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Study of The Efficiency of Using Pseudomonas Spp in Wastewater Treatment

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Abstract . The search for easy and effective wastewater treatment options is essential in light of the worsening water pollution problem with increasing population and industrialization. Isolation of Pseudomonas aeruginosa bacteria from sewage-contaminated water and evaluation of its efficiency in removing these pollutants. The capacity of Pseudomonas aeruginosa strains to remove chemical contaminants and heavy metals under several environmental conditions was examined after they were isolated from polluted wastewater and genetically characterized. Advanced genetic testing and regular water analyses were used to assess their effectiveness. The performance of several drinking water treatment plants was also measured in terms of nitrate removal, with varying results depending on the substrates tested. removal were more than The pollutant removal exceeded 87% for nickel, which was the highest, while it was 30% for nitrate, which was the lowest. These results indicate the potential use of this bacteria as a potential environmentally friendly wastewater treatment organism, and its effectiveness could be significantly improved with simple modifications to treatment conditions.

Highlights:

1. Pseudomonas aeruginosa effectively removed up to 70% of organic pollutants (COD) and over 60% of nitrogen compounds from wastewater.
2. The bacteria showed high heavy metal removal efficiency, with 87.2% for nickel and 77.5% for zinc.
3. Nitrate removal was the lowest (30.3%), highlighting the need for optimized treatment conditions to improve efficiency.

Keywords: Pseudomonas spp, wastewat , nitrogenous pollutants , organic pollutants.

Introduction

The environment is heavily burdened globally by the substantial rise in population growth in the majority of metropolitan areas and the reliance on natural resources. The existence of contemporary industries and their inappropriate usage, which produces a lot of trash and pollutes the environment, make this worse [1]. Furthermore, radioactive waste and chemical pollutants in the environment are caused by the extensive usage of raw materials in enterprises. It is costly to sort and treat these wastes, if at all feasible, or to dispose of and manage them generally, and they harm the environment in ways that are hard to repair [2]. The excessive release of nitrogen and organic matter in recent years has destabilized the ecosystem overall and caused eutrophication of the water [3]. Anaerobic and aerobic wastewater treatment is one of the most used biological treatment strategies [4]. One of the best methods for treating wastewater before releasing it into natural aquatic habitats is biological treatment. The simplicity, little secondary contamination, and low cost of biotechnology are its

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advantages [5]. Utilizing microorganisms in sophisticated biotechnological procedures, such as biofertilization, conversion, biodegradation, and other techniques, can efficiently treat a variety of wastes [6]. Because they may lower biological oxygen demand and sediment solids, bacteria are among the most significant microorganisms that contribute to the breakdown and stability of organic materials in wastewater [7]. Microorganisms, particularly bacteria, are used by humans to remediate wastewater because they are crucial to the waste's breakdown cycle [8]. In addition to their rapidity in carrying out treatment procedures, bacteria are chosen over other microorganisms in bioremediation because of their capacity to decrease nutrients and boost biomass [9]. Plants, soil, and water are just a few of the settings from which the bacteria Pseudomonas aeruginosa may be isolated. It is a member of the Gram-negative bacterial genus. [10]. This species is one of the most remarkable in that its life and metabolic activities are so vastly diversified [11]. Many environments can harbor the development of these microbes. [12]. Pseudomonas aeruginosa, as it is known, can be found in dirty places like wastewater and contaminated soil, and has the ability to degrade contaminants[13]. At room temperature, the majority of strains show promise in the removal of nitrogen and organic materials from wastewater purification procedures [14]. Because it has a variety of mechanisms, including enzymes, that enable it to consume a wide range of polycyclic and monocyclic compounds, Pseudomonas aeruginosa has demonstrated a high potential for wastewater treatment. This lowers the chemical oxygen demand (BOD), which in turn reduces the need for additional chemicals [15,16].

Materials and Methods

Samples were collected from sources contaminated with wastewater, followed by the isolation and selection of Pseudomonas spp. strains with the ability to remove pollutants. After purification, the strains were identified using microbiological and biochemical analyses, along with gene sequencing techniques, particularly 16S rRNA gene analysis, to confirm the identity and precise classification of the strains. Subsequently [17,18], industrial or domestic wastewater (natural or artificially simulated) was prepared and prepared for testing. The isolated bacteria were added, and the samples were incubated under varying environmental conditions, including temperature differences (especially low temperatures), aeration levels (aerobic, anaerobic, and facultative), and different treatment periods. During the treatment phases, periodic measurements of chemical contaminants such as chemical oxygen demand (COD) [19], nitrate (NO_3^-), ammonia (NH_4^+), total nitrogen (TN), phosphate (PO_4^{3-}), and some heavy metals such as zinc and nickel [20,21], were conducted using validated analytical techniques. Advanced genetic analyses were also performed to identify enzymes and genetic traits associated with the bacteria's ability to adapt to the environment and biodegrade.

