Environ Res Tec, Vol. 8, Issue. 4, pp. 823-831, December 2025

Environmental Research and Technology
https://dergipark.org.tr/en/pub/ert
DOI: https://doi.org/10.35208/ert.1545330

Environmental Research & Technology

Research Article

Assessment of industrial waste management practices: a case study of Henkel Reghaïa (Algeria)

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ARTICLE INFO

Article history
Received: 09 September 2024
Revised: 10 November 2024
Accepted: 16 December 2024

Key words:
Algeria, Henkel Reghaïa, industrial waste, sustainability, waste management

ABSTRACT

Waste management in the liquid detergents and bleaching agents production unit of Henkel in Reghaïa, Algeria, has been thoroughly examined. The study is based on rigorous waste collection and quantification, as well as a survey conducted among the company's employees and managers. The results indicate a predominant distribution of waste in the categories of cardboard, construction waste, and plastics, with the hierarchy of waste types influenced by industrial activities. The analysis of employees' knowledge and practices reveals significant gaps in the management of special waste and selective sorting, underscoring the importance of awareness and training. The managers, on the other hand, acknowledge the need for better organization and a more proactive strategy for sustainable waste management. The study conducted during this survey questions concludes that additional efforts are needed to enhance waste sorting, increase staff awareness, and implement waste management practices that comply with international environmental standards.

Cite this article as: Keddari D, Boutouatou F, Boumezbeur I, Zouidi M, Sebbih A, Kemoukh R, Seghiri M, Harkat I, Smatti-Hamza I. Assessment of industrial waste management practices: a case study of Henkel Reghaïa (Algeria). Environ Res Tec 2025;8(4) 823-831.

INTRODUCTION

Human interactions with the environment affect both biotic and abiotic elements. Pollution, driven by high concentrations of harmful substances, deteriorates air, water, and soil quality, and significantly affects human health. Although the industrial revolution has brought about technological and social advancements, it has also introduced numerous pollutants.

Currently, environmental pollution is a major public health issue, responsible for approximately 9 million deaths annually worldwide according to the WHO [1]. Waste management has become a critical concern for industries that now face increasingly stringent legal obligations. While waste has always existed, the growing scale of production and consumption has increasingly turned waste into a significant environmental challenge. The ideal waste management approach is

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one where waste is minimized, ideally prevented from being produced altogether, as part of the transition to more sustainable practices. Although waste has always existed, it has increasingly become a source of nuisance over time. Furthermore, the modernization of lifestyles has led to the emergence of waste that cannot be naturally integrated into the material cycle [2-4]. In this context, the issue of waste, its management, and its associated nuisances have consistently been at the forefront of criticism. Since the early 2000s, Algeria has committed to improving environmental quality and enhancing citizens' living conditions. Significant efforts have been made towards integrated and efficient waste management. However, the observed deficiencies indicate that current measures need reinforcement for the country to advance towards a circular economy, which is expected to be a crucial lever for economic growth [5-8].

According to a GIZ study (Deutsche Gesellschaft für Internationale Zusammenarbeit), Algeria produces approximately 2,547,000 tonnes of industrial waste annually. This includes around 1.2 million tonnes of packaging and plastic waste, over 2 million used tires, 110,000 tons of oil and lubricants, and 173,800 tons of electronic, electrical, and household waste [5, 9].

To address waste management challenges, Algerian authorities have implemented several measures, including laws n°1-19 of 2001 on waste management and n°03-10 of 2003 on environmental protection. Prioritizing the valorization of industrial waste through recycling and reuse, initiatives such as the National Program for Industrial and Special Waste Management (PNAGDES) launched in 2006 aim to promote waste management-related professions and establish collection, transportation, aggregation, treatment, and valorization channels [10-12].

Beyond environmental protection, these actions also aim to enhance Algeria's economic dimension by reducing its external financial dependency. Waste recovery and recycling contribute to substituting imports for local production, thereby optimizing available productive resources and encouraging investment and business creation [10, 13-15].

