Plasmids – A potential future resource to recover from wastewater

Advances in Recovering Plasmids from Wastewater – A State of the Science (NTRY8R15a)

The Central Issue
Recent studies have shown that the bacteria and plasmids in wastewater treatment systems remain largely uncharacterized and represent a potential source of novel gene products. Due to the variety of plasmid genes and the transferability of plasmids, they form the foundation for many of the molecular tools and methods that support and improve multiple industries, such as agriculture, chemical production, paper, textiles, and healthcare.

Context and Background
Plasmids, at the most basic level, are small rings of DNA that bacteria use to transmit information. There is an interest in evaluating plasmid recovery because plasmids and their encoded genes have been used to improve a wide variety of biological and chemical processes. Equally important is research demonstrating that wastewater systems harbor large numbers of bacteria containing plasmids.

To better understand how water resource recovery facilities (WRRFs) can develop and enter the market of plasmids mining and recovery, the researchers sought to answer the following questions based on an intensive literature review:

■ What types of plasmids are present in wastewater?
■ What is the fate of plasmids in wastewater treatment systems?
■ What is involved in the process of isolating and determining the function of plasmids?
■ What is the potential value of recovered plasmids from wastewater?
■ How can utilities become involved in mining plasmids?

Findings and Conclusions
The likelihood of WRRFs recovering, processing, and selling plasmids by themselves is unlikely at this time due to the high costs and risks associated with plasmid recovery and the low or negative expected value to be obtained. The researchers outline a 20-year framework that WRRFs can use as triggers for when and how to investigate plasmid and/or genetic resource recovery.

The researchers found that studies have shown a surprising amount of bacterial diversity in WRRFs, and the growing body of literature related to plasmids in wastewater suggests that it harbors a wide variety of plasmids that contain genes that could serve as biocatalysts for industrial processes. At this time, it is estimated that approximately 20% of the plasmid DNA recovered from municipal wastewater sources represents genes with functions yet to be characterized. Limited research suggests that plasmids are more resistant to disinfection. However, little to no information exists on how plasmids degrade in the various aerobic, anoxic, and anaerobic processes.

The research report discusses the tools for extractions of plasmid DNA and the approaches for screening the functions encoded therein. It also proposes a classification scheme for plasmid-related products that facilitates the evaluation of their value as recovered products and envisions a pathway forward for the future development of recovering plasmids from wastewater.

Management and Policy Implications
WRRFs might consider collaborating and partnering with academia and/or industry in order to pursue this possible commodity from wastewater. Although the recovery of plasmids from WRRFs is currently limited, the wastewater industry has the potential to unlock a new set of plasmids and genes that could provide multiple benefits to society.
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Possible Plasmid-Based Products

- Plasmid-based end products (enzymes)
- Bulk plasmids
- Plasmids with known function and no IP restrictions
- Plasmids with known function and IP restrictions
- Intellectual rights to use plasmid

No market

Most lucrative and most difficult

Related WE&RF Research

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<th>Project Title</th>
<th>Research Focus</th>
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<td>Nutrient Recovery – State of the Knowledge Report (2010)</td>
<td>Discusses processes used to extract specific chemical compounds, with market value, from wastewater treatment streams. This information led to WE&amp;RF’s Resource Recovery Challenge.</td>
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<td>Resource Recovery from Wastewater: A Research Agenda (NTRY2C13)</td>
<td>Explores the various options for the recovery of resources from wastewater – recycled water, energy from methane capture, phosphorus recovery, and biosolids with improved bioavailability.</td>
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<tr>
<td>Beyond Nutrients: Recovering Carbon and Other Commodity Products from Wastewater (NTRY3R13)</td>
<td>The recovery of high value carbon products and non-nutrient commodity products is the next step in resource recovery. However, the recovery of these products is contingent not only on the availability of technologies that are mature, reliable, and cost competitive with existing treatment options, but also on whether the implementation of these technologies is synergistic with the goal of producing a high quality effluent water that can be discharged to the environment or reused without detrimental impact on human and environmental health.</td>
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