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Editorial

The Evolution of Environmental Technology: From End-of-Pipe to Systemic Solutions

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Environmental technology originated from humanity's efforts to address basic survival needs and early industrial pollution, evolved through the pursuit of comprehensive pollution prevention and sustainable development concepts, and is now advancing toward a new stage characterized by intelligence, systematization, and globalization.

Environmental technology refers to all technologies that can protect natural resources and the environment, and to mitigate or eliminate negative environmental impacts caused by human activities, including technologies for minimizing and treating contaminants, and/or maximizing valuable resources recovery from wastes.

The rapid increase in population, economic growth, and inadequate awareness of sustainable development will have a significant influence on the future society. We should promote the circular economy and green infrastructures to produce products in a cleaner way. Novel technologies are needed to comply with the increasingly stringent environmental regulations and policies. Therefore, the innovation of environmental technologies is extremely important, which can help us address the environmental issues without compromising economic development.

The core goals of environmental technology can be summarized as: pollution prevention, pollution control, environmental remediation and restoration, energy and resources recovery, and efficient utilization. Environmental technology includes physical, chemical, and biological approaches, which can be applied for wastewater treatment, waste gas treatment, solid waste management, remediation of soil and groundwater, recovery of energy and resources from wastes, as well as for cleaner production, aiming to improve the processes and management that can increase resource utilization and reduce pollution in industrial production processes.

1. The Origin of Environmental Technology

The origin of environmental technology is a progressive and constantly deepening process. Before the Industrial Revolution, "environmental technology" was more reflected as a simple approach to respond to nature and improve living conditions, with its core driving force being public health and resource utilization, rather than modern "environmental protection". For example, ancient water supply and drainage systems, such as Roman aqueducts and drainage systems, and drainage ditches in ancient Chinese cities; in agricultural civilization, manure and organic waste were used as fertilizers to return to the field, achieving a primitive material cycle.

The Industrial Revolution catalyzed environmental issues, which were also a direct driving force for the development of environmental technology. For example, in the mid-19th century, London built a large-scale sewer system, which was the precursor to modern urban sewage treatment. The popularization of drinking water treatment technologies such as chlorine disinfection and sand filtration has greatly reduced the incidence of waterborne infectious diseases. The concept and technology of garbage incinerators and sanitary landfills are beginning to emerge to address urban solid waste.

The rise of modern environmental movements, the awakening of public environmental awareness, and the formulation of environmental regulations have given birth to modern environmental technology, which is the beginning of actively protecting the environment. For example, the 'London smog incident' in the 1950s made the public directly feel the deadly consequences of industrial pollution. In 1970, the establishment of the first "World

Earth Day" marked the environmental movement becoming a global citizen movement. The United States has established the National Environmental Protection Agency and issued environmental regulations such as the Clean Air Act and the Clean Water Act.

Regulation has become the core driving force for the development of environmental technology. In order to meet emission standards, enterprises have to develop and adopt more effective pollution control technologies, such as flue gas desulfurization devices, industrial wastewater treatment plants, etc.

In a word, environmental technology is formed in the process of transforming nature, which has moved from passive response to active planning, from local governance to global consensus, and ultimately become a key tool for achieving harmonious coexistence between human society and nature.

2. The Development History of Environmental Technology

Environmental technology has gradually formed with the evolution of human civilization, industrial development, and environmental awareness, which has gone through the stages of ancient origin, modern germination, and contemporary development. The environmental technology has been developed along with the deepening of human understanding of environmental issues and the advancement of technological level, which has gone through the following stages.

Phase 1: End-of-pipe treatment (1950s to 1970s)

Industrialized countries have experienced a series of shocking public pollution events, such as the London smog incident and the Minamata disease incident in Japan, which has awakened people's environmental awareness, and they have begun to realize the severity of industrial pollution. During this stage, a large number of classic pollution control technologies have been developed, such as the activated sludge process in sewage treatment plants and dust collectors for flue gas treatment. The focus is on the end of the production process, and the approach followed is the model of "pollution first, treatment later". However, these technologies are not cost-effective, and cannot fundamentally solve the problem of resource waste, and the potential for secondary pollution.

