Editorial: Modern management options for solid waste and by-products: sustainable treatment and environmental benefits

Funari, V., Dalconi, M. C., Farnaud, S., Nawab, J., Gupta, N., Yadav, K. K., Kremser, K. & Toller, S

DOI 10.3389/fenvs.2024.1385669
ESSN 2296-665X

Publisher: Frontiers Media

frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 08 March 2024
DOI 10.3389/fenvs.2024.1385669

OPEN ACCESS

EDITED AND REVIEWED BY
Oladele Ogunseitan,
University of California, Irvine, United States

*CORRESPONDENCE
Valerio Funari,
valerio.funari@cnr.it

RECEIVED 13 February 2024
ACCEPTED 14 February 2024
PUBLISHED 08 March 2024

CITATION
Funari V, Dalconi MC, Farnaud S, Nawab J, Gupta N, Yadav KK, Kremser K and Toller S (2024), Editorial: Modern management options for solid waste and by-products: sustainable treatment and environmental benefits. *Front. Environ. Sci.* 12:1385669. doi: 10.3389/fenvs.2024.1385669

Editorial: Modern management options for solid waste and by-products: sustainable treatment and environmental benefits

Valerio Funari[1]*, Maria Chiara Dalconi[2], Sebastien Farnaud[3], Javed Nawab[4], Neha Gupta[5], Krishna Kumar Yadav[6,7], Klemens Kremser[8] and Simone Toller[1]

[1]National Research Council of Italy (CNR), Department Earth system science and environmental technologies, Institute of Marine Science (ISMAR), Roma, Italy, [2]Geoscience Department, University of Padua, Padua, Italy, [3]Coventry University, Centre for Health and Life Sciences, Coventry, United Kingdom, [4]Department of Environmental Sciences, Kohat University of Science and Technology, Kohat, Pakistan, [5]Department of Environment and Development Studies, Bundelkhand University, Jhansi, India, [6]Madhyanchal Professional University Ratibad, Faculty of Science and Technology, Bhopal, India, [7]Al-Ayen University, Scientific Research Center, Environmental and Atmospheric Sciences Research Group, Nasiriyah, Iraq, [8]Department of Agrobiotechnology, Institute of Environmental Biotechnology, University of Natural Resources and Life Sciences, Tulln an der Donau, Austria

KEYWORDS

resource and energy efficiency, wastewater (WW), compostable and organics, municipal solid waste incineration (MSWI) ash, plastics, legacy waste, bioremediation, cleaner production

Editorial on the Research Topic
Modern management options for solid waste and by-products: sustainable treatment and environmental benefits

Earlier reports (NRC, 1999; NRC, 2004) recognized the tremendous importance of every nation developing commodity accounts to track sources, flows, and dispositions of materials to determine best strategies for improving environmental and economic performances in resource usage. These accounts would provide information to legislators and decision makers, supporting societal transition to sustainability. The concept of urban mining emerged, and the research community started sharing the goal of recovering every component and element from virtually any type of production, including buildings, infrastructures, vehicles, and products of various kinds. Waste can represent a significant source of resources, with concentrations of elements often comparable, if not higher, than natural deposits (e.g., Baron et al., 2019; Funari, 2022). In this context, method development using biotechnology, capable of providing low carbon and energy options, is also fervent to enhance the material cycle in different sectors (e.g., Gomes et al., 2020). We conducted a rapid bibliometric analysis and, although the search query was unrefined, some waste categories can be identified as main target materials in the recent scientific literature for urban mining at broad. These include mining waste, metallurgical slag, combustion residues, waste from electric and electronic equipment

(WEEE), waste from the automotive sector, ceramics, other waste from the oil and gas industry, manufacturing, agro-food industry, plastics, wastewaters, etc.

The Research Topic titled "*Modern Management Options for Solid Waste and By-Products: Sustainable Treatment and Environmental Benefits*," compiles groundbreaking research on diverse aspects of waste management and environmental sustainability, ranging from biodiesel blending for improved low-temperature operability to microbial remediation of rare earth elements (REE), and extends to modern assessments of incineration waste or legacy waste. These scientific articles collectively contribute to the ongoing dialogue on waste management, challenging fuel optimization, environmental risk assessment, microbial remediation, and other innovative waste treatments such as plastic enzymatic degradation and leaching for secondary resources recovery. In this Research Topic, target materials include palm oil and its derivative, residual MSWI bottom ashes, legacy wastes from anthropic activities, REE-bearing wastewaters, compostable waste, and plastics (PET waste). In the present Research Topic of Frontiers, a total of 12 manuscripts were received, out of which seven were accepted and published.

