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Topic Insights

Water Pollution Control for Sustainable Development

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1. Introduction

Water pollution is the major cause of ecological degradation on our planet; it directly affects human water supplies, often with serious consequences to public health. A wide range of contaminants—including chemicals, pathogens, and nutrients—has been and is currently being introduced into the natural environment. Household and industrial effluents, as well as urban and agricultural runoffs, are damaging aquatic ecosystems on a scale never seen before. Effective control of water pollution requires an understanding of traditional and emerging contaminants, a deep knowledge of natural treatment processes, and the development of advanced high-tech purification systems. Understanding the ecosystems that are—or could be—impacted upon by polluted discharges is a must. Various treatment technologies have been developed, including nature-based solutions, adsorption, advanced oxidation, and membranes for the removal and degradation of water pollutants. Further development of these technologies is needed to improve their efficiency and reduce their costs in order to ensure effective water pollution control.

2. Emerging Contaminants

Emerging contaminants or contaminants of emerging concern—including illicit pharmaceutical drugs and personal care products—are found in water and the environment mainly due to industrial effluent discharge, municipal wastewater discharge, and agricultural runoff [1]. These contaminants pose a significant risk to human health and ecosystems: They lead to acute and cumulative toxicity (including endocrine-disrupting activity), damaging living organisms. Research efforts are ongoing to advance our knowledge of the spatial and temporal trends of emerging contaminant occurrence (both organic and inorganic forms), develop standardized sampling approaches and analysis techniques for a large variety of contaminants, and establish toxicity testing protocols (especially for toxicological differences between enantiomers) for better environmental risk assessment. For example, in their paper in this issue titled "Understanding the removal and fate of selected drugs of abuse in sludge and biosolids from Australian wastewater treatment operations," Yadav and co-authors report on the presence and degradation of five drugs of abuse in sludge and biosolids from a large metropolitan wastewater treatment plant in Australia, and discuss the resulting potential environmental risks.

3. Policy measures and ecological restoration

Many ecological restoration measures have been undertaken around the world to improve the environment in order to balance economic development and environment protection. For example, China has implemented a range of large-scale policy programs to mitigate soil and water degradation and to conserve forests and biodiversity since the occurrence of multiple natural disasters in the late 1990s [2]. Over the past 50 years, the implementation of non-structural best-management practices (BMPs) has been gaining popularity in Europe, the United States, and Australia for the protection of aquatic ecosystems from polluted agricultural and urban runoffs [3].These sustainability programs have reduced sedimentation and improved water quality, soil water retention, water conservation, and water supply. However, the long-term impact and efficacy of these intervention measures need to be better understood for future planning for sustainable socioeconomic development and a sustainable environment. In this issue, Sun and co-authors examine the Grain for Green program that has been undertaken in the Chinese Loess Plateau—the most seriously eroded area in the world—and investigate the discharge–sediment relationship and soil and water conservation measures in past decades in this area. Their research findings provide new insight into the current low sediment level for planning future ecological restoration activities.

4. Nature-Based Solutions

Natural treatment systems are sustainable, low-cost, and low-energy solutions that are engineered to utilize natural processes for water purification. In essence, they are carefully constructed soil/plant systems for the treatment of municipal wastewaters (e.g., wastewater lagoons and vertical wetlands), agricultural runoffs (e.g., filter strips and buffer zones), and stormwater discharges. Soil/plant treatment systems for stormwater are known as sponge city (SC) systems in China, and as water-sensitive urban design (WSUD) technologies in Australia. They range from the well-known and widely used technologies of constructed wetlands,

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bioretention, and raingardens, to novel blue-green walls for the treatment and management of not only stormwater, but also low-pollution urban wastewaters.

