

Purple bacteria and their less known applications

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Jungwoo Lee, High-School Student, and Arpita Bose, Associate Professor at Washington University in St. Louis, guide us through purple bacteria and their less-known applications, including wastewater treatment and biofertilization

Purple bacteria, also known as purple photosynthetic bacteria, which belong to the phylum Proteobacteria, can be classified into purple sulfur bacteria (PSB) and purple non-sulfur bacteria (PNSB).

Purple non-sulfur bacteria introduction

In contrast to PSB, PNSB demonstrate the ability to utilize various electron donors and acceptors, which further expands their applications. Their adaptable metabolism, coupled with well-defined genetic manipulation techniques, positions PNSB as ideal models for elucidating the intricacies of metabolic pathways, which hold significant implications for diverse biotechnological applications, including wastewater treatment, and as biofertilizers.

Biological treatments for wastewater

Biological treatments present a more economical, less harmful, and comprehensive approach to treating wastewater compared to physical or chemical methods, provided suitable organisms and/or enzymes are utilized. Furthermore, biological treatment techniques also enable the extraction of organic compounds from wastewater, such as phosphorus or carbon. Phosphorus and carbon extracted from these facilities are often repurposed as fertilizers and raw materials for other bioproducts.

Biological treatments are categorized into suspended growth and attached growth methods. Suspended growth involves planktonic cells growing without attachment to a substrate. This can occur in bioreactors, where wastewater is introduced to planktonic cells and held for a specific duration before being removed.

Alternatively, attached growth involves the formation of a biofilm, where a group of microbes adheres to a surface and generates an extracellular polymeric substance (EPS) matrix. This matrix provides the biofilm with increased resistance to external physiochemical stresses and enhances the microbial ability to capture substances like heavy metals.

Purple non-sulfur bacteria explored

PNSB, under light-available anaerobic conditions, utilize photoheterotrophy as their primary method of metabolism. When performing photoheterotrophy, PNSB harness light energy and utilize organic compounds as carbon sources to metabolize. Notably, besides using organics as electron sources, purple non-sulfur bacteria (PNSB) can also utilize inorganic substances like minerals as electron donors.

PNSBs are especially known for their efficiency when applied in wastewater treatment. The original wastewater treatment process involves physical, chemical, and biological methods to remove pollutants and contaminants from wastewater before its safe release into the environment. Here, the PNSB provide a cost-effective, less toxic, and comprehensive approach to produce single cell proteins.

PNSBs can be used for both suspended and attached growth biological treatment methods. Suspended growth involves planktonic cell growth without substrate support, whereas attached growth forms biofilms on surfaces, enhancing resistance to environmental stresses and substance sequestration.

As PNSBs can grow without needing oxygen, PNSBs often illustrate high efficiency at converting organic waste into useful products like bioplastics under anoxic conditions.

In addition, PNSBs can assimilate chemical oxygen demand (COD), phosphorus, and nitrogen, acting as a protein or fertilizer source. Such benefits are in stark contrast with the conventional usage of other microbes.

Purple non-sulfur bacteria research

To corroborate, the effectiveness of PNSBs has been proven in many studies, demonstrating that PNSB efficiently remove organic material from various wastewaters. Wastewaters treated with PNSB illustrate substantially low COD rates, indicating the effective removal of organic pollutants and reduced environmental impact in wastewater treatment processes. As such, these processes of wastewater treatment allow the resource recovery of water.

Numerous microbes have been explored for their capacity to treat wastewater and convert waste materials into valuable products, particularly fertilizers. In pursuit of cost-effective solutions, photosynthetic microbes currently also emerge as promising candidates owing to their ability to harness sunlight as an abundant energy source. PNSB are more desirable than other popular choices like microalgae. Use of microalgae often necessitates substantial light exposure and aeration that can cause problems in some situations.

Photosynthetic PNSBs and more

In contrast, photosynthetic PNSBs exhibit resilience even in low-light environments and thrive without oxygen. Their metabolic processes enable them to efficiently break down organic waste materials, transforming them into a variety of beneficial products, with fertilizers being a significant output. PNSBs can contribute significantly to soil fertilization

through various mechanisms. Firstly, they directly enrich the soil by serving as a source of essential nutrients, such as nitrogen, phosphorous, and potassium (NPK), as dead or decaying cells.

Additionally, living microbial cells play an indirect yet crucial role in nutrient acquisition, notably through nitrogen fixation and via plant growth-promoting substances (PGPS). As such, PNSB's deceased biomass boasts a favorable NPK content, with a notable abundance of phosphorous derived from their capacity to accumulate polyphosphate.

Although PNSB may require potassium supplementation due to their low potassium content, they excel in nitrogen fixation and phosphorous chelation when alive, thereby enhancing nutrient availability to plants. Remarkably, certain PNSB species can conduct nitrogen fixation under microaerobic conditions, broadening the range of environments suitable for their application. As such, while PNSB inoculation alone may yield limited effects on plant growth and yield, their incorporation enhances the efficiency of synthetic nitrogen fertilizers, demonstrating the potential of microbial intervention in optimizing agricultural productivity.

Summary of purple bacteria and their applications

In summary, purple non-sulfur bacteria have a variety of characteristics that allow them to flourish in a range of environmental settings. Their use in wastewater treatment and as a biofertilizer emphasizes their importance for fostering environmental sustainability and resolving pollution issues. Taking advantage of purple non-sulfur bacteria's metabolic potential presents a viable way to reduce environmental pollution and improve ecosystem health, especially as the water crisis continues to aggravate.

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