Yuan et al. examined the cold filter plugging point (CFPP) to assess the low-temperature operability of neat biodiesel compared to biodiesel–petrodiesel blends. This study utilized six types of palm biodiesels (including palm oil, palm stearin, and palm olein methyl esters in undistilled and distilled forms) to investigate their CFPP across the spectrum of 100 vol% biodiesel (B100) to 100 vol% diesel (D100 or B0). The findings revealed that the CFPPs of biodiesel were consistently lower than the initial CFPP of D100. The most significant depression effect was observed in the CFPP of B10, which was substantially reduced to about 3°C–7°C compared to D100 in both petrodiesels. Specifically, the CFPP of B10 ranged from −7 to −8°C and from −10 to −13°C in both petrodiesels, whereas the CFPPs neat fuels were −4 and −6°C, respectively. Undistilled palm oil and palm olein biodiesels exhibited a more pronounced depression effect in CFPP compared to distilled palm biodiesels at the same level of biodiesel–petrodiesel blends, covering a wider range for the depression effect. Blending undistilled and distilled forms of palm oil, palm stearin, and palm olein methyl esters with major Taiwanese petrodiesels resulted in a significant depression effect in CFPP, meeting CNS 1471 diesel standard even at low blending levels.

Not only cleaner production, but also appropriate management of valuable environments is a significant challenge for regulators and managers worldwide. Transitional environments' sensitivity to anthropogenic modifications is a key subject while assessing options for sustainable resources management. Solid wastes deposited in coastal zones is highly susceptible to contaminant release, posing a significant risk. The contamination risk of legacy disposal sites along the coast is associated to factors such as sea level rise, saline intrusion, hydrological extremes, and the high variability of both ecological and human receptors.

Riley et al. present a multi-criteria decision analysis that integrates the principles of Conceptual Site Models (Source-Pathway-Receptor) at a national scale in England and Wales to identify legacy waste sites where the occurrence of pollutant linkages is most likely. Through the integration of spatial data and exposure analysis, more than 3,000 legacy waste deposits identified in England and Wales were located within coastal zone. Locations without existing coastal defences or flood management infrastructure account for the majority of priority sites identified by authors' analysis. Besides undefined sources of contamination, classified as mixed wastes, mining and industrial wastes displayed a strong regional distribution, especially north-east and south-west of England, south Wales, and post-industrial estuaries. The approach prioritizes legacy waste sites vulnerable to contaminant release, considering factors such as flood projections, management infrastructure, and proximity to ecological features. It can be used to direct more high-resolution site assessment and restoration efforts.

Some waste categories, including industrial waste, are used as road pavement, soil embankments, as well as landscaping to restore areas impacted by anthropic activities. However, this strategy might have low resource efficiency. Consequently, solid wastes are also examined for their potential as secondary raw materials and for their metal value, as some may support eco-technological management practices. To promote efficient reuse and treatments of MSWI (Municipal Solid Waste Incineration) bottom ashes, mineralogical characterization and mineral leaching is necessary. One major issue is determining whether results from a specific plant can be generalized. Mantovani et al. conducted a study on bottom ash samples from five waste-to-energy (WtE) plants in northern Italy, focusing on the role of grain sizes. The authors found that the chemical composition of selected incinerators is similar, with some differences in minor and trace elements. The mineralogical composition affects the pH, release, and toxicity of leachates. Many parameters such as ambient pH and the standard leaching of Cl, Cu, Cr, and sulphates, exceed regulatory limits. Unfortunately, grain size sorting alone is unable to reduce risk levels, although it can be useful for mineral beneficiation and metal recovery. Ghani et al. reported on MSWI bottom ash environmental assessment and recoverability of metals and secondary raw materials. They calculated a high enrichment factor based on Earth crust's averages for Zn, Cu, and Pb. The degree of elements extractability was high (>80%), particularly in the fine-grained fractions of MSWI bottom ash. However, the results were less satisfactory for trace elemental flows such as those of REE. Contextually, elemental removal by leaching can be used to provide a secondary raw material less susceptible to contaminant release and reactive at disposal sites. To the point, aqua regia digestion is an effective method for assessing both environmental impact and recovery potential, and the authors believe this method suitable for standardization.

