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Bio sorption Studies on Textile Effluent Using Packed Bed Reactor with Aspergillus Niger Biomass

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Abstract: The disposal of effluent is a major source of pollution in water bodies, textile effluent is a problem of major concern in the locale. Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. Treatment for textile effluent involves the usage of chemicals to remove dye which is incompetent in removing the heavy metals and other organic matter in the effluent which remains unprocessed. The biosorption studies using *Aspergillus niger* biomass showed an overall decolorization of around 85% with a metal adsorption rate of 81% which can be feasibly utilized for the ecofriendly treatment of textile effluents

Key Word: Adsorption, Biomass, Decolourisation, Eco-friendly

1. Introduction

Textile effluent water contains a variety of pollutants that can be harmful to both human health and the environment. These pollutants can include heavy metals, dyes, solvents, acids, and other toxic chemicals that are used in the textile industry. Here are some ways in which textile effluent water can be harmful to society:Environmental pollution: Textile effluent water, if not treated properly, can contaminate water bodies such as rivers and lakes, leading to pollution of the environment. This can harm aquatic life and disrupt the ecological balance of the surrounding areas.Health hazards: The toxic chemicals present in textile effluent water can pose serious health hazards to humans. Exposure to these pollutants can cause skin irritation, respiratory problems, and even cancer in the long term.Contamination of soil: When textile effluent water is discharged into the soil, it can contaminate the soil, making it unsuitable for agricultural purposes. This can lead to a decrease in crop yield and food production, leading to food scarcity and economic losses.Negative impact on tourism: Pollution caused by textile effluent water can have a negative impact on tourism, as it can lead to the degradation of scenic places and discourage tourists from visiting.Therefore, it is important to purify textile effluent water before discharging it into the environment to reduce the potential harm caused to society. This can be achieved through the use of various treatment processes such as physical, chemical, and biological methods, which can remove the pollutants present in the water and make it safe for discharge. By purifying textile effluent water, we can protect both the environment and the health of the people who live in the surrounding areas.

2. Materials and Methods

Biosorption is the process of using biological materials to remove contaminants from water or other fluids. Aspergillus niger is a type of fungus that has been used for biosorption due to its ability to adsorb heavy metals, dyes, and other pollutants. Here are some materials and methodology for biosorption of textile effluent water using Aspergillus niger biomass.

Materials:

- Aspergillus niger biomass (obtained through cultivation of the fungus)
- Effluent water (collected from a wastewater treatment plant)
- Nutrient broth (to support the growth of Aspergillus niger)
- Shake flasks or bioreactors (to hold the Aspergillus niger and effluent water mixture)
- Analytical instruments (to measure the concentration of pollutants before and after biosorption)

Methodology:

1. Preparation of Aspergillus niger biomass: Aspergillus niger can be grown on nutrient agar plates or in liquid nutrient broth. Once the fungus has grown, it can be harvested and washed to remove any residual media or contaminants.
2. Preparation of effluent water: Effluent water can be collected from a wastewater treatment plant and filtered to remove any large particulate matter. The water should be analyzed for the presence and concentration of target pollutants.
3. Biosorption experiment: The Aspergillus niger biomass is added to the effluent water in shake flasks or bioreactors. The mixture is agitated gently to allow the fungal cells to come into contact with the pollutants in the water.
4. Monitoring of biosorption: The concentration of pollutants in the effluent water is monitored at regular intervals using analytical instruments such as UV-Vis spectrophotometers or atomic absorption spectrometers. This allows for the determination of the rate and extent of biosorption.
5. Data analysis: The data obtained from the biosorption experiment is analyzed to determine the efficacy of Aspergillus niger biomass for removing pollutants from effluent water. This can include calculating the percentage removal of pollutants and comparing it to other biosorption materials.

Overall, the use of Aspergillus niger biomass for biosorption of effluent water can be an effective and environmentally friendly way to remove pollutants from wastewater.

Subjects & selection method: The subject of biosorption of textile effluent water using Aspergillus niger biomass falls under the field of environmental biotechnology. This research topic involves the use of a biological material (Aspergillus niger biomass) to remove pollutants from wastewater, which is a critical issue for the environment and human health.