Results and Discussion

The results in the table below showed the effective ability of bacteria to reduce and remove pollutant concentrations from sewage. The ratios showed that bacteria have a clear ability to reduce chemical oxygen demand levels by up to 70%. This high percentage is evidence of the bacteria's ability to decompose complex organic compounds and convert them into a usable energy source. The removal of ammonia pollutants was up to 61%, which indicates the bacteria's ability to perform high and effective nitrification work under different conditions such as ventilation and temperatures. As for total nitrogen, the percentage was about 61%. This result reflects the positive ability of these bacteria to analyze different types of nitrogen, whether organic or inorganic. As for nitrate, the result was unexpected, as it was the lowest at 30.3%. This indicates the weak efficiency of bacteria in removing nitrate compared to

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other pollutants. As for phosphate, the percentage witnessed an acceptable decrease of 34.1%, which indicates the bacteria's ability to absorb phosphate. And its accumulation during growth and reproduction in living cells, as for sulfate, the removal rate was 59%, which indicates that the bacteria consume sulfate and convert it to a less harmful form through effective biological mechanisms. Regarding heavy metals such as zinc and nickel, the percentage was positive and very high with a slight difference, as the percentage was 87.2 for nickel compared to 77.5 for zinc. This is due to the ability of bacteria to precipitate and absorb heavy metals inside and outside the cells. These results are nothing but clear evidence of the ability of these bacteria to remove and analyze organic pollutants or convert them to a less harmful form with a symbolic cost compared to other traditional methods (**Table 1**).

Table 1: results for wastewater treatment using Pseudomonas spp.

Pollutant	Bacterial Strain	Treatment Duration	Concentration Before (mg/L)	Concentration After (mg/L)	Maximum Removal Efficiency
COD (Chemical Oxygen Demand)	P. aeruginosa	6 hours	734	220	70%
NH_4^+ (Ammonium Ion)	P. aeruginosa	96 hours	77	30	61%
TN (Total Nitrogen)	P. aeruginosa	96 hours	330	129	60.9%
NO_3^- (Nitrate)	P. aeruginosa	6 hours	33	23	30.3%
PO_4^{3-} (Phosphate)	P. aeruginosa	6 hours	72	41	43.1%
SO_4^{2-} (Sulfate)	P. aeruginosa	6 hours	94	38.5	59%
Zn (Zinc)	P. aeruginosa	6 hours	0.89	0.20	77.5%
Ni (Nickel)	P. aeruginosa	6 hours	0.78	0.10	87.2%

Conclusions

Many pollutants, such as organic matter, nitrogen, phosphates, and heavy metals, can be effectively removed from wastewater by Pseudomonas species; in certain indications, their removal rate has exceeded 70%. These strains' potential for application in low-cost bioremediation systems is increased by their demonstrated capacity to function well in a range of environmental conditions, including cold temperatures. The findings also demonstrated that the effectiveness of nitrate removal is comparatively poor, underscoring the significance of enhancing operating conditions, including aeration, in order to attain superior outcomes. Therefore, Pseudomonas species can be regarded as a viable and sustainable wastewater treatment alternative.

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Recommendations

1. Encourage the use of Pseudomonas species in biological wastewater treatment plants because they work better and cost less than chemical treatments.

2. To evaluate the efficacy of the species in action, do extensive field tests in various environmental settings (such as extremely contaminated water or cold temperatures).

3. To improve the nitrate removal efficiency, which was lower than that of other pollutants, operating conditions, including aeration and incubation times, should be optimized.

4. Research the utilization of bacterial consortia, which are groups of bacteria that combine multiple types to boost the removal effectiveness of various contaminants simultaneously.
5. To improve removal efficiency and get greater water quality, combine biological purification with other treatment technologies (such filtration or adsorption).

6. To increase sustainability, promote collaboration between academic institutions and environmental centers to create treatment solutions based on locally isolated bacteria from the environment.

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