Waste management has become a global research domain that addresses various types of natural and human waste. This management aims to limit environmental impacts at each stage, from collection to disposal, thereby avoiding water, air, and soil pollution. In Algeria, waste management is critical for industries, particularly those producing detergents and adhesive products, because of the strict environmental legislation and the potentially hazardous nature of their waste [15-17].

Henkel, operating in Algeria since 2000 in the detergent, cleaning products, and adhesive technologies sectors, has faced significant challenges in waste management. As production units spread across several Algerian cities, integrated and effective waste management is essential [18]. To manage these wastes, it is crucial to inventory the types and quantities of waste generated; determine collection, sorting, and potential valorization methods; and define appropriate treatment processes. These issues require a systematic approach that aligns with both international and local environmental standards [14, 18, 19].

Industrial waste management, particularly in the detergent and chemical manufacturing sectors, plays a crucial role in reducing environmental impacts and promoting sustainability. According to Chaouachi and Balsalobre-Lorente [7], efficient waste management strategies involve waste reduction, recycling, and the adoption of cleaner production technologies. These strategies not only help mitigate pollution but also contribute to the economic and environmental sustainability of the industrial sector.

Several studies have examined industrial waste management in various regions. For instance, Dahmane et al. [14], conducted a similar study in Algeria particularly in Oran that focused on waste management strategies using a circular economy approach, highlighting significant challenges related to recycling and waste segregation in industrial settings, including detergent production. Other studies, such as Al-Maaded et al. [5], have investigated the plastic recycling industry waste management practices in Qatar and identified gaps in current regulatory frameworks, particularly regarding plastic waste management and recycling technologies. These studies underscore the importance of improving waste management practices to address growing environmental concerns.

In Algeria, waste management, particularly in the industrial sector, faces several challenges. These include inadequate waste segregation practices, limited recycling infrastructure, and a lack of stringent enforcement of environmental regulations. This situation is exacerbated by the rapid growth of industrial sectors such as detergent production, which generates large quantities of diverse waste materials. These challenges highlight the need for research aimed at improving waste management practices within Algerian industries

This study is necessary because it addresses the specific waste management practices within Henkel's production unit in Reghaïa, a case that has not been explored in the existing literature. While global studies on industrial waste management in detergent production are available, there is a clear gap when it comes to understanding the specific waste management challenges faced by Algerian companies, especially within the context of national regulations and environmental concerns

The aim of this study was to evaluate waste management practices within Henkel's liquid detergent and bleaching agent production unit in Reghaïa, to create a comprehensive inventory of the waste produced by this unit, and to identify opportunities for improvement in industrial waste management. The contribution of this study lies in its focus on Henkel Reghaïa, offering a unique case study in an Algerian context where limited research has been conducted. Our findings provide practical insights into the types of waste produced, the current management practices, and the opportunities for improvement. By proposing tailored strategies for waste reduction and better management practices,

this study bridges the gap between industrial practices and sustainable environmental policies, supporting the need for more effective waste management regulations.

MATERIALS AND METHODS

Company Overview and Reghaïa Site Description

Henkel, a German chemical company established in 1876, is a global leader in detergents, home products, personal care, and adhesive technologies. A company's core mission is to deliver brands and technologies that simplify, enhance, and enrich everyday life. Henkel Algeria, the local subsidiary, achieved its first certifications in December 2005 for ISO 9001 "Quality Management System" and ISO 14001 "Environmental Management System," with renewals in 2009 and 2015, reflecting the company's significant advancements. The Reghaia site, which encompasses an area of 7 hectares, is a crucial component of Henkel's operations in Algeria (Figure 1). Located to the south of the Alger-Constantine railway and north of National Road No. 5, the site was initially established by ENAD in 1960. It transitioned to a partnership in 1995, before Henkel acquired full ownership in 2002. Specializing on the production and commercialization of liquid detergents and bleach, the Reghaïa site has an annual production capacity of 125,000 tons and employs 278 staff members is from 2022. The Reghaïa facility adheres rigorously to the SHEQ policy (Safety, Health, Environment, and Quality) and is certified under four standards: ISO 9001 for quality management, ISO 14001 for environmental management, ISO 45001 for occupational health and safety, and ISO 50001 for energy management.

