Executive Summary

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What sorbents technologies are best for nutrient removal and recovery?

State of Knowledge of the Use of Sorption Technologies for Nutrient Recovery from Municipal Wastewaters (NUTR1R06x)

The Central Issue

Fertilizer is an essential part of food production. The components in fertilizers that are required for the growth of plants are phosphorus and nitrogen, nutrients which cannot be substituted. Depletion of global phosphate rock stores provides motivation for identifying alternative sources of nutrients. Concerns over their loss and growing cost have increased the drive to find another source of these essential nutrients. Wastewater treatment traditionally viewed nutrients as nuisance contaminants that cause eutrophication in receiving waters. Recovery of nutrients from wastewater may be viable; and, in turn, help eliminate nutrients in the effluent.

Context and Background

Developing a low-cost technology that recycles nutrients and produces low nutrient effluent will not only help cut operational costs, but will also give wastewater treatment plants a source of income by selling the recycled nutrients back to industry. Adsorption offers a highly efficient and stable, low-cost technology for phosphorus and nitrogen removal. Consequently, the researchers conducted a literature review of publications that address the use of conventional and innovative adsorbents for nitrogen and phosphorus recovery from wastewaters.

Advantages and Disadvantages of Different Sorbent Technologies

Conventional Sorbent Technologies		
	Advantages	**Disadvantages**
Activated carbon (AC)	■ Easily manufactured. ■ Can be manipulated to remove a variety of different contaminants.	■ Difficult to find the appropriate type of AC in terms of amount and type of functional groups due to surface properties. ■ Low adsorption capacities.
Natural minerals	■ Widely available, inexpensive, and have an affinity for phosphate adsorption, making them attractive materials to use if adsorption capacities can be increased.	■ Highly varied adsorption characteristics. ■ Unpredictable nature of sorbents due to impurities and imperfections.
Natural zeolites	■ Adsorb ammonia through cation exchange. ■ High surface area, thus a good sorbent material. ■ Low cost.	■ Low adsorption capacities.
Ion exchange resins	■ Excellent response to shock loading of systems. ■ Excellent source for ammonium recovery if ion exchange capacities are maximized. ■ Since engineered, the framework of the resin can be produced with minimal impurities and inconsistencies, thus maximizing the capacity of the resin.	■ Competition effects due to resin being non-selective for the sorbate of focus, thus decreasing adsorption capacity. ■ Decreased adsorption capacity could also be seen at pH values which are not optimal for phosphate or ammonium exchange.
Metal oxides	■ Easily synthesized in higher purity and consistency. ■ Can be manufactured as nanoparticles making them attractive for use as sorbents since they have very specific surface properties that can be highly specific, efficient, and cost effective.	■ Decrease in adsorption capacity. ■ Less phosphorus being desorbed after each desorption cycle. ■ Competition effects in wastewater for nutrient recovery.
Non-Conventional Sorbent Technologies		
	Advantages	**Disadvantages**
Biosorbents (biowastes)	■ Abundant in hydroxyl functional groups which suggests the material would be effective as a sorbent. ■ Readily available, inexpensive, renewable sources. ■ Reduction in cost to wastewater treatment. ■ Takes waste products that cause environmental burden and makes them useful.	■ May only be useful in localized areas where the waste products are easily available.

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Findings and Conclusions

This research summarizes the state of the knowledge on the use of sorption technologies for recovering nitrogen and phosphorus from municipal wastewaters. It summarizes the advantages and disadvantages of commercially available sorbents to help identify sorbents or reactions that are best for nutrient removal and recovery. After review of the literature, ion exchange resins and metal oxide sorbents were deemed to have characteristics that, once optimized, have the greatest potential for use in nutrient recovery. The researchers found that adsorption is an attractive treatment method due to its stability, simple operating conditions, and production of less waste sludge.

The researchers also believe that additional research is needed on:

- Sorbent effectiveness in real wastewater samples – While the majority of studies look into the effects of competition with other species, the true performance of sorbents cannot be evaluated until subjected to real world samples.
- Organic nitrogen and phosphorus species – Research is needed to determine a method to convert organic N and P to forms that are useful in nutrient recovery.
- Sorbate desorption and sorbate reuse – Studies have focused on one or two regeneration studies, but have not established the effects of long-term use.

Management and Policy Implications

Adsorption can be applied to treatment plants of large and small scale. It is specifically beneficial for dilute waste streams. This study will help utilities determine whether or not they should invest in nutrient recovery as a revenue generating option; and if so, which is the best method.

Related WERF Research

Project Title	Research Focus
Towards a Renewable Future: Assessing Resource Recovery as a Viable Treatment Alternative (NTRY1R12)	Reviews the technical and economic benefits associated with extractive nutrient recovery, which the researchers define as nutrient recovery processes whereby chemical nutrient products devoid of organic matter are produced. By studying the challenges and benefits for adopting recovery, this research informs future efforts to recover and produce additional value-added products from wastewater and can provide water resource recovery facilities with tools required to make informed decisions that can simultaneously benefit the environment as well as lower O&M costs.
Resource Recovery from Wastewater: A Research Agenda (NTRY2C13)	Provides a review of the processes and technologies currently used to recover resources from wastewater, including carbon removal and recovery, nutrient (phosphorus and nitrogen) recovery, sludge production and utilization, and describes large- and small-scale treatment technologies for carbon, nitrogen, and phosphorus recovery. The information in the report is intended to facilitate the adoption of "resource recovery" in a major shift from conventional industry practice to more sustainable wastewater treatment.

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