Preface

Engineering and sustainable development are intrinsically linked. Many aspects of sustainable development depend directly on appropriate and timely actions made by engineers. Green engineering focuses on how to achieve sustainability through science and technology for it is one of its fundamental principle to consider the environment when designing products and technologies.

Today, the term ‘green’ is used widely (and often inappropriately) in connection with many types of technologies. Generally, a technology is defined ‘green’ because it requires less non-renewable energy sources than others or reduces the use of hazardous chemicals. However, a truly “green” technology should consider the recycling potential, the nutrient and the energy recovery as well as ensure the preservation of ecosystems. It can be argued that green engineering is not simply good chemical engineering or industrial ecology, which alone is not enough to achieve sustainability. Indeed, even systems with efficient material and energy use can overwhelm the recovery capacity of a region or lead to other socially unacceptable outcomes.

As the quantity and quality of the resources and the resilience of the environment changes over time, the most sustainable technological solutions will change accordingly.

Green engineering was originally defined by the U.S. Congress Office of Technology Assessment as “green design involving two general goals: waste prevention and better material management”. More recently, green engineering was more broadly defined by the U.S. Environmental Protection Agency (EPA) as “the design, commercialization, and use of processes and products that are feasible and economical while minimizing: generation of pollution at the source and risk to both human health and to the environment”. However, sustainability is not only an issue for green engineering.

The design, the development, and the implementation of chemical products are also looking at reducing or even eliminating the use and generation of substances that may be hazardous to both human health and the environment, and therefore to green chemistry.

According to U.S. EPA, "green chemistry is required to promote innovative chemical technologies aimed at reducing or eliminating the use or generation of hazardous substances in the design, manufacture and use of chemical products." Both green engineering and green chemistry are based on twelve principles and the terms are often used interchangeably. However, although some principles may be common to both disciplines, it is clear that there are significant differences in their philosophy. Disciplines such as toxicology and thermodynamics play important roles in green chemistry despite they are not specifically included within the principles. Chapter 1 introduces green chemistry and its principles in relation to the technologies for the removal of emerging compounds from water and wastewater.

How to evaluate and to achieve sustainability in wastewater treatment plants (WWTPs)? Their crucial role in protecting human and environmental health is widely recognized. However, their impacts have simply been shifted to another part of the overall life cycle when wastewater treatment is carried out by using hazardous or non-renewable materials. Therefore, in evaluating the sustainability of WWTPs, engineers should consider the entire life cycle, including those of materials and of energy inputs. Chapter 2 reviews the removal of emerging contaminants and industrial pollutants in general from water and wastewater by using natural materials or agricultural waste as adsorbents. The problem associated with current treatment technologies lies in their lack of sustainability. If we look at centralized systems, for instance, it is clear that they are not always the best solution. The reasons are many:

- they flush contaminants out of residential areas by using large amounts of water;
- they often combine domestic wastewater with rainwater, causing the discharge of large volumes of polluted wastewater;
- they can contribute to spread a contained domestic health problem to an entire settlement or even to a region.

Furthermore, many treatment systems are functioning properly but are nevertheless unsustainable as they do not take into account the culture, the land, the climate, and the energy consumption of the country.

Chapter 3 focuses on the fate of organic chemicals in constructed wetlands and aims at improving their assessment in full-scale studies. The removal of some categories of trace contaminant of worldwide relevance, classified as Endocrine Disruptor Compounds (EDCs) and Pharmaceuticals and Personal Care Products (PPCPs), has been reviewed together with the mechanisms associated to their removal.

When a wastewater treatment technology has a high removal efficiency for contaminants, but consumes high amount of energy, this contributes to atmospheric carbon dioxide emissions. Thus, there is no net sustainability advantage in the treatment technology. In Chap. 4, the authors highlight some of the science and technology being developed to improve the solar photocatalytic decontamination of water-containing pesticides. The potential of oxidative photochemical methods using sunlight as promising alternatives to non-efficient conventional treatments is discussed in Chap. 5.

In an era when there is growing concern for the impact that our current environmental strategies has at both local and global level, it is crucial to develop more environmentally friendly wastewater treatment technologies. The hope is for these technologies to reach the environmental, economic, and societal sustainability that will contribute to reduce sanitation problems, diseased, and poverty.

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