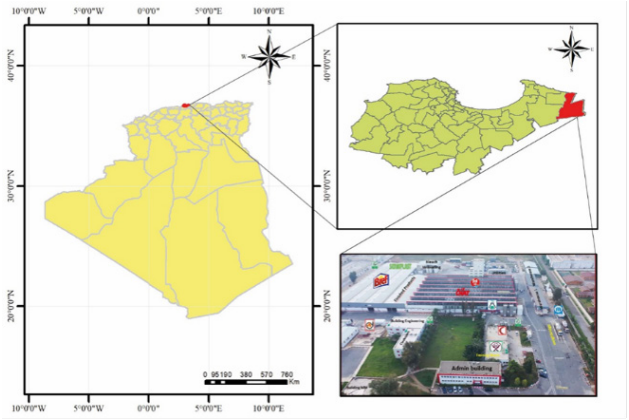

Figure 1. Geographical location of the study area (Henkel Company)

Waste Collection and Quantification

The waste generated by Reghaïa was categorized into six distinct groups: cardboard, construction waste, general waste (including non-recyclable materials such as food waste and non-reusable packaging), plastics, metals, and wood waste. Waste quantification was conducted through daily measurements at certified industrial scales, which facilitated the precise analysis of variations. Among these categories, general waste encompasses non-recyclable materials or those that do not fit neatly into other specified categories, such as mixed office waste, food waste, and unsuitable packaging. In contrast, construction waste includes leftover building materials like concrete and bricks, while metal waste consists of scrap metals from damaged or unused equipment, packaging, and other metallic components generated during production and maintenance processes.

Survey and Data Analysis

In 2022, a survey was conducted within Henkel Reghaïa involving 250 participants, including employees and managers across eight departments. The primary objective was to assess the participants' knowledge and engagement in waste management practices, focusing on critical aspects such as sorting, the 3Rs (Reduction, Reuse, Recycling), and foundational training.

Two distinct questionnaires were developed for this survey: one with 220 employees and another with 30 managers. The employee questionnaire encompassed seven key variables to evaluate employees' knowledge and practices regarding waste management. This included closed-ended questions (yes/no), cafeteria-style questions, probing questions for in-depth responses, and open-ended questions for detailed information. Concurrently, the manager questionnaire aimed to establish a comprehensive overview of current waste management practices, while encouraging the adoption of approaches that are economically feasible, environmentally sustainable, and socially acceptable.

The data collected from these questionnaires were analyzed using R software (version 4.2.3; R Core Team, 2023) and RStudio (RStudio Team, 2024), with the goal of identifying gaps in the understanding and application of waste management principles.

RESULTS AND DISCUSSIONS

Identification of Waste Quantity Generated by Henkel Reghaïa

The analysis of waste generated by Henkel Reghaïa in 2022 revealed a distinct distribution across various waste categories. The majority of the waste produced consists of cardboard (40%), followed by construction waste (20%), general waste (15%), plastics (14%), metals (10%), and wood waste (1%) (Figure 2). This hierarchy in waste quantities is attributable to the nature of the company's operations. Cardboard and construction waste, being the most voluminous, result from frequent usage, rapid replacement cycles, urbanization, and the associated management and recycling challenges, as highlighted by Tam et al. [20] and Radu and al [21].

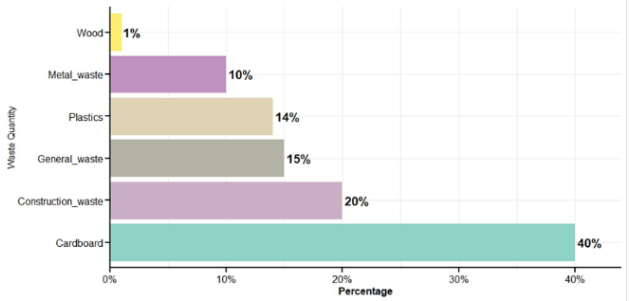

Figure 2. Distribution of collected waste by category in Henkel Reghaïa for 2022

Estimation of Different Types of Waste in the Company

Survey results from employees indicated that over 34% considered waste as residual matter, while 30% perceived it as a refuse (Figure 3). This perception directly influences employees' waste management practices. According to Ajzen [22], attitudes and behaviors are shaped by beliefs and perceptions, underscoring the importance of awareness in transforming perceived waste into potential resources. Agovino et al. [23] demonstrated that awareness of waste management can alter such perceptions.