Modern society is heavily dependent on critical raw materials, such as indium (In), gallium (Ga), REE, phosphates, etc., which are utilized in new and green technologies. This opened research priority on environmentally friendly methods of processing still-not-recyclable materials and wastewater such as those based on biotechnology. Rassy et al. knowing that microorganisms can hoard REE naturally, wanted to check if REE were spun into the pellets by centrifugation, adsorbed, or incorporated in the cells. The authors successfully followed REE bioaccumulation using REE standard-spiked samples during their experiments, which involved stepwise washing of the cells. Some microorganisms yielded more than half of the total REE concentrations used in the synthetic solutions.

Sobieraj et al. also dealt with biotechnology exploring energy-efficient pathways for carbon monoxide generation. The authors reviewed the basic biochemistry needed for the production of

biobased carbon monoxide, including many industrial-scale bioprocesses aimed at organic matter decomposition. They conducted a bibliometric analysis, emphasizing its significance in industrial chemistry and biology with a comparison between aerobic and anaerobic CO generation, an appraisal of microorganisms potentially involved, and identifying mixed composting as a possible research priority.

Liu et al. worked on poly (ethylene terephthalate) (PET), a widely used synthetic polyester plastic resistant to biodegradation in landfills or the natural environment. Addressing environmental concerns related to PET wasted, this review focuses on PET-degrading enzymes, particularly IsPETase from *Ideonella sakaiensis*. The current state of the art regarding enzyme structure, ligand-protein interactions, and molecular engineering for improved PET-degrading performance is reported. Ideonella sakaiensis IsPETase was found to streamline PET biodegradation at 30°C, showing a lower degrading activity than that of, for example, chitinase enzymes. Consequently, the molecular engineering of more efficient PETases is still required for industrial applications.

The ultimate objective of this Research Topic was to picture the current research priorities as potential avenues for the circular economy, stimulating a think-tank on assessment and reduction of environmental impacts and diversification of resource supply. The Research Topic editors underscore the critical importance of adopting sustainable waste management practices for a greener and healthier future.

Author contributions

VF: Conceptualization, Supervision, Writing–review and editing. CD: Writing–review and editing. SF: Writing–review and editing. JN: Writing–review and editing. NG: Writing–review and editing. KY: Writing–review and editing. KK: Writing–review and editing. ST: Writing–original draft, Writing–review and editing.

Acknowledgments

The authors thank all experts and scholars for contributing with high quality papers to this Research Topic, and the reviewers for providing constructive comments. VF also acknowledges the support from PNRR MUR project ECS_00000033_ECOSISTER through the National Research Council of Italy.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

References

Baron, S., Tămaş, C., Rivoal, M., Cauuet, B., Télouk, P., and Albarède, F. (2019). Geochemistry of gold ores mined during celtic times from the north-western French massif central. *Sci. Rep.* 9, 17816. doi:10.1038/s41598-019-54222-x

Funari, V. (2022). "Chapter 24 - sustainability assessment of bioleaching for mineral resource recovery from MSWI ashes," in *Circular economy and sustainability*. Editors A. Stefanakis. and I. Nikolaou (Amsterdam, Netherlands: Elsevier Radarweg). doi:10.1016/B978-0-12-821664-4.00023-6

Gomes, H. I., Funari, V., and Ferrari, R. (2020). Bioleaching for resource recovery from low-grade wastes like fly and bottom ashes from municipal incinerators: a SWOT analysis. *Sci. Total Environ.* 715, 136945. doi:10.1016/j.scitotenv.2020.136945

National Academies of Sciences, Engineering, and Medicine (2004). *Chapter: front matter, materials count: the case for material flows analysis*. Washington, DC: The National Academies Press. doi:10.17226/10705

National Research Council (1999). *Our common journey: a transition toward sustainability*. Washington, DC: The National Academies Press. doi:10.17226/9690