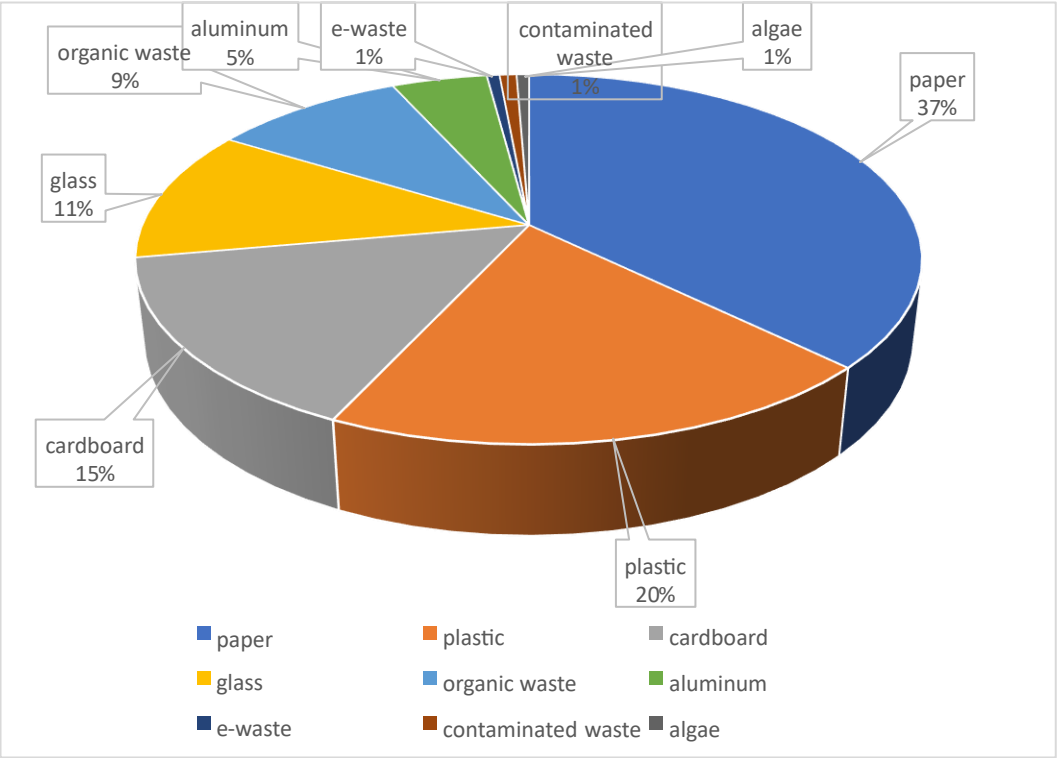

Figure 30: Percentage of total waste composition collected from the laboratories

4.2. Discussion

- Based on the information collected, laboratory waste was the heaviest in weight compared to other waste streams due to the large number of laboratories and the activities of students and engineers in them, with the total weight in 15 days being 74,251 kg. As for the waste classification, paper represents the highest fraction of all at 37%, followed by plastic at 20%, cardboard at 15%, glass at 11%, organic waste at 9%, aluminum at 5%, and other wastes (electronic waste, polluted waste, and algae) at 3%.

- The waste collected from the administration and offices does not pose a hazard like laboratory waste. The amount collected in 15 days was not significant due to the lack of waste-generating activities in the administration, with the total weight being 14,675 kg. Regarding waste classification, paper represents the highest fraction with 44%, followed by cardboard at 31%, plastic at 20%, organic waste at 3%, and aluminum at 2%.

- The waste collected from the classrooms was of average weight due to the students' active participation in the classrooms, where they are tested and taught. The total weight collected from the classrooms was 25.621 kg. As for the waste classification, paper represents the highest fraction with 49%, followed by plastic at 26%, cardboard at 15%, organic waste at 8%, and aluminum at 2%.