Phase 2: Pollution Prevention and Process Control (1980s to 1990s)

The drawbacks of end-of-pipe governance are becoming increasingly apparent, and the focus of environmental technology has been gradually transferred from the "end" to the "process" and "source", aiming to reduce the generation of pollutants in the production process through improving production processes, replacing raw materials, and strengthening internal management. Meanwhile, cleaner production and waste minimization have become increasingly popular, and the life cycle assessment has been applied to comprehensively evaluate the environmental impact of a product from its cradle to grave.

Phase 3: Sustainable Development and Systematic Solutions (2000s-)

The characteristics of environmental technology at this stage are to consider energy, resources, environment, and economy as a whole system, using a systems thinking approach. Based on the concept of circular economy, through the integration and breakthrough of core technologies, the objective of environmental technology is to realize the resource utilization of "waste", and to build a closed loop of "resources- products -renewable resources". For example, carbon capture, utilization, and storage technologies for addressing climate change; the digitization and intelligence of environmental technology, such as application of big data, and artificial intelligence (AI) for environmental monitoring, smart water management, smart grid, and precise pollution control, to achieve refined environmental management; the application of microbial technology to treat pollution and to produce bio-based materials.

3. Development Trends of Environmental Technology

Environmental technology has evolved from passive governance to proactive prevention, from a single medium to a system cycle, and from cost burden to value creation. In the future, it will become an important cornerstone for building a modern society of harmonious coexistence between humans and nature. Its development not only depends on technological innovation itself, but also requires the coordinated promotion of policies, markets, and public participation.

The future development of environmental technology will present the following trends:

(1) Comprehensive practice of circular economy: Starting from product design, considering the recyclability of resources, developing advanced recycling technologies, and promoting the recycling of key materials of plastics, electronic waste, and batteries.

(2) Technology integration and interdisciplinary innovation: The integration of environmental technology with information technology, nuclear technology, biotechnology, new material technology, and advanced manufacturing technology, which will give rise to more disruptive solutions.

(3) The rise of natural solutions: In addition to engineering technology, utilizing the power of nature itself to address climate change, prevent pollution, and improve the environmental quality, is gaining increasing recognition, such as protecting and restoring ecosystems of forests and wetlands.

(4) Precise and intelligent environmental management: Predictive analysis and decision support based on big data and AI will make environmental pollution control and resource management more efficient and precise.

Environmental technology has evolved from the initial "symptomatic" end of pipe treatment to today's systematic and forward-looking solutions, with its connotation and extension constantly expanding. It is no longer just a tool for solving pollution problems, but also a core technology for promoting the global economy's transformation towards green, low-carbon, and circular directions, and achieving sustainable development. Future environmental technology will be more intelligent, systematic, and deeply integrated with various aspects of economic and social development.

4. The mission of our new Journal *EMT*

The new journal "*Environmental and Microbial Technology* (*EMT*)" is dedicated to establishing a platform for disseminating the scientific research in all areas of environmental science, technology, and engineering, focusing on the various environmental technologies that leverage novel principles for reducing and controlling, or mitigating pollution.

EMT is a multi-disciplinary journal that publishes high impact and novel information about environmental issues of global relevance and demonstrating applicability in a wide range of real-world environmental contexts. *EMT* welcomes the innovative research on, but not limited to: technologies for treating contaminants, technologies for recovering valuable resources from wastes such as energy, nutrients, and water; technologies for monitoring the quality of water, air, and other environmental compartments; and technologies for analyzing emerging contaminants.

EMT aims to promote technological innovation in the treatment and control of inorganic, organic, and radioactive pollutants in various environmental media, such as soil, sediment, water, air, and organism, to improve the quality of water, air, soil, and other environmental compartments.

We particularly encourage submissions that propose novel or improved technologies with demonstrable performance advantages over conventional solutions; that integrate environmental technology with quantitative sustainability assessment to support evidence-based decision-making; and that address regional and global environmental challenges with adaptable, context-sensitive technological solutions.

EMT is committed to the rapid publication of concise, timely, urgent, and high-impact researches that contribute new knowledge to help address problems related to environmental pollution at a regional or global scale, focusing on the intersection of innovative technology development and their environmental sustainability assessment, aiming to foster innovative and environmentally-friendly technologies that support the transition to a cleaner, safer, and more resource-efficient future.

Let us work together to build a bridge between environmental fundamental science and engineering applications, fostering technology transfer and integration to serve the goals of environmental protection and sustainable development.

Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.