The selection of Aspergillus niger as the biosorbent is based on its ability to adsorb heavy metals, dyes, and other pollutants, which has been demonstrated in previous research. Aspergillus niger is also easy to grow in laboratory settings and can be obtained from common sources such as soil and food.

Effluent water was selected as the target wastewater to study the effectiveness of Aspergillus niger biomass for biosorption. Effluent water is the wastewater that has been treated in a sewage treatment plant but still contains some pollutants. The treatment plant's effluent water contains various pollutants, including heavy metals, organic compounds, and pathogens, which can cause serious environmental problems and pose a health hazard to humans and animals.

The selection of this research topic is essential as it can provide a sustainable and cost-effective solution for wastewater treatment. The use of Aspergillus niger biomass for biosorption can be a green technology that can replace conventional wastewater treatment methods. The study can also provide new insights into the potential of Aspergillus niger biomass as a biosorbent and open up new avenues for research in the field of environmental biotechnology.

Inclusion criteria:

1. Aspergillus niger biomass: Only Aspergillus niger biomass that has been cultured under controlled conditions should be used for the biosorption experiment. This is to ensure the consistency and reproducibility of the results.
2. Effluent water: The effluent water should be collected from the same source and should have a similar composition and concentration of pollutants. This is to ensure that the biosorption results are not affected by the variability of the effluent water.
3. Concentration of pollutants: The concentration of the target pollutants in the effluent water should be within a certain range to ensure that the biosorption process is efficient and effective. The concentration of the target pollutants should be measured using reliable analytical methods.
4. Biosorption time: The duration of the biosorption experiment should be predetermined and kept constant for all samples. This is to ensure that the results are comparable and consistent.
5. Biosorption conditions: The biosorption experiment should be conducted under controlled conditions, such as temperature, pH, and agitation. This is to ensure that the biosorption results are not affected by external factors.
6. Analytical methods: The same analytical methods should be used to measure the concentration of pollutants in the effluent water before and after biosorption. This is to ensure that the results are comparable and accurate.

Exclusion criteria:

1. Contaminated Aspergillus niger biomass: Any Aspergillus niger biomass that is contaminated with other microorganisms or pollutants should be excluded from the experiment. This is to ensure that the results are not affected by other factors.
2. Toxic or hazardous pollutants: Effluent water that contains toxic or hazardous pollutants should be excluded from the experiment. This is because Aspergillus niger biomass may not be able to effectively remove these pollutants, and their presence may pose a health risk to the researchers or the environment.
3. Extreme pH or temperature: Effluent water that is too acidic or too alkaline, or that has an extremely high or low temperature, should be excluded from the experiment. This is because these conditions may negatively impact the viability and effectiveness of the Aspergillus niger biomass.
4. Inconsistent or unreliable analytical methods: Analytical methods that are inconsistent or unreliable should be excluded from the experiment. This is to ensure that the results are accurate and reproducible.

5. Non-standardized biosorption conditions: Biosorption conditions that are not standardized or consistent, such as variations in the volume of effluent water or the amount of Aspergillus niger biomass used, should be excluded from the experiment. This is to ensure that the results are comparable and consistent.

Procedure methodology

The selection methodology for biosorption of textile effluent water using Aspergillus niger biomass involves the following steps:

1. Identification of research question: The first step is to identify the research question, which is usually related to the efficiency and effectiveness of Aspergillus niger biomass for biosorption of effluent water.
2. Literature review: A comprehensive literature review should be conducted to identify previous studies that have investigated the biosorption of effluent water using Aspergillus niger biomass. This will help to identify knowledge gaps and areas where additional research is needed.
3. Selection of Aspergillus niger biomass: The next step is to select the appropriate Aspergillus niger biomass to be used in the biosorption experiment. The biomass should be cultured under controlled conditions and should have the ability to adsorb the target pollutants.
4. Collection of effluent water: The effluent water should be collected from a wastewater treatment plant and should be analyzed to determine its pollutant composition and concentration.
5. Biosorption experiment design: The biosorption experiment should be designed to optimize the biosorption conditions, such as pH, temperature, biomass dosage, and contact time. The biosorption experiment should be replicated multiple times to ensure the reproducibility of the results.
6. Analysis of biosorption efficiency: The efficiency of biosorption should be determined by measuring the reduction in pollutant concentration in the effluent water before and after biosorption. The analytical methods used to measure pollutant concentration should be consistent and reliable.
7. Statistical analysis: Statistical analysis should be conducted to determine the significance of the biosorption results and to identify any trends or patterns in the data.
8. Interpretation of results: The results of the biosorption experiment should be interpreted in the context of the research question and the literature review. The strengths and limitations of the study should be identified, and recommendations for future research should be provided.

