



POLLUTION CONTROL AND WASTE TREATMENT

Yeast offers versatile and environmentally friendly technologies, paving the way for a cleaner future.



ROLE OF YEAST

The use of yeast in the areas of pollution control and waste treatment is largely attributed to its metabolic capabilities, resilience in various environmental conditions, its diversity, and its ability to be genetically modified for enhanced performance.

BIOREMEDIATION AND POLLUTANT DEGRADATION

- Due to their ability to metabolize a wide range of organic pollutants, yeasts (particularly *Saccharomyces cerevisiae*) can degrade hydrocarbons, phenols, and other toxic organic compounds through their enzymatic pathways. For instance, *Candida tropicalis* has shown efficacy in degrading phenol, with removal efficiencies reaching up to 98% under optimal conditions.
- Additionally, yeasts can be used to remediate heavy metals through biosorption, a process where metal ions are sequestered by the cell wall components. For instance, *Saccharomyces cerevisiae* can absorb significant amounts of cadmium and lead from aqueous solutions, for heavy metal bioremediation and potential recycling of some valuable heavy metals.

WASTEWATER TREATMENT

- Yeasts can be integrated into treatments of industrial effluents. For example, *Saccharomyces cerevisiae* has been used in anaerobic digesters to improve the degradation of brewery wastewater, resulting in increased biogas production and reduced chemical oxygen demand (COD) levels.
- Moreover, the use of yeast in constructed wetlands and biofilters has been shown to effectively remove nitrogen and phosphorus from wastewater, thereby preventing its eutrophication.

GENETIC ENGINEERING FOR ENHANCED PERFORMANCE

- Thanks to genetic engineering, yeasts can express foreign genes that enhance their pollutant degradation capabilities. For instance, recombinant *Pichia pastoris* expressing organophosphorus hydrolase can degrade organophosphate pesticides, achieving degradation rates up to 95%.
- CRISPR-Cas9 technology has been employed to create yeast strains with enhanced tolerance to toxic environments and improved metabolic pathways for the efficient breakdown of pollutants.

ECONOMIC AND ENVIRONMENTAL BENEFITS

The use of yeast in pollution control and waste treatment offers several benefits:

- Yeasts are cost-effective due to their rapid growth rates.
- Most yeast species grow under anoxic conditions, with less oxygenation costs.
- In some cases, the yeast biomass generated from the waste treatment can be separated and used in fertilizers or even animal feeds, due to its high protein and vitamin content.
- These processes are more sustainable than conventional chemical treatments that are more costly and environmentally damaging with harmful byproducts.



SPECIES OF YEAST USED

- **Oxidative yeasts:** Species like *Candida tropicalis*, *Pichia anomala*, and *Hansenula polymorpha* demonstrate robust abilities to degrade a wide range of pollutants, including:
 - Hydrocarbons: *Candida guilliermondii* can remove up to 90% of total petroleum hydrocarbons.
 - Phenolics: *Rhodotorula mucilaginosa* exhibits high efficiency in degrading phenolic compounds, a common class of industrial pollutants.
- **Mixed cultures:** Combining yeast with other microorganisms like bacteria or algae can create synergistic effects. For example, yeast-algae consortia can simultaneously remove organic matter and nutrients from wastewater.



PROCESS

- Yeast treatment typically involves cultivating a chosen yeast strain in a bioreactor containing the polluted wastewater. These yeasts utilize the pollutants as a carbon and energy source for their growth. The process can be aerobic (requiring oxygen) or anaerobic (without oxygen), depending on the specific yeast and contaminant. The treated wastewater undergoes further processing to remove the yeast biomass before discharge.
- Yeast-based bioremediation typically involves the following steps.
 - Inoculation: Yeast strains are introduced to the polluted medium (e.g., wastewater, soil).
 - Nutrient addition: Nutrients necessary for yeast growth, such as nitrogen and phosphorus, are added to the medium.
 - Aeration: Oxygen is supplied to facilitate aerobic metabolic processes.
 - Fermentation and degradation: Yeast metabolizes pollutants through fermentation, breaking down complex organic compounds into simpler, less harmful substances.
 - Separation: Treated water or soil is separated from yeast biomass, which can be further processed or used as biofuel.



A SHORT HISTORY

- **In the 1970s**, pioneering work by Yoshizawa in Japan demonstrated the effectiveness of yeast in wastewater treatment. Since then, these technologies have been increasingly used.
- **In 2022**, the Marc Regnier Prize was awarded to the Sublimus project for its sustainable methods of extracting rare and precious metals from urban wastewater, particularly activated sludge.



KEY DATA

- **Organic matter removal:** Yeast can achieve high removal rates of organic matter, as measured by Chemical Oxygen Demand (COD), with report of reductions exceeding 95% for specific wastewater.
- **Heavy metal bioaccumulation:** Certain yeast strains can accumulate heavy metals like chromium and lead, offering a bioremediation strategy for metal-contaminated environments.
- **Organic Pollutant Degradation:** *Candida utilis* has been shown to degrade up to 90% of phenol and other toxic organic compounds in industrial effluents.
- **Wastewater Treatment Efficiency:** Yeast-based treatments can reduce biochemical oxygen demand (BOD) and chemical oxygen demand (COD) by up to 85%, making the water safe for discharge or reuse.



PROSPECTS AND INNOVATIONS

- **Engineered yeasts:** Researchers are exploring genetic modification of yeast strains to enhance their pollutant degradation capabilities and tolerate extreme conditions.
- **Biodiesel production:** Yeast can convert the **lipids present in wastewater** into biodiesel, offering a sustainable approach to waste treatment and fuel generation.
- **Bioaugmentation:** Developing microbial consortia, including yeast and bacteria, to target a broader range of contaminants.