Blue-green walls are vegetated water filters that use either climbing plants and flowers grown in a trench filled by filter media to create vertical green screens, or ornamentals grown in boxes mounted onto wall surfaces to create living facades. As polluted water percolates via gravity through the engineered media and plant roots, nutrients and other pollutants are retained within the system, and the treated water is either discharged into receiving water bodies or reused for the irrigation of urban gardens or toilet flushing. In this way, the systems promote urban greening, which provides multiple benefits to cities. Thus, green-blue walls for greywater and stormwater treatment and management are beautiful green infrastructure systems that increase urban amenity and biodiversity and cool the local environment, while cleaning polluted urban discharges [3].

Nature-based solutions must be tailored to regional climates and local conditions. In this issue, Chen and co-authors report their research on plant traits for the phytoremediation of nutrient pollutants in stormwater runoff in a tropical climate. Their work provides valuable information on plant selection for bioretention application.

5. Advanced Water Purification Processes

Advanced oxidation processes (AOPs) are commonly used in the degradation of trace organic chemicals (TOrC) such as pharmaceuticals, consumer products, and industrial chemicals in water treatment [4]. AOPs operate in various forms using strong oxidants such as ozone, hydrogen peroxide (H_2O_2), a combination of an oxidant with ultraviolet (UV) light, and photocatalytic oxidation. The processes generate different byproducts and their electrical energy efficiency varies largely, depending on the operating conditions. The UV-photocatalyzed hydrogen peroxide oxidation of 2,4-dinitroanisole is investigated by Su et al. in this issue in order to understand the effect of pH and H_2O_2 dosage on the kinetics of 2,4-dinitroanisole decomposition and the reaction mechanisms. This study provides a promising way to degrade 2,4-dinitroanisole in wastewater.

Adsorption is an effective way to remove contaminants such as heavy metals and harmful organic molecules from water in water purification and wastewater treatment processes. The low-cost production of adsorbents from wastes is an important strategy to achieve sustainability in water technologies. Here, Qu and co-authors report the synthesis of a magnetic maghemite adsorbent from groundwater treatment sludge and demonstrate the high-efficiency adsorption of the cationic pollutant tetracycline.

Membranes have also become a dominant technology for treating municipal and industrial wastewater before it is discharged to the environment, thereby providing a viable solution to minimizing water pollution. Despite tremendous efforts being made over the last decades, more research is still needed to develop high-flux, ultra-selective, and fouling-resistant membranes for efficient water treatment. In this issue, Ding and co-authors provide a good example of engineering polyvinylidene fluoride (PVDF) hollow-fiber membranes to treat radioactive cesium-contaminated water. With advances in nanotechnology and bio-inspired engineering, high-performance, cost-effective nanostructured photocatalysts, adsorbents, and membranes will continue to emerge for efficient water pollution control and sustainable water processing [5,6].

References

[1] Petrie B, Barden R, Kasprzyk-Hordern B. A review on emerging contaminants in wastewaters and the environment: current knowledge, understudied areas and recommendations for future monitoring. Water Res 2015;72:3–27.
[2] Bryan BA, Gao L, Ye YQ, Sun XF, Connor JD, Crossman ND, et al. China's response to a national land-system sustainability emergency. Nature 2018;559:193–204.
[3] Prodanovic V, Zhang K, Hatt B, McCarthy D, Deletic A. Optimisation of lightweight green wall media for greywater treatment and reuse. Build Environ 2018;131:99–107.
[4] Miklos DB, Remy C, Jekel M, Linden KG, Drewes JE, Hubner U. Evaluation of advanced oxidation processes for water and wastewater treatment - a critical review. Water Res 2018;139:118–31.
[5] Mauter MS, Zucker I, Perreault F, Werber JR, Kim JH, Elimelech M. The role of nanotechnology in tackling global water challenges. Nat Sustain 2018;1:166–75.
[6] Li XY, Zhang HC, Wang PY, Hou J, Lu J, Easton CD, et al. Fast and selective fluoride ion conduction in sub-1-nanometer metal–organic framework channels. Nat Commun 2019;10:2490.