Overall, the selection methodology for biosorption of effluent water using Aspergillus niger biomass should be rigorous and well-planned to ensure that the results are reliable and meaningful.

Statistical analysis

Statistical analysis of textile biosorption of effluent water using Aspergillus niger biomass involves the following steps:

1. Descriptive statistics: Descriptive statistics should be used to summarize the data, such as mean, standard deviation, and range. This will provide an initial understanding of the data and its distribution.
2. Normality test: The normality of the data should be tested using a normality test, such as the Shapiro-Wilk test. This will determine if the data follows a normal distribution, which is a prerequisite for many statistical tests.
3. Analysis of variance (ANOVA): ANOVA should be used to determine if there are any significant differences in the biosorption efficiency among the different textile samples or experimental conditions. If significant differences are found, post-hoc tests such as Tukey's HSD or Bonferroni correction can be used to identify which groups are significantly different.
4. Regression analysis: Regression analysis can be used to determine the relationship between the biosorption efficiency and the independent variables, such as the pH, temperature, biomass dosage, and contact time. This can help to identify the optimal biosorption conditions.
5. Correlation analysis: Correlation analysis can be used to determine if there is a relationship between the biosorption efficiency and the pollutant concentration in the effluent water. This can help to identify the pollutants that are most effectively removed by Aspergillus niger biomass.
6. Principal component analysis (PCA): PCA can be used to identify patterns and relationships among the different variables, such as the textile samples, experimental conditions, and biosorption efficiency. This can help to identify the most important factors that influence biosorption efficiency.
7. Statistical significance: The statistical significance of the results should be determined using appropriate tests and criteria. The level of significance should be chosen based on the research question and the desired level of confidence.

Overall, statistical analysis is an important part of textile biosorption of effluent water using Aspergillus niger biomass, as it helps to identify patterns, relationships, and significant differences in the data. The choice of statistical tests and criteria should be based on the research question, the nature of the data, and the desired level of confidence.

3. Result

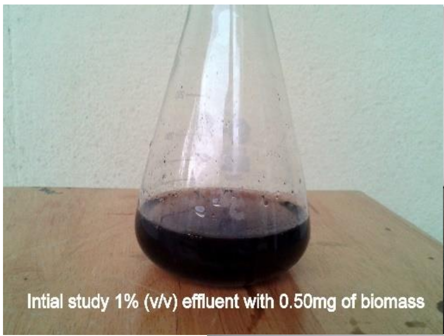
- The samples from the process were collected in an interval of 1 day alternatively and the decolourization was noted by analyzing the sample in UV-Visible spectrophotometry The results showed that the decolorization of the effluent was about 83.21% and hence the fungal biomass can be effectively used for the biosorption studies in the bench scale pilot setup.

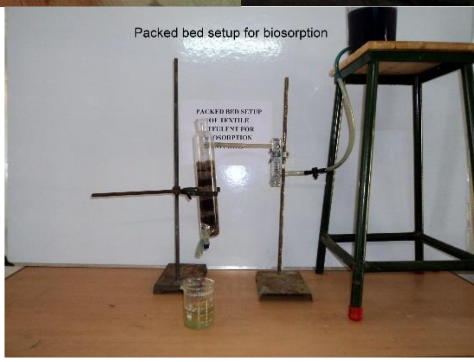
Column Designing

The column designing is carried out to determine the efficacy of the biomass in a bench scale pilot setup. The reactor used is a packed bed column which is packed with the biomass and coir such that the layers provide an effective effluent treatment system. The biomass is packed along with the coir in alternating layers such that the effluent has to pass through the layers providing an optimum and effective effluent treatment system. Thus the packed bed reactor is mostly referred than to other reactor types for this treatment process

