Asian Journal of Applied Science and Technology (AJAST)
Volume 10, Issue 1, Pages 153-157, January-March 2026

Integrated Management of Multisource Waste in Tunisian Research Institutes: Oriented Outlook of INRAP with its Environmental and Valorization Approach

Samira Bejaoui[1*], Salwa Ben Aissa[2], Foued Bougoffa[3] & Hassen Jaafar[4,5]

[1,2,3,4]*Institut National de Recherche et d'Analyse Physico-chimique, BiotechPole Sidi Thabet, 2020 Ariana, Tunisia.*
[5]*Laboratoire Matériaux, Traitement et Analyse (LMTA), INRAP-BiotechPole Sidi Thabet, 2020 Ariana, Tunisia.*
Corresponding Author (Samira Bejaoui) Email: samira_bejaoui2004@yahoo.fr[*]

DOI: https://doi.org/10.38177/ajast/2026.10111

Article Received: 20 January 2026 *Article Accepted: 24 March 2026* *Article Published: 28 March 2026*

ABSTRACT

Scientific research, although a source of progress, generates a significant amount of varied waste. Concerning specialized institutes in physico-chemical analysis, this issue takes on particular importance due to the complex nature of the activities carried out, combining, technical testing, maintenance activities, physico-chemical analyses and administrative functions. Inadequate management can lead to significant environmental, economic, and security risks. Waste sorting and treatment are crucial challenges to ensure the sustainable and responsible operation of all laboratories.

Keywords: Waste Management; Environment; Green Process; Sustainability; Analysis; Chemistry; Safety; Handling; Sorting; Valorization.

1. Introduction and General Classification

In the current raising context of structural waste management [1], the National Institute for Research and Physico-Chemical Analysis (INRAP) is a key player involving this process, as it consists of a central administration, a maintenance and IT service, 3 research laboratories, and a central analysis platform comprising 17 analysis departments. These departments generate several types of waste, including primarily:

1) Waste from chemistry (Organic solvents, acids and bases, heavy metals…)
2) Solid waste: Laboratory glass and plastics, filtration material, soiled containers, broken glassware…)
3) Electrical waste and electronic equipment (PCs, keyboards, mice, obsolete equipment, electronic components, batteries…)
4) Waste from the vehicle fleet: mechanical spare parts, tires…
5) Printing waste (Cartridges, inks, …)
6) Metal waste from the maintenance and machining service
7) Waste from cleaning activities (cleaning products)
8) DIY waste (paint, varnish, glue, sealant, gardening)
9) Other waste: Clean packaging, papers, cardboard, recyclable plastics
10) Residual household waste…

Each type of waste has its own specific environmental and health risks, requiring rigorous sorting and appropriate treatment channels [2].

2. Environmental Strategy

In Tunisia, the National Waste Management Agency (ANGed) is an official Tunisian reference organization, one of whose missions is mastering the management of different waste types. Earlier, it was established inspired manual dedicated to identification, classification, packaging, storage, transportation, and waste treatment from laboratory activities [3]. At INRAP, the "Chemical Waste Management and Environmental Safety" team has adopted the management model mentioned by ANGed to develop an adequate waste sorting system specific to our wastes (www.anged.nat.tn). To achieve this purpose, the waste management team has implemented adapted strategies:

1) Diagnosis of current situation: It was conducted to inventory the various wastes generated by different INRAP departments for preliminary classification.
2) Establishment of sorting areas and waste identification: Dedicated containers are installed for each waste type. Each waste type must be clearly labeled according to its nature and hazard.
3) Implementation of safety equipment: For handling hazardous or risky waste.
4) Separation of hazardous and non-hazardous waste: It is essential to avoid any mixing between waste categories to facilitate their treatment.
5) Secure storage of hazardous waste: Chemical waste containers are kept in separate rooms away from work areas to avoid risk of incidents such as leaks.
6) Collaboration with specialized contractors for waste collection: Contracts with companies approved by ANGed for the collection and treatment of chemical waste.
7) Ensuring traceability of the various collected wastes.
8) Respect of color codes: Adoption of color codes to facilitate sorting.

