

Editorial: Sustainable waste management via material recovery and energy production

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As the world population continues to grow, so does the amount of waste produced by the agricultural, industrial and commercial sectors, as well as by households. Waste management is becoming an increasingly important issue, not only for environmental reasons but also for economic and social reasons. The circular economy (CE) framework has been popularised as a basis for policies intended to deal with the waste management problem (Korhonen *et al.*, 2018). Despite the lack of a precise definition of CE (Kirchherr *et al.*, 2017), it is clear that the framework is similar to the earlier industrial ecology (IE) concept that tries to emulate closed material loops found in nature (Walsmley *et al.*, 2019). However, specific engineering solutions are needed to operationalise the CE framework. In this special issue, we focus on the challenges faced in the management and treatment of different types of waste, and how they can be addressed.

One of the key challenges in waste management is the management of plastic waste. According to Statista (2023), global plastics production was estimated at 390.7 million metric tons in 2021 with an annual increase of 4%. Most plastic products are single-use plastics like containers, bottles and grocery bags, and they are the major contributors to the global plastic waste pollution problem. One of the most straightforward methods in addressing this issue is to recycle the plastic waste. However, recycling plastic waste is very challenging owing to non-homogeneous plastic wastes being found in the recycling site. Segregation of waste is the key to recovering plastic wastes. Next, such waste should be upgraded or recycled in other industries to extend the lifespan of the plastics.

In this issue, Mohan *et al.* (2023) discuss the design and construction of semi-automated machines that convert plastic waste into construction materials. The authors also looked into the control of the machines, as well as the detailed study of the mechanical properties of construction materials that can be converted from plastic waste.

Following on from recovering the plastic waste in the construction industry, Ramalingam *et al.* (2023) examine the potential of recycled low-density polyethylene (a soft, flexible,

lightweight plastic material) and fly ash (normally produced by coal-fired thermal power plants in developing countries) to make paver blocks. As reported in the results, through sintering technology, the produced products were tested for their structural stability and suitability as paver blocks, and it was found out that a composite of 60% fly ash and 40% polymer provides the needed properties.

Another challenge in resource and waste management is the sustainable use of water (Rockström *et al.*, 2023). Water is a finite resource and its availability is becoming increasingly uncertain due to climate change and population growth. To recover used water, various research works have been conducted. In this themed issue, Sahu and Kumar (2023) evaluated the potential use of treated sewage water in construction industry as mixing and curing water. In this work, the usage of potable water and treated sewage water is compared. Based on the results, it is found that the concrete produced from treated sewage water has similar compressive strength and durability as the concrete made by potable water. By implementing this recovery method of sewage water, the significant consumption of potable water can be reduced, especially in mega cities.

Besides plastics and water, agricultural waste management is also another area that requires focus. Due to all agriculture wastes being lignocellulosic materials, this type of waste (known as biomass) has a high potential to be converted into various value-added products. In this themed issue, Imteaz *et al.* (2023) presented a model to predict bioethanol fuel production from rambutan fruit waste.

Note that to maximise resource conservation and sustainable development, recovery of individual types of waste is sufficient. The challenge of resource management is to ensure that natural resources (e.g., water, air, soil, minerals and energy, etc.) are used in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, it is important to transform the current production and consumption model into the CE

model. This model is an important concept for achieving sustainable development around the world.

Closing this themed issue, Sapsford *et al.* (2023) discussed CE landfills for temporary storage and treatment of mineral-rich wastes. The proposed concept aims for value recovery from mineral-rich waste where they are temporarily stored and cleaned in landfill, and the time in storage is used for remediation of contaminants, and at the same time concentration of valuable components. From this, the components that are originally treated as waste are separated and used for other applications, and their value salvaged.

In short, waste and resource management are critical issues that require the attention of the global research community. As presented in this themed issue, the concept of waste and resource management can be applied in different areas, aspects and scales, and each of us play a vital role in designing and constructing the infrastructure that supports these activities within sustainable limits. Through scientific research and technological innovation, we can create a more sustainable future for humanity.

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