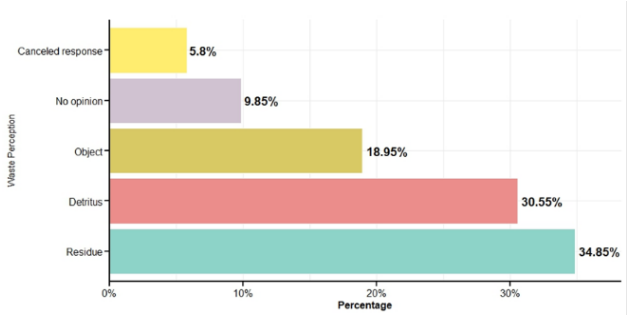

Figure 3. Estimation of waste percentage based on employee perceptions in Henkel Reghaïa

Assessment of Employees Knowledge and Practices in Waste Management

Employees knowledge of different types of waste

The evaluation of employees' knowledge regarding various waste types revealed that while more than half were familiar with household waste, their understanding of hazardous, medical, and special waste was inadequate (Figure 4). This gap may hinder effective waste management, particularly for special wastes that require specific handling.

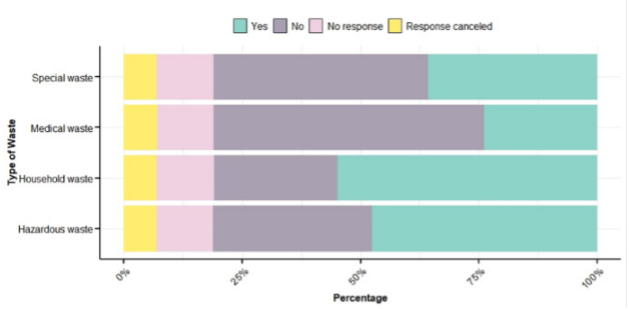

Figure 4. Employees knowledge of different types of waste in Henkel Reghaïa

Perception of actions and measures for reducing special waste

The results show that 50% of employees were unaware of measures to reduce special waste (Figure 5). Source reduction is critical for effective waste management. Training is essential to enhance these practices, as emphasized by Hopewell et al. [24].

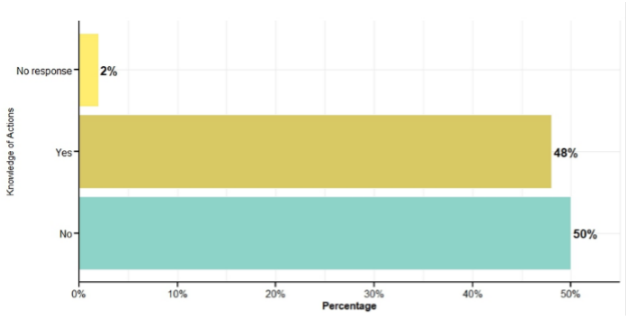

Figure 5. Employees knowledge of actions and measures to reduce special waste in Henkel Reghaïa

Perception of selective waste sorting

Selective sorting is practiced by approximately 23.5% of employees, whereas 3% do not engage in it (Figure 6). Effective selective sorting is fundamental to improving the quality of recyclable materials, as noted by Kaza et al. [2].