Figure 1. Color-coded segregation containers used for sorting different waste categories at INRAP

3. Impact and Valorization

Regular staff training and awareness is essential to ensure correct waste handling and strict application of sorting procedures [4]. The waste management and environment team plan to organize regular awareness sessions on waste management soon and to provide clear instructions on sorting and storage procedures.

Despite the efforts of the Waste Management and Environmental Safety Team and the commitment of the General Directorate Board, the chemical waste management system remains in a primary early stage. This limitation is mainly attributable to the financial constraints associated with its deployment, including the continuous increase in costs related to the acquisition of waste containment and packaging equipment, the supply of personal protective equipment, specialized personnel training, as well as the development of a storage infrastructure compliant with current regulatory standards.

The high cost associated with waste removal and treatment constitutes a major economic and environmental challenge [5], requiring the adoption of effective mitigation strategies, articulated around the following axes:

1) Waste reduction at source: Process optimization and the application of low-impact techniques help minimize the consumption of critical resources. For example, implementing automated Solid Phase Extraction (SPE) to replace liquid-liquid extraction in chemical analyses constitutes a more efficient alternative, reducing the use of hazardous solvents and limiting polluting discharges [6].

2) Reduction of dependence on fossil fuels and transition to renewable sources: The use of sustainable alternatives such as solar, wind energy, or green hydrogen, produced from renewable resources, represents a promising approach. In particular, “Green Hydrogen” can be used as an energy vector for the conversion and valorization of biodegradable waste into energy, thus contributing to a circular economy and reducing greenhouse gas emissions.

3) Substitution of products with high environmental impact: Reducing the use of substances that are difficult to biodegrade is a priority, involving their replacement by more environmentally friendly alternatives, such as bio-packaging, which offer better biodegradability and a lower ecological impact [7].

4) Encouragement of research in the field of waste valorization: It is crucial to encourage researchers to develop advanced and ecologically sustainable processes. This includes, for example, the development of innovative recycling technologies, such as prototypes for redistilling organic solvents using renewable energy sources, as well as the optimization of biological treatment techniques for more sustainable waste management.

4. Conclusion

Waste management in research institutes represents a complex but essential challenge. A proactive approach integrating sorting, securing, valorization, and training not only helps reduce environmental impacts but also optimizes resources and ensures staff safety. This approach helps promote sustainable research, combining scientific innovation and environmental responsibility. "Such an approach is no longer an option, but a necessity."

Future efforts should focus on the following key areas:

1) Development of dedicated treatment infrastructure: Establishing specialized facilities.
2) Integration of green chemistry principles: Promoting ecological methods.
3) Capacity building by regular training programs: Improve waste monitoring and traceability.
4) Advancing research innovation in waste valorization: Supporting projects on recycling or solvent recovery.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not–for–profit sectors.

Competing Interests Statement

The authors have not declared any conflict of interest.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

Informed Consent

Not applicable for this study.

Availability of data and material

Supplementary information is available from the authors upon request.

Institutional Review Board Statement

Not applicable for this study.

References

[1] Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. International Journal of Environmental Research and Public Health, 16: 1060. https://doi.org/10.3390/ijerph16061060.

[2] Magriotis, Z.M., Saczk, A., Ribeiro Salgado, H.M., et al. (2021). Chemical waste management in educational institutions. Journal of Environmental Science and Sustainable Development, 4: 160–176.

[3] Benolli, F., Dal Santo, V., Econdi, S., et al. (2019). Handbook chemical and biological waste management. ISTM – CBRN Project 65.

[4] Zambia Ministry of Health (2024). Laboratory waste management guidelines. 1st Edition.

[5] Lyu, Y., Yan, K., Tian, J., & Lyujun, C. (2023). High cost of waste treatment calls for systematic rethinking: A case study for a chemical industrial park in China. Journal of Industrial Ecology, 27: 362–375. https://doi.org/10.1111/jiec.13331.

[6] Xiao, Y., He, Y., Ji, C., et al. (2023). Development of an automated solid phase extraction instrument for determination of lead in high-salt foods. Food Chemistry, 404: 134680. https://doi.org/10.1016/j.foodchem.2022.134680.

[7] Gotowska, M., & Jakubczak, A. (2025). Sustainable biodegradable waste management for circular economy: Comparative assessment of composting technologies. Sustainability, 17: 8978. https://doi.org/10.3390/su17208978.