Concept of circular sewage and biowaste management for waterfront area

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In recent years, a significant increase in interest in water tourism has been observed. In Poland, this trend is particularly evident in the Great Masurian Lakes region. During the summer season, approximately 80,000 people use recreational vessels in this area. Uncontrolled discharge of sewage generated by such vessels poses a serious threat to the water quality of the lakes. For example, the progressive eutrophication of Lake Bełdany has led to a reduction in its surface area from 1,241.6 ha to 944 ha. To counteract these negative impacts, it is essential to develop and implement solutions that enable the collection and treatment of sewage and waste generated by water tourism. The aim of this poster is to present a concept of a circular sewage and biowaste treatment system for a waterfront area.

The concept is based on data from one of the holiday resort located in the water area in the Great Masurian Lakes region (Table 1).

Table 1. Wastewater and biowaste balance for the period from May 1, 2025, to December 31, 2025 (245 days)

Month	Wastewater (m^3/day)	Biowaste (kg/day)
Max daily disposal	88.93	81
Average daily disposal	19.90	20.50
Number of days with disposal	169	162
Number of days without disposal	76	83

The concept involves water recovery while simultaneously minimizing the carbon footprint of the technical solutions. Water reclamation and reuse will occur from at least 60% of the wastewater stream. Reclaimed water will be used for maintenance purposes, e.g., boat washing, irrigation of green areas, or flushing toilets. This will allow for a significant reduction in water intake from natural sources. An integral part of the installation will be a module for the recovery and utilization of waste heat from wastewater. This module will be based on a heat pump system using untreated wastewater as the lower heat source. Heat will be extracted through a dedicated immersion heat exchanger, the concept of which requires addressing several technological challenges, including stable and reliable operation with a contaminated medium, small temperature differences, and efficient recovery of low-temperature heat. A key technical challenge is the development of a scalable solution ensuring safe and reliable operation, as well as the selection of operating parameters that enable efficient utilization of waste heat while maintaining optimal operating conditions for the remaining components of the installation, particularly the wastewater treatment module.

The concept also involves recycling organic and biogenic compounds. This will be achieved through composting of sewage sludge, kitchen biowaste, and green matter (grass, leaves). The sanitary-safe compost will be used to fertilize garden plants and ornamental shrubs and to mulch the soil.

To minimize risks to people and the environment, risk management will be an integral part of the system. It aims to support the operator in ensuring the reliable maintenance of the water recovery and reuse system by optimizing the scope of monitoring and operational activities. Based on reclaimed water quality data, QMRA and risk analyses for people, vegetation, soil, and receiving water bodies, risk management guidelines for decentralized water recovery and reuse installations will be developed. These guidelines will include simulations of hazardous event scenarios and a monitoring and response plan.

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