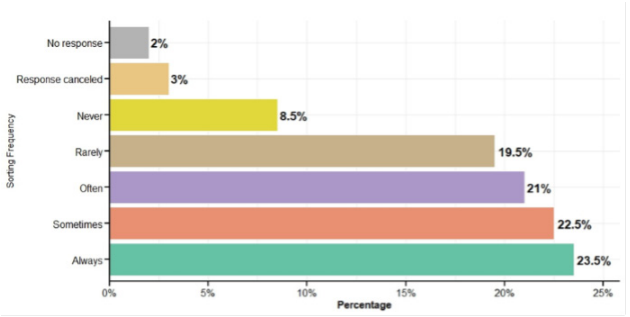

Figure 6. Frequency of waste sorting across departments in Henkel Reghaïa

Basic training for employees in waste management

The training provided to employees on waste management was generally inadequate, with 70% having not received proper training (Figure 7). According to Zorpas and Lasaridi [25], adequate training is crucial to improve waste management and reduce waste generation.

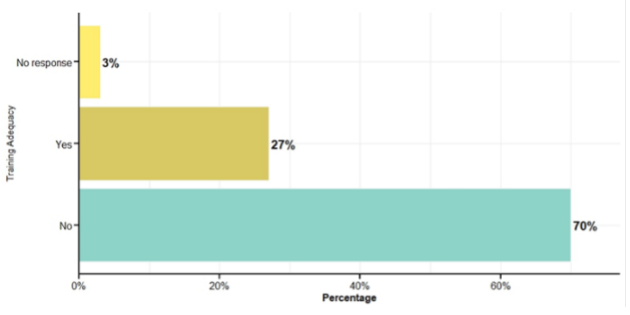

Figure 7. Training of employees in waste management in Henkel, Reghaïa

Availability of adequate resources for effective management of special waste

A significant proportion of the employees (60%) believed that the resources available for managing special waste were sufficient (Figure 8). However, there is room for improvement in terms of capabilities and resources, as indicated by Scott and Davis [26].

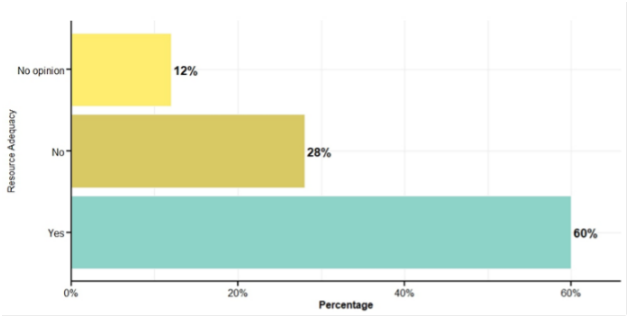

Figure 8. Availability of resources for better waste management in different departments in Henkel Reghaïa

Results of the Managerial Questionnaire

The managerial questionnaire aimed to gather perspectives from Henkel Reghaïa 's managers on waste management, highlighting the current practices, challenges, and areas for improvement. The results revealed a range of viewpoints, with a consensus on the importance of awareness campaigns and adherence to waste management procedures (Table 1).

According to the managers, significant SHEQ policy (Safety, Health, Environment, and Quality) improvements were implemented in the waste storage area at Henkel Reghaïa in 2022. Previously, the storage bins were unlabeled, and the waste storage area was poorly organized (Figure 9). Currently, however, waste is stored in a dedicated, well-ventilated facility, sheltered from the elements, where it is properly sorted and placed in clearly labeled bins according to its type. These measures have led to a significant improvement in the company's overall waste management practices.

In summary, while waste valorization is an upstream solution to disposal, the findings highlight the critical need to enhance selective sorting and increase staff awareness for more sustainable waste management. These observations align with the recommendations of Velenturf and Purnell [27] and Awewomom et al. [28], which emphasize the importance of corporate engagement in environmental sustainability.

Improvement Pathways

To maintain competitiveness and ensure long-term sustainability, companies must integrate the management of all environmental impacts into their strategic planning. Employee and manager participation is essential, as a participatory approach is key to achieving strategic objectives.

