European Commission

Science for Environment Policy

Radiation processing may be faster, cleaner and more efficient at removing pollutants from drinking and waste water than conventional techniques

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Source: Trojanowicz, M., Bojanowska-Czajka, A. & Capodaglio, A. G. (2017). Can radiation chemistry supply a highly efficient AO(R)P process for organics removal from drinking and waste water? A review. *Environmental Science and Pollution Research*, 24: 20187–20208 DOI 10.1007/s11356-017-9836-1.

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The presence of organic pollutants in waste water and drinking water can have alarming environmental and public health implications. Current water treatment methods have limitations: they can only remove certain contaminants, to certain extents, and also produce harmful by-products. New and improved methods are required. A recent review paper presents radiation processing as a promising approach, providing strong evidence of its efficacy, efficiency, safety, and feasibility. Focusing particularly on the use of electron-beam processing for the removal of organic pollutants from waste water and drinking water, the researchers present a compelling picture, relevant to stakeholders involved in water treatment and management.

Water is increasingly contaminated with organic pollutants. Some of these are contaminants of emerging concern (CECs), including pharmaceuticals and personal care products that act as endocrine disruptors and pose a danger to environmental and public health. Developing new and improved methods for the identification and removal of these pollutants from effluents and drinking waters is, therefore, a pressing societal concern. At present, no treatment technologies capable of simultaneously and completely removing all CECs from water are in use. Current methods only remove certain contaminants, to a greater or lesser extent.

At present, the most common treatment methods for the removal of organic pollutants are Advanced Oxidation Processes (AOPs) such as oxidation, chlorination, ultraviolet irradiation, ultrasonic irradiation, and photocatalysis. These generate highly reactive oxidative radicals in the water being treated, which cause organic pollutants to degrade. However, AOPs have their limitations. They often require extended contact times with the water if contaminants are to be fully destroyed, and can generate by-products with as-yet unknown environmental or health effects. Moreover, full destruction of CECs is heavily dependent on environmental and process conditions, and often requires costly additives, which can generate additional residues with their own environmental, public health and occupational safety concerns.

Radiolytic processes offer a promising alternative. Radiolysis uses radiation to decompose pollutants along oxidative and reducing pathways simultaneously — making it faster and more efficient than conventional AOPs. Radiation can be generated by an ionising source such as an X-ray, γ-ray or electron beam (EB). In recent years, EB accelerator technology has developed significantly, and its lower running costs and increased ease of operation make it a practical choice for water-treatment applications. EB irradiation offers several advantages over other water-treatment technologies: no chemical additives are required, no by-products are created, no lengthy exposure times are necessary and workers are not required to handle any highly reactive liquids or gases.

Continued on next page.

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This research, which summarises the removal efficiencies of radiation processing in relation to pharmaceuticals and other pollutant types, is likely to be of interest to those involved in the treatment, management and monitoring of waste water and drinking water, including scientists and policymakers. Waste-water and drinking-water treatments have different objectives; the latter aim to produce water that is free from any harmful microorganisms and organic pollutants, and safe for human consumption, while the former aim at the decomposition/degradation of mainly organic pollutants. The extent to which radiation processing, and EB in particular, can contribute to these objectives is variable. Nonetheless, the researchers propose that radiation processing has the potential to become a practical, safe and highly efficient complement to conventional physicochemical and biological methods; it could be used to optimise future water-purification processes, through the development of hybrid installations, for example.

It should be noted that additional research on applied radiolytic treatment methods at a larger scale is required, as the majority of studies have so far been limited to laboratory-scale systems. However, a number of case studies applying ionising radiation to waste-water treatment in pilot- and full-scale facilities have produced promising results.