Process Parameters

The study is to provide an optimum and effective effluent treatment process which can be obtained only through the maintaining and studying some of the important process parameters throughout the process which determines the total process efficiency when scaled up to a larger industrial application. The process parameters maintained were retention time. porosity and flow rate. These three are the important factors that determine the total process efficiency in the reactor.





Retention Time:

The retention time is defined as the time given for the effluent to react with the mass and the retention of the effluent in the total reactor. This helps to determine the optimal time taken for the total decolourization and the adsorption of the heavy metals to the mass the retention time is calculated by:

$$\text{Retention time } T = \frac{\text{Working volume of the reactorml/min}}{\text{Volumetric flow rate}}$$

The retention time is inversely proportional to the rate of biosorption that occurs in the exor the increase in the retention time increases the efficiency of the biosorption and the decrease in the retention time decreases the efficiency of the biosorption,

Flow Rate:

The flow is the amount of effluent which is allowed to enter the reactor and this flow rate determines the total time taken for the effluent to move through the column and exit the reactor. This flow rate determines the effectiveness of the reaction with the time

$$\text{Flow rate } v = \frac{\text{Treated effluent collected}}{\text{Time}}$$

The flow rate determines the efficiency and the number of cycles required for the treatment process, with the increase in floss rate there is decrease in the biosorption

S.No	Dilution	Optical density at 540nm	Percentage of decolourization
0	10	0.000	0.00
48	10	0.061	17.36
96	10	0.103	30.85
144	10	0.126	38.25
192	10	0.191	59.14

240	10	0.033	64.78
288	10	0.037	76.89
336	10	0.038	83.56

4. Discussion

The effluents discharged from the textile industries are a major problem for water resources. Many novel techniques have been implemented in order to minimize the rate of contamination in the effluent but most of the processes are not cost effective. The present study for the treatment of effluent using fungal biomass provides a good alternative that shows comparatively higher efficiency and lower cost. Aspergillus niger is one of the most common fungal species which can be isolated and obtained easily throughout the temperate zone This microorganism can be targetted towards different types of harsher effluents in order to minimize their toxicity for the purpose of usage. The results from the current study revealed that Aspergillus niger has a good capacity fordecolourization of the dyes from the effluent and it also adsorps heavy metals significantly which was already studied and reported by (Mukhopadhyay et al, 2008) Chromium is present predominantly in the textile effluents which increases toxicity in the water bodies. Most of the commercially available treatment process like chlorination, membrane filtration, and aerobic and anaerobic digestion does not target the heavy metals from the effluents.

According to the present study Aspergillus niger biomass along with coir when packed in the column provides good efficiency for the removal of heavy metals as well as decolourization of dyes is also improved. In reference with (Marrot et al., 2001) the results reported were for batch stadies of the dye decolurization process and the current study proved that the efficiency of the biomass for biosorption were on par to the results obtained. The characterization and analysis of the effluent were carried as reported by (Sivakumar et al., 2011) by which the analysis was carried out. The normal effluent treatment process was reported by (Kikani et al., 2006) and when compared to the results of commercial treatment, the study provides a cost effective and total effluent process.

It is also been proved that most of the characteristic properties of the effluents such as color, density, total dissolved solids. BOD, COD, and heavy metals concentration also show a significant reduction in their amount after treatment which was analyzed only in the batch studies reported by (Wijetunga et al. 2010). Hence most of the organic and inorganic toxic constituents of the effluent can be reduced by this specific process using fungal biomass. This technique can be effectively implemented for total effluent treatment in textile industry sector.

5. Conclusion

Pollution is a major problem faced in todays scenario. The industries are discharging enormous amounts of effluents which deplete the water ecosystem. Eco friendly process and proper treatment of waste is necessary.Biomass is a promising aspect for the effluent treatment.

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