Table 1. Analysis of responses from Henkel Reghaïa managers regarding waste management

Question Category	Analysis of Responses
What does waste management represent for companies ?	Most managers (65%) view waste management as an environmental concern, reflecting an increased awareness of ecological issues. Approximately 25% viewed it as a regulatory burden, while the remainder viewed it as a contribution to environmental protection.
Is there a waste management department in the company ?	62% of managers were aware of a dedicated waste management department with trained personnel responsible for awareness. About 10% believed that a service provider handles waste collection.
Which types of waste pose management problems for the company ?	80% of managers identified special waste, particularly hazardous waste, as a major issue for both internal and external treatment. Others consider households and similar waste to be more problematic.
Do managers know the quantities of waste produced ?	85% of managers are aware of the quantities of waste produced by using inventory records and weighing methods. The remaining 15% do not directly track waste quantities but rely instead on invoices from collectors and external treatment agencies for this information.
How can preventive actions be developed ?	52% of managers confirmed that prevention actions can be achieved by reducing packaging, minimizing waste, and reusing materials.
Has the company developed initiatives for recycling ?	67% of managers do not intend to develop recycling initiatives, whereas 33% are exploring external recycling channels and view selective sorting, training, and employee involvement as priorities.
Are there sufficient means for sustainable management ? If so, how ?	80% of managers confirmed the presence of necessary means for sustainable management, primarily through awareness campaigns, implementation of waste management procedures, acquisition of appropriate equipment, and allocation of a budget for the safe disposal of special waste.

Figure 9. Storage area at Henkel Reghaïa in 2022, following improvements for better organization and identification of stored waste

Waste management has become a global necessity for companies to remain competitive. This includes adapting to regulatory changes, rising treatment costs, and constraints imposed by clients. Studies have highlighted several benefits of adopting a comprehensive waste management approach, including:

- Understanding waste flows and volumes,
- Managing financial aspects,
- Meeting or anticipating regulatory requirements,
- Enhancing economic performance by reducing costs associated with collection, transport, and disposal, and strengthening the company's ecological reputation.

A sustainable waste management plan encompasses several key phases (Figure 10).

Phase I: Understanding Waste: Assess the types, quantities, and environmental risks of waste to improve management practices.

Phase II: Understanding Regulations: Monitor and comply with legal requirements for waste management to avoid regulatory risks.

Phase III: Identifying Weaknesses: Using insights from the previous phases, identify areas for improvement, such as non-compliance, reduction opportunities, and employee engagement.

Phase IV: Developing an Action Plan: Prioritize and implement corrective actions with scheduled timelines, necessary resources, and continuous monitoring.

Phase V: Evaluating Actions: Use measurable indicators to assess improvements and plan future actions for enhanced performance.

Phase VI: Implementing the 3RV-E: Prioritize waste reduction, reuse materials when possible, and recycle waste into secondary raw materials before final disposal.

Effective selective sorting at the source, along with comprehensive staff training and engagement, is crucial for optimizing waste valorization and reducing waste volumes. Companies must take responsibility for their environmental impact by respecting ecological balance and preserving natural ecosystems. This can be achieved through resource optimization, minimizing waste, and ensuring the sustainability of renewable resources.

In summary, sustainable waste management is not only a corporate responsibility but also essential for long-term environmental protection and public health.

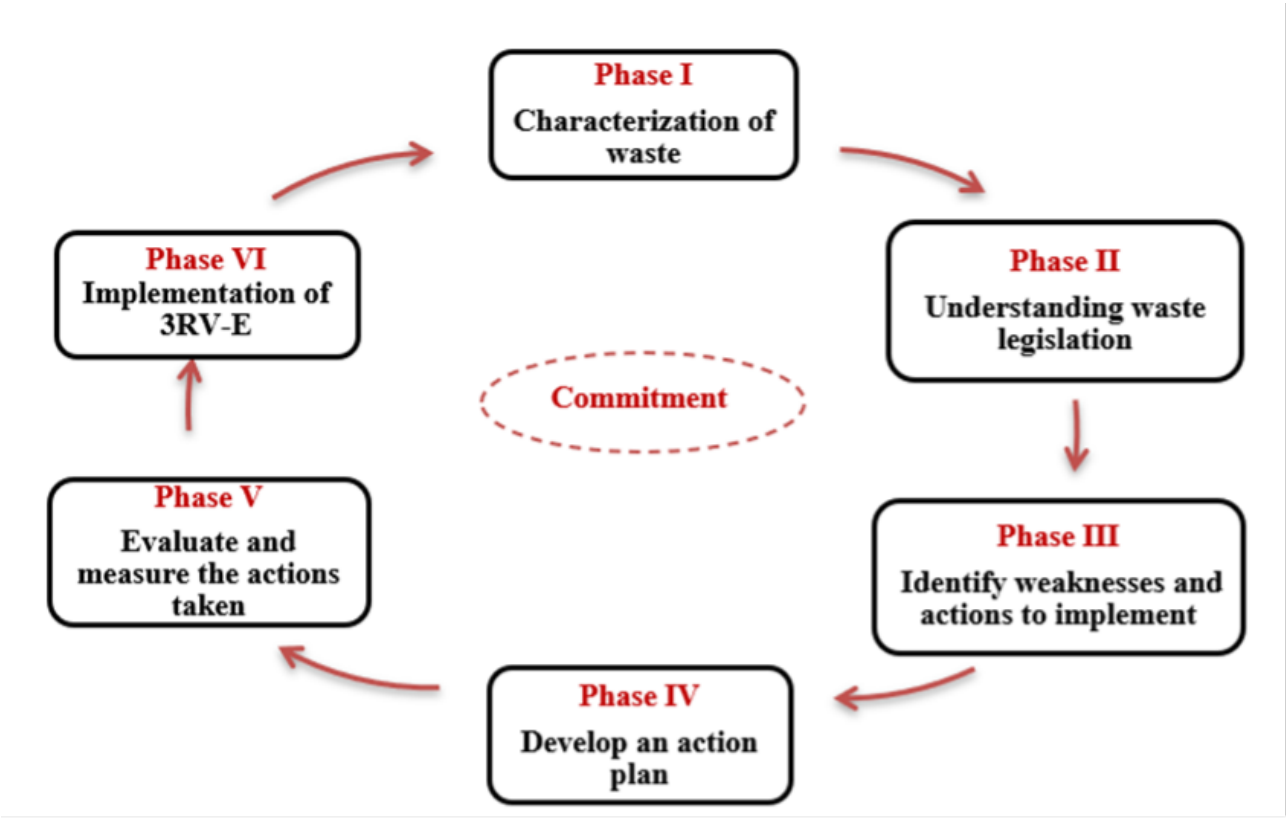

Figure 10. Phases of improvement in waste management within a company

CONCLUSION

This study underscores the challenges and opportunities associated with waste management within Henkel Reghaïa's production unit. The predominance of cardboard and construction materials reflects the site's industrial activities but also reveals potential areas for improvement, particularly in selective sorting and special waste management. Although the results aligned with initial expectations regarding waste types, the level of awareness among employees about waste reduction actions was lower than anticipated. This finding highlights the need for ongoing training and awareness programs to bridge this gap. Managers reviewed the employees' responses, and feedback indicated a degree of surprise regarding these awareness gaps, suggesting further improvement is needed in internal communication and environmental training. This study contributes to industrial waste management research by offering a framework for understanding waste practices and awareness in Algerian industrial settings, underlining the importance of integrating sustainable practices across all personnel levels. The importance of this study lies in its focus on improving waste management within the industrial sector in Algeria, particularly in the context of transitioning to a circular economy. By identifying specific areas for enhancement, the research offers actionable recommendations for reducing environmental impact and aligning waste management practices with international standards. However, the limitations of this study include its focus on a single production unit, which may not represent practices across all sectors. Additionally, restricted resources limited the depth of employee training sessions, which could have influenced the observed levels of awareness. Future research could benefit from longitudinal studies to observe changes in awareness and practices over time, along with the inclusion of diverse industrial sites. Researchers should also consider the impact of specific training interventions on waste reduction behaviors to identify the most effective methods for fostering sustainable practices. To achieve truly effective waste management, it is imperative to strengthen existing capacities, improve procedural organization, and foster a culture of sustainability within the company.

ACKNOWLEDGMENT

We extend our gratitude to Henkel Reghaïa for their support and cooperation during this study. Special thanks to the Territory Planning Research Center (CRAT) for their invaluable resources and expertise.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

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