Wastewater Refinery

Subjects: Environmental Sciences

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Definition

The concept of wastewater refinery introduces a new concept of wastewater treatment and management that aims at extracting the most of wastewater components such as water, energy, nitrogen, phosphorous, to co-produce different valuable outputs. It represents a paradigmatic shift in wastewater management, and it is well aligned with the concept of circular economy. A case study on Qatar's wastewater revealed that significant quantities of valuable resources are embodied in the country's wastewater, with potential to be recovered. Valorisation of organic constituents and the recovery of nitrogen, phosphorus, and sulphide should be given priority.

1. Introduction

Quantity and quality of wastewater depend on many factors such as human behaviour, lifestyle, standards of living, water management systems including the design of sewer systems, and regulatory frameworks [1]. There is a close link between wastewater treatment and sustainable development. Within the Agenda 2030 for Sustainable Development of the United Nations, Sustainable Development Goal 6 (SDG 6) specifies that countries should halve the proportion of untreated wastewater and substantially increase recycling and safe reuse by 2030. The different options of wastewater treatment, recycling and reuse are not only contributing to reducing adverse environmental impacts, but also to alleviating water scarcity and fostering more sustainable resource management practices. While resource recovery from wastewater is not a new approach, the focus so far has mainly been on a recovery of a single material or increasing the effectiveness and efficiency of technical solutions. However, the wastewater refinery approach provides holistic optimization recovery of different valuable wastewater components.

2. The Concept of Wastewater Refinery

The concept of wastewater refinery [2] is in analogy to the concepts of petroleum refinery and biorefinery, where different technologies and processes are combined (usually in one factory) to make the most of components embodied in the influent to be processed (petroleum or crude mineral oil in the case of a petroleum refinery, biomass in the case of a biorefinery), and to generate a variety of marketable products in parallel. Central characteristics of a wastewater refinery is co-production, i.e. the joint delivery of several valuable products based on using a diversified processing scheme at one site or within a structurally coupled network of specialized facilities. The integrated processing of wastewater with the aim of combined generation of different valuable outputs, including bulk materials, fine chemicals and energy, opens opportunities for synergies to achieve high efficiency and effectiveness of wastewater valorisation.

A fabric designed to integrate a diversified set of processing facilities for the recovery of resources from wastewater and for recycling, or a network of such facilities, contributes to implementation of circular economy. In addition, it has the potential to turn the treatment of wastewater from a major cost into a source of profit.

The design of a wastewater refinery would require a detailed assessment of both the technical and the economic feasibility of integrated wastewater processing and must be tailored based on the wastewater characteristics and composition.

2.1 Case Study on Qatar's Wastewater

A case study based on material flow analysis was conducted on the municipal wastewater in Qatar [2] to show the potential recovery of valuable constituents embodied in wastewater. Results revealed that there is a significant potential to recover several valuable components. Nitrogen and phosphorous contained in Qatari wastewater alone could have a market value of more than US$5 million per year. Another promising valorisation pathway is the recovery of biogas via anaerobic digestion, where the potential was estimated to be around 27 million m^3 of methane (equivalent to an energy content of more than 270 GWh) per year. Furthermore, significant quantities of sulphide are contained in Qatar's wastewater, with potential to be recovered using standard technical solutions. Other potentially valuable components such as chloride or oil and grease are present in significant quantities and could be included in more complex wastewater recycling schemes for targeted recovery and valorisation.

The case study on Qatar illustrates that benefits of integrated wastewater processing are not limited to recovery and recycling of components that represent the pollutant load of water flows, but also include reuse of water itself after wastewater treatment. Qatar suffers from physical water scarcity where valorisation of treated wastewater has been identified as an option to alleviate water stress in the country [3]. Treated wastewater could be used for irrigation purposes in agriculture, to replenish groundwater reservoirs or for specific applications in households or industry where the required water quality complies with implementing cascaded water usage schemes, i.e. where water in downstream applications has already served for other applications but is still fit for the specific purpose, such as for toilet flushing.

This case study did not provide a review of the best available techniques that could be transferred to Qatar as well as an analytical assessment of economic viability. Further research is required to investigate the best technical solutions and their economic performance under an existing situation in practice. The promising results of the presented case study pave the way for the implementation of wastewater refineries for the case of Qatari wastewater and for wastewater elsewhere.

3 Conclusions

A wastewater refinery aims at joint production of different marketable products based on wastewater as the resource, using advanced integrated processing schemes at one single location or within a network of facilities. The conceptual idea of wastewater refinery was proven for the case of Qatar by exploring material flow analysis of different constituents embodied in wastewater. The case study on Qatari wastewater confirms availability of significant quantities of potentially recoverable resources which could be used for different purposes. This includes reuse of treated wastewater for irrigation, groundwater replenishment or cascaded water application schemes such as toilet flushing. Implementation of an integrated wastewater refinery is highly promising for the recovery of nutrients such as phosphorous and nitrogen to be used for agricultural fertilizers, the recovery of sulphide and energetic valorisation of organic constituents.

References

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Keywords

Wastewater refinery;Wastewater;Resource recovery;Circular economy;Mass flow analysis;Nutrients

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