Conclusion

Conclusion

University campuses are dynamic environments that generate substantial amounts of waste due to their academic, research, residential, and commercial endeavors. As institutions that influence public knowledge and social conduct, universities possess both a responsibility and a singular chance to pioneer in sustainable waste management. Never the less, numerous till encounter crucial hurdles, encompassing in adequate waste segregation, lack of infrastructure, deficient awareness, and limited funding for proper waste treatment systems.

When waste is mis-managed, the ramifications extend beyond campus borders. Incorrect disposal methods can lead to the contamination of water sources through leachate, degradation of soil due to hazardous and electronic waste, and air pollution from open burning or methane emissions from organic waste. These environmental dangers not only harm ecosystems but also affect the health and well-being of students, personnel, and surrounding communities.

Implementing effective waste treatment strategies — such as recycling programs, composting of organic waste, anaerobic digestion, chemical neutralization of hazardous materials, and safe disposal of e-waste — can significantly diminish these impacts. Furthermore, integrating environmental education into campus life and involving students in sustainability initiatives can further reinforce positive waste behaviors and long-term cultural shifts.

In conclusion, university waste management is not merely an operational concern, but a vital element of environmental responsibility and institutional leadership. By investing in sustainable waste treatment systems and promoting a campus-wide commitment to waste reduction, universities can serve as role models for the wider society. In doing so, they contribute to local environmental health, meet global sustainability aims, and prepare future leaders to address environmental challenges with knowledge and accountability.

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The Annexes

- (Official Journal of the Algerian Republic, 2006): Executive Decree No. 06-104 of 29 Muharram 1427, corresponding to February 28, 2006, establishing the waste classification system, including hazardous waste.

- (Official Journal of the Algerian Republic, 2006): Executive Decree No. 05-314 of 6 Chaâbane (J.O.A) of September 26, 1426, corresponding to Law No. 01-19 of December 12, 2001, relating to the management, control, and disposal of waste.

- (Official Journal of the Algerian Republic): Executive Decree No. 03-478 (J.O.A) Defining the Management Procedures for Healthcare Activities.

  - Survey in the two pictures below.

Questionnaire sur la méthode d'élimination des déchets chimiques et dangereux générés par les laboratoires استبيان حول طريقة التخلص من النفايات الكيميائية والنفايات الخطرة الناتجة عن المختبرات/

1- Quelle est votre spécialité d'étude? / ما هو تخصصك الدراسي؟

- ◯ Génie chimique / الهندسة الكيميائية
- ◯ Génie environnemental / الهندسة البيئية
- ◯ Pharmacie industrielle/ الصيدلة الصناعية
- ◯ Génie des polymers / هندسة البوليمرات
- ◯ Génie des matériaux / هندسة المواد
- ◯ Autre / أخرى .....

2- Quels types de déchets chimiques ما هي أنواع النفايات الكيميائية التي تتعامل معها؟ (اختر كل ما ينطبق) / traitez-vous ? (Sélectionnez tout ce qui s'applique)

- ◯ Solvants / مذيبات
- ◯ Acides/ أحماض
- ◯ Bases/ قواعد
- ◯ Matériaux radioactifs / مواد مشعة
- ◯ Substances toxiques/ مواد سامة
- ◯ Autre / أخرى.....

3- Comment éliminez-vous les déchets chimiques dans/ votre laboratoire? كيف تتخلص من النفايات الكيميائية في مختبرك؟

.....
.....
.....
.....
.....
.....
.....

4-Avez-vous été formé à la gestion des déchets / chimiques? هل تم تدريبك على كيفية التعامل مع النفايات الكيميائية؟

Oui / نعم

Non / لا

(Si oui, veuillez expliquer en détail.)

.....

.....

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.....

.....

.....

5-Quels sont les défis que vous rencontrez / dans l'élimination des déchets chimiques? ما هي التحديات التي تواجهها في التخلص من النفايات الكيميائية؟

.....

.....

.....

.....

.....

.....

Nom:

Prénom:

La date: