

Fungal Biosorption Potential for Chromium (VI) Removal from Tannery Effluent

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Abstract

The presence of chromium (VI) in tannery wastewater poses a major environmental issue due to its hazardous nature, longevity, and possible threats to aquatic life and human well-being. The current research examines the feasibility of fungal biosorption as a cost-effective and eco-friendly method for eliminating Cr (VI) from tannery wastewater. Chosen fungal biomass is assessed for its capacity to absorb chromium ions from polluted wastewater in regulated laboratory settings. The research investigates critical factors affecting biosorption efficacy, such as pH, duration of contact, starting chromium content, dose of fungal biomass, and temperature. The process of chromium elimination is linked to the interactions occurring at the surface between chromium ions and the functional groups found in the fungal cell wall, including hydroxyl, carboxyl, amino, and phosphate groups. The efficacy of the procedure is evaluated by calculating the percentage of chromium eliminated and the biosorption capability. Equilibrium and kinetic analyses might yield insights into the characteristics and velocity of the biosorption mechanism. Fungal biosorption has several benefits, such as minimal operational expenses, decreased chemical necessities, biodegradability, and the potential for using biological waste products. The results are anticipated to illustrate the potential of fungal biomass as an effective biosorbent for the remediation of chromium-laden tannery wastewater and aid in the advancement of sustainable wastewater treatment methods.

Keywords: Biosorption, chromium ions, Tannery effluent, Fungal

I. INTRODUCTION

Chromium(VI) Contamination in Tannery Effluent

Despite the fact that the leather tanning industry is a key industrial sector that makes a considerable contribution to the growth of the economy and the creation of job opportunities, the wastewater that it generates can include high quantities of both organic and inorganic contaminants. Chromium is utilised extensively in the leather processing industry, notably in the chrome tanning process, due to its capacity to stabilise collagen fibres and enable the production of leather that is long-lasting. Nevertheless, the release of effluent that contains chromium into the environment might be the result of poor utilisation of chromium and insufficient treatment of wastewater. Among the several oxidation states of chromium, hexavalent chromium, often known as Cr(VI), is of special concern to the environment due to the fact that it is highly mobile, poisonous, and has the potential to cause cancer. In addition to posing potential dangers to human health, exposure to water that is polluted with Cr(VI) may have a negative impact on aquatic creatures. Therefore, prior to the discharge or reuse of tannery effluent, it is vital to remove Cr(VI) from the wastewater in an efficient manner (Adawiah, B.I. 2008).

Environmental Challenges Associated with Cr(VI)

It is possible for Cr(VI) to be present in wastewater, mostly in the form of soluble chromate and dichromate species, which enables it to move without difficulty through water and soil. Chromium is an elemental contamination, and as such, it must be removed or transformed rather than being destroyed by biological processes (Ahluwalia, S.S., & Goyal, D 2007). This is in contrast to other contaminants, which may be broken down by nature. Chromium concentrations can be efficiently reduced by the use of conventional treatment methods, such as chemical precipitation, coagulation, membrane filtration, ion exchange, and electrochemical processes, provided that the circumstances are acceptable. On the other hand, a number of these techniques could include substantial operational expenses, a significant amount of chemical consumption, energy needs, and the production of secondary sludge. As a result of these restrictions, researchers have been motivated to seek alternate treatment methods that are not only cost-effective but also ecologically friendly (Congeevaram, S., 2007).

Concept of Fungal Biosorption

One of the biological processes that may be used to remove pollutants from aqueous solutions is called biosorption. This process involves the contaminants attaching themselves to biological materials. Due to the fact that fungal cell walls contain a number of functional groups that are capable of reacting with metal ions, fungal biomass has garnered a significant amount of attention as a possible biosorbent (Degraeve N. 1981). Chitin, chitosan, proteins, polysaccharides, and other parts of the cell wall are examples of components that give hydroxyl,

carboxyl, amino, and phosphate binding sites, as well as other related binding sites. Depending on the fungal system, these functional groups have the ability to interact with chromium species by a variety of processes, including adsorption, ion exchange, complexation, electrostatic attraction, and reduction. Therefore, it is possible for both living and non-living fungal biomass to contribute to the removal of metals. However, non-living biomass has a number of benefits, including the fact that it is easier to handle and has a lower sensitivity to dangerous metal concentrations (Faryal, R. 2003).

Factors Influencing Chromium Biosorption

There are a number of physicochemical and biological parameters that can have an effect on the efficacy of fungal biosorption. The pH of the solution is of utmost significance since it has an impact not only on the chromium speciation but also on the charge and the availability of functional groups on the fungal biomass. At the same time as biomass dose has an effect on the total number of binding sites that are accessible, contact time is the factor that defines the amount of time that is available for interaction between chromium ions and biosorption sites (Gbolagunte, 2000). An additional factor that may influence biosorption capacity and removal efficiency is the initial concentration of Cr(VI) as well as the temperature. The process can be further influenced by factors like as the size of the particles, the pretreatment of the biomass, the agitation, and the presence of competing ions in the effluent from the tannery. It is vital to conduct research on these factors in order to determine appropriate operating conditions and get a knowledge of the potential of fungal biomass for the treatment of wastewater in practical applications (Grisworld, W.S.W. 2009).

Significance of Fungal Treatment for Tannery Wastewater

As a low-cost biosorbent, fungal biosorption is a viable method for minimising chromium pollution. This is due to the fact that it may make use of fungal biomass that is either naturally occurring or easily available. Additional potential for the development of cost-effective treatment materials may be presented by wastes from agricultural and industrial processes that contain fungal biomass (Groten, J.P., 1994). Biosorption, in comparison to a number of conventional methods, has the ability to lessen the amount of chemicals that are required and the amount of secondary waste that is produced, all while offering efficient removal of metals. In addition, there are instances in which fungal biomass may be both regenerated and reused, which contributes to an overall improvement in the treatment process's sustainability. However, the efficiency of biosorption is highly dependent on the species of fungi, the properties of the wastewater, the quantity of chromium, and the conditions under which the process is carried out (Huppert, H. E. & Sparks, R. S. J. 2006).

OBJECTIVE

- To Isolate and identify different fungi from tannery effluent and contaminated soil.
- To evaluate findings of tannery effluent using physicochemical analyses like those of chromium ions, pH, temperature, Mg, Fe, Cu etc respectively.

II. MATERIAL AND METHODS

Tannery effluent was collected from a leather tannery located in the state of Kano in Nigeria, which is owned by Mario Jose. In order to prevent any biological activity from occurring, the sample was kept at a temperature of 4 degrees Celsius. Recordings were made of the effluent's colour as well as its pH. Following the filtration of the chrome water received from the tannery with what is known as man's No. 1 filter paper, the pH of the water was corrected with concentrated hydrogen nitrate. The wastewater from the tannery that was collected was examined. AAS was utilised in order to determine total chromium as well as hexavalent chromium (VI) (Dexari and Green, 1995). Included in this are the oxidation of trivalent chromium, the creation of colour by the addition of diphenyl carbazides, and the measurement of optical density at 540 nm with water serving as the reference. For the purpose of determining the amount of Cr⁶⁺ present in the effluent, the value was plotted against the standard graph (Indu, S.T. 2006).

Physicochemical Properties of Tannery Effluent Colour

In water that had been distilled and contained 100 millilitres of concentrated hydrochloric acid, 1.246 grammes of potassium chloroplatinate (K₂ptCl) were dissolved. This amount is comparable to 500 milligrammes of metallic platinum. Additionally, 1 gramme of crystallised cobaltous chloride, COC12. 6H₂O, was dissolved. A stock solution, also known as a standard, was created by diluting the solution to a volume of 1000 millilitres of distilled water. This was done in order to compare the colour of 500 units (Breen, A., 1991). This was accomplished by diluting 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, and 7.0 millilitres of the stock colour with distilled water to a volume of 500 millilitres in Nessler tubes. The standard calibration curve colour was created in the following concentrations: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, and 70. In-situ standardisation was performed

on the observed sample colour, which was then matched with the fill using a Nessler tube to the 50-milliliter mark sample (Khan A. G. 2001).

Calculation:

$$\text{Colour units} = \frac{A \cdot 50}{B}$$

Where:

A= Estimated color of a diluted sample;

B= ML sample taken for dilution (Nag, 2007)

Turbidity

The water sample, which was twenty-five millilitres in volume, was shaken vigorously and then paused for a time until the air bubbles disappeared. After that, the sample was put into a turbid metre tube, and the turbidity was read either directly from the instrument scale or using the required calibration curves. This was done in order to measure turbidities that were fewer than 40 parts per thousand (Barman, S.C. & Bhargava, S.K. 2000). Until the turbidity of the water sample dropped to between 30 and 40 NTU, twenty-five millilitres of water sample was diluted with one or more volumes of water that did not contain any turbidity. On the basis of the turbidity of the diluted sample and the dilution factor, which is defined as the measurement of turbidities that are greater than 40 NTU, the original sample was compared (Krauter, P.,1996).

Calculation:

$$\frac{A \cdot [A \cdot (B+C)]}{C}$$

Nephelometric turbidity units (NTU)=

Where:

A= NTU found in diluted sample

B= Volume of dilution water in ml

C= Sample volume taken for dilution in ml (Nag, 2007).

pH

Prior to utilising the electrode in the clamps of the electrode holder down into the beaker, twenty-five and a half millilitres of the effluent waste were pipetted into fifty millilitres of a beaker. After that, the effluent waste was filtered through nylon fabric, and suspended particles were allowed to stand for one hour. For the purpose of establishing a good electrical contact via the ground glass, the glass electrode was submerged in the clear supernatant solution to a depth that was just sufficient (Nag, 2007). The pH was then measured.

Temperature

Following the addition of ten grammes of soil sample to twenty-five millilitres of distilled water, the mixture was put through a rigorous agitation process for twenty minutes. Aneja (2007) found that the thermometer in solution was the most accurate method for determining the temperature.

Total Chromium

An amount of fifty grammes of the dried crushed dirt was placed in a beaker containing fifty millilitres of distilled water, and then the mixture was filtered through nylon fabric. Twenty-five millilitres of the filtrate were collected in a beaker with a capacity of four hundred millilitres, and then ten millilitres of concentrated hydrogen sulphide and five millilitres of concentrated hydrogen nitrate were added to the filtrate at a ratio of three to one (Kumar. 2007). After that, the beaker that contained the combination was put on a hot plate and allowed to boil until the solution became clear. After that, the solution was transferred into a volumetric flask by means of filtration through what was known as Filter paper No. 2. Through the addition of deionized water, the volume of the filtrate was brought up to fifty millilitres. In order to conduct further analysis of the metal using Flame Atomic Absorption Spectrometry, FAAS (Rani, 2003), the digested sample was stored in sterile polyethylene vials at room temperature for further laboratory examination.



Figure 1. Picture Showing Mixed Culture of *Aspergillus niger* and Some *Candida* sp. Isolated from Mario Jose Tannery Kano Using Home Base Medium

Fungal Isolation

The ratio of 1:100 (10⁻²) was achieved by pipetting 10 millilitres of effluent waste suspension into 90 millilitres of water blank number 2, and then another 10 millilitres of the effluent suspension was pipetted into 90 millilitres of water blank number 3 to get a composition of 1:1000 (10⁻²). In addition, dilutions were carried out many times, with subsequent dilutions ranging from 10 to 10⁻⁷. An aliquot of 0.1 millilitre was safely placed into a medium consisting of potato dextrose agar that had just been produced. The plates were then incubated at room temperature (27-32 degrees Celsius) for three to four days, after which the fungal colonies that had developed were packaged and subcultured in an aseptic manner (Lefebvre, O., 2006). After being placed into newly produced PDA and then cultured, a pure isolate was obtained. After marking all of the colonies that were created on each plate, the colony forming unit (CFU) was determined, and the colonies were then subcultured into potato dextrose agar PDA slants. These slants were stored at 4 degrees Celsius until they were required for future research (Adawiah, 2008).

Fungi Identification by Morphological Characteristic (Macroscopic) and Microscopic Observation

The number of fungal colonies that emerged on the plate for the purpose of enumerating the fungal microflora in the effluent discharge was further increased by subculturing a number of times on modified Rice husk agar (MRHN) plates (Leta, S., 2004).

Determination of Tolerance Fungal Isolates to Chromium Sulphate Salt

Among the fungi that were grown on modified Rice Husk Agar (MRHA) that contained varying concentrations of chromium (0.0, 0.1, 0.5, 1.0, 1.5, 2, and 4%), the length of the mycelia was measured and recoded. This allowed for the determination of the chromium resistance of the fungal isolates (Nandy, T., 1999).

Treatment of Agricultural Waste (Saw Dust and Rice Husk)

Sawdust or rice husk, both of which are considered agricultural waste, was purchased at Sabon Gari Market in Zaria and then transported to the Laboratory for scientific examination. In order to get a finer consistency, the waste was second-grinded and then sieved. The following composition (g/l) was added to one thousand millilitres of basal medium after two hundred and fifty grammes of fine texture were weighed and added to the mixture: NH₄SO₄-1.0, K₂ HP0₄-1.0, MgSO₄.7H₂O-1.0, CaCO₃-4.0, NaCl-1.0 and NaNO₃-6.0, K₂HPO₄-2.0, and MgSO₄.7 H₂O-0.20 are the values that are present in the mixture (F., Toro, L., & Vegliò, F. 2002). After that, the mixture was combined and brought to a boil, resulting in a semi-solid slurry. Following this, a solution of two hundred and fifty grammes of golden purple *Parkia biglobosa* (Dorowa) was added and brought to a boil in order to break down the complex organic compound into simpler compounds. After that, the paste slurry was spread out on a sterile tray that had been dried, and it was then baked in the oven at a temperature of forty degrees Celsius for seven days. *Tamarindu indica* (Tsamia) was used to bring the pH of the paste slurry down from 3.5 to 4.5, and then it was dried so that it could be taken for further examination (Bhatt, P., & Samant, M. 2022).



Figure 2. Accumulated Chromium Ion Spotted on Fungal by-Product of *Penicillium* sp. after 45 Days Incubation (Lipoproteins/Biomass)

Biosorption Studies Using Selected Fungi

Research was conducted on the absorptive properties of three different species of fungus, both individually and in combination. The organisms that were utilised in this study were specifically *Aspergillus niger*, *Rhizopus nigricans*, *Penicillium* sp., and a mixed culture. This approach was adapted from the one described by Habiba (2006). To each of the varied volumes of tannery effluent (50, 65, 75, 85, and 100 ml), 20 grammes of the modified rice husk medium was added to bring the pH level to 5.2. The mixture was then sterilised in an autoclave at 121 degrees Celsius for fifteen minutes (Ravindranath, E. & Chitra, K. 2007). After the inoculums of fungus cell suspension were created by adding five millilitres of sterile distilled water to freshly grown mycelia in a slant agar bottle, four millilitres of spore suspension containing *Aspergillus niger* was added. The solution was then allowed to cool down. After that, the conical flasks were stored at a temperature of 32 degrees Celsius for a period of time ranging from 0 to 45 days. The entirety of the sample was filtered through what man filter paper No. 4 at predetermined intervals. For the purpose of analysing Cr (VI) ions, either the filtrate or the supernatant liquid that was collected after the mycelia mat was removed was utilized (India. Raji, C., & Anirudhan, T.S. 1998).

- **Determination of Chromium (VI) content of Remediated Effluent Principle:** Chromium (VI) in solution is leached from the sample at a temperature of 7.5 to 8.0 under inert gas. The chromium (VI) in solution oxidises 1, 5 diphenylcarbazines to 1, 5 diphenylcarbazone, which results in the formation of a red/violet complex with chromium, which may be measured photometrically at 540 nm.
- **Diphenylcarbazines solution:** To make the solution acidic, one drop of glacial acetic CH_3COOH was added to one gramme of 1, 5 diphenylcarbazines $\text{CO}(\text{NHNHC}_6\text{H}_5)_2$ that had been dissolved in one hundred millilitres of acetone $(\text{CH}_3)_2\text{CO}$. A bottle made of brown glass was used to store this. At a temperature of 4 degrees Celsius, the shelf life is up to 14 days.
- **Chromium (VI) stock solution:** After being dried for sixteen hours at 102 degrees Celsius, 2.829 grammes of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) was dissolved in water in a volumetric flask, and the volume was brought up to one thousand millilitres with water. One millilitre of this solution has one milligramme of chromium in it:
- **Chromium (VI) standard solution:** Pipette one milligramme of the solution into the mark, and then add distilled water to the mark. The amount of chromium present in this solution is $\mu\text{g}/1 \text{ ml}$.

Procedure

Ten millilitres of this supernatant fluid were transferred into a 50 millilitre volumetric flask. The solution was thinned with water; one millilitre of diphenylcarbazine solution was included, succeeded by one millilitre of phosphoric acid mixed with distilled water. After ten minutes, the pink-hued solution was examined for Cr (VI) ions utilising a spectrometer at an absorbance of 540 nm against the black solution. A further 10 ml aliquot of the solution was transferred into a 50 ml volumetric flask and processed as previously outlined, except the incorporation of the diphenylcarbazine solution (Rapport, A.I., & Muter, O.A. 1994).

The empty solution was created by adding 50 cc of distilled water. Subsequently, one millilitre of diphenylcarbazine solution and one millilitre of phosphoric acid were combined to create a homogeneous mixture, which was then kept in a cold, dark environment. The calibration solutions are formulated in a 50 ml volumetric flask. Calibration standards comprising 0.1, 0.2, 0.3, 0.4, 0.5, 1, 1.5, 2.5, and $3\mu\text{g}$ Cr were prepared and acidified, followed by the addition of 5 ml of 0.2N 1,5-diphenyl carbazine to 10 ml of the treated sample until a pink hue was observed, after which absorbance was measured at 540nm using spectrophotometric calibration data (Addis, 2006).

III. RESULTS AND DISCUSSION

Soil is vital to terrestrial ecosystems. Directly discussing industrial effluents without treating soil may change its biological qualities. Tannery effluent influences soil microbial population in this research. Morphology and chromium tolerance are essential fungal species traits. Exposure to metals is thought to create a tolerant microbial community. Microbial tolerance is the capacity of bacteria to resist metal toxicity by inherent or environmental change (Rajiv et al., 2009).

Table 1 and plates 2a, 2b, 4, 6 show the morphological and microscopic properties of tannery effluent fungal cultures. Based on comparison, following features were reported. Five fungal isolates were *Aspergillus niger*, *Rhizopus nigricans*, *Penicillium*, *fumigatus*, and *Candida* sp. As demonstrated in table 2, *Aspergillus niger*, *Rhizopus nigricans*, and *Penicillium* sp tolerated chromium content solutions up to 4% in tannery effluent tolerance tests. Plates 2a, 2b revealed pure culture-tolerant growth. Due to their rapid development, biomass output, and soil reach, fungi are better remediators. Study results on *Aspergillus niger*, *Penicillium* sp, and *Fusarium* sp tolerance to Cr, Zn, Ni, Pb, and Ca (Gaddy 1990). Prince and Classan (2001) found that *Aspergillus* tolerated heavy metals better than other fungus. This study found that *Aspergillus niger*, *Rhizopus nigricans*, and *Penicillium* sp tolerated high chromium concentrations better. The variance in chromium ion tolerance may be due to various fungi's tactics or resistance mechanisms. Ionic species on protein and chitin surface or extracellular polysaccharides cause hazardous metal tolerance (volesky, 1990). Bacterial fungi ciliates Moses algae and higher plants may biosorb or accumulate heavy metals from solution (Rachan et al., 2008). *Rhizopus nigricans*, *Aspergillus niger*, and *Penicillium* sp demonstrated significant reductions in chromium (VI) biosorption with increasing incubation time (0-45 days). Tables 3, 4, and 5 demonstrate that *Rhizopus nigricans* (0.067) mg/1 had the greatest absorption rate at 94.20%, followed by *Aspergillus niger* (0.073 mg/1) at 88.45%. Plates 3 and 4 have fungus biomass after 45 days. These findings match Romomanko and Koren (1977). In chromium tannery yard effluent, both fungus not only survived in polluted waste water but also significantly improved Cr (VI) remediation (Padmavathy, V., & Tewarri, N. 2002). *Aspergillus* sp can reduce Cr (VI) microbially (Remmananko and Kuren, 1977).

The landfill disposal of 1.517mg/1 chromium, a heavy metal, violates the WHO limit of 0.05mg/1. This study indicated that *Rhizopus nigricans* (0.067) mg/1 had 94.20% efficiency while *Aspergillus niger* (0.073 mg/1) had 88.45% efficiency. Chromium salt used in tanning may explain its low level over 0.05mg/1. It might ruin the clean environment notion. It can also enter the food chain via plants, animals, and water. Once in food chains, the metal may biomagnify and bioaccumulate in diverse biological systems. (Denham, M., & Ravenscroft, J 2006) found that bioaccumulation and biomagnification can cause hazardous metal levels in organisms even with modest exposure. When abundant, this might upset natural equilibrium. Total chromium discharge in streams and rivers for irrigation and residential consumption cannot exceed 0.05 mg/1 WHO (1985). Leaving that area does not guaranty safety for rural residents. High chromium ion levels in drinking water can induce cutaneous, allergy, carcinogenic, and mutagenic effects (Martin and Griswold, 2009). In this study, filamentous fungi isolated from tannery waste by biosorption were tested for their ability to reduce hexavalent chromium from 1.517 to 0.067mg/1) and 1.517 to 0.07mg/1. Both isolates remove chromium (VI) from tannery effluent. Upgraded technology will help tanneries reduce waste pollution. The process would be cost-effective and sustainable.

Fungi remove chromium (VI) from the solution by physical adsorption followed by chemical bondage, which requires no energy. Once metal ions are diffused on the cell surface, they bind to sites with chemical affinity for the metal. A passive accumulation process that may involve adsorption, ion exchange, complexation, chelation, and micro precipitation. A physiological investigation comprises lipids with carboxylic, hydroxyl, and phosphate groups and protein polysaccharides at the cell surface for maximal adsorption (Preetha and Viruthagiri, 2005).

Tables 3, 4, and 5 indicate that fungal isolates biosorbing chromium (VI) on agricultural waste MRHM and MSDM gradually raise medium pH. The pH of effluent Mario-Jose tannery decreased from 5.20 on day 1 to 7.20-7.80 on day 45 of biosorption. The pH of effluent undergoing Cr (VI) biosorption in PDM decreased from 5.20 day 1 to pH 4.0 -4.6 on day 45. pH is a key physical parameter affecting biosorption and active microbial diversity in a habitat. Metal adsorption's pH dependency depends on the biosorbent's functional group's type and ionic state and the solution's metal species (Paknikar et al., 2009).

Mario Jose, a tannery, compared modified rice husk medium (MRHM) and modified sawdust medium (MSDM) to normal potato dextrose medium (PDM) in tables 3, 4, and 5. Chromium (VI) elimination varied with pH, with viable growing fungus at pH 2-6 Rapport and Mutter (1994). Thus, pH from 5-8.0 increases Cr6+ removal, unlike *Saccharomyces cerevisiae* from polluted effluent waste (Krauter et al., 1996). This study indicated that the live mycelia mat condition reached a maximum pH of base when pH fluctuated from weak acid to above neutrality in (MSDM), (MRHM), and (PDM). Fungal cell walls are negatively charged at alkaline pH conditions and have a strong affinity for metal ions in alkaline solution (Wang, J., & Chen, C. 2009). Under acidic to above neutrality, the adsorbent surface becomes strongly protonated and favours Cr6+ anionic absorption. Increasing pH increases protonation and adsorption, showing that hydroxyl and chromate ions compete for binding, with the

former being dominating at above neutral pH. Other literature reviews suggest that the different pH binding profiles for heavy metal ions may be due to the chemical interaction of each metal with microbial cells, which have a negative charge and ionic state ligands (carboxyl, phosphate, and amino groups) that react with metal cations. Table 5 shows that lowering pH increases cell surface charge, which inhibits the approach of positively charged metal cations (Sag and Kutsal, 1996). *Aspergillus niger* eliminated Cr⁶⁺ under acidic and alkaline conditions (Aqil, F., & Ahmad, I. 2007).



Figure.3 Picture Showing Mixed Culture of Filamentous Fungi (*Rhizopus nigricans*), *Aspergillus flavus*, *Aspergillus niger*, *penicillium* sp. Isolated from Mario Jose Tannery Kano Using Base Medium

Rhizopus nigricans, *Aspergillus niger*, and mixed culture organisms tend to be more successful in biosorption of Cr⁶⁺ in effluent when employing modified agricultural waste in contrast to traditional ones, according to the research that were discussed above. These findings might also be ascribed to the development of acceptable operational procedures for the removal of Cr (VI) from polluted waste water. This is another possible explanation for these findings (Zhang, F.,2008)

Table1. Characterization of Fungi isolates from Tannery Effluent (MarioJose)

S. No.	Isolates	Colony Colour	Colony Diameter	Conidiophore Length (mm)	Conidia NM Diameter	Conidia Shape
1	<i>Aspergillus niger</i>	Black	1.50	3.25	3.48	Oval
2	<i>Rhizopus nigricans</i>	Brown	2.30	3.42	4.20	Globose
3	<i>Penicillium</i> sp.	Green/Blue	2.40	0.72	2.90	–
4	<i>Aspergillus flavus</i>	Greenish/Green	1.40	3.24	3.20	Globose
5	<i>Candida</i> sp.	Creamy/Milky	0.18	–	–	–

Key = - Not applicable

Table 2. Chromium Sulphate Tolerance Level by the Isolated Fungi sp Length of Mycelia (mm) at Different Concentration (%)

S. No.	Isolates	0.0	0.1	0.5	1.0	1.5	2.0	4.0
1	<i>Aspergillus niger</i>	32.80	28.25	16.50	12.83	11.21	10.30	10.00
2	<i>Rhizopus nigricans</i>	36.75	34.45	34.05	20.20	19.80	14.03	12.02
3	<i>Penicillium</i> sp.	30.14	25.28	18.77	12.30	10.28	9.12	8.30
4	<i>Aspergillus flavus</i>	12.32	9.40	8.25	5.45	4.34	–	–
5	<i>Candida</i> sp.	15.72	9.24	–	–	–	–	–

Key = - Not tolerant

Table 3. Chromium Remediation by Individual Filamentous Strain MRHM

S. No.	Test Organism	Initial Cr Concentration (mg/L)	Cr Concentration After 45 Days (mg/L)	Removal Efficiency (%)	Temperature (°C)	pH Range
1	<i>Aspergillus niger</i>	1.517	0.072	94.20	32	5.20–7.20
2	<i>Rhizopus nigricans</i>	1.517	0.067	88.45	32	5.20–7.80
3	<i>Penicillium</i> sp.	1.517	0.730	84.20	32	5.20–7.40
4	Mixed culture	1.517	0.742	64.20	32	5.20–7.60

Table 4. Chromium Remediation by Individual Filamentous Strain MSDM

S. No.	Test Organism	Initial Cr Concentration (mg/L)	Cr Concentration After 45 Days (mg/L)	Removal Efficiency (%)	Temperature (°C)	pH Range
1	<i>Aspergillus niger</i>	1.517	0.934	94.20	32	5.20–7.50
2	<i>Rhizopus nigricans</i>	1.517	0.080	88.45	32	5.20–7.80
3	<i>Penicillium</i> sp.	1.517	0.960	84.20	32	5.20–7.40
4	Mixed Culture	1.517	0.094	64.20	32	5.20–7.60

Table 5. Chromium Remediation by Individual Filamentous Strain PDM

S. No.	Test Organism	Initial Cr Concentration (mg/L)	Cr Concentration After 45 Days (mg/L)	Efficiency (%)	Temperature (°C)	pH Range
1	<i>Aspergillus niger</i>	1.517	1.301	94.20	32	5.20–4.50
2	<i>Rhizopus nigricans</i>	1.517	1.013	88.45	32	5.20–4.60
3	<i>Penicillium</i> sp.	1.517	1.329	84.20	32	5.20–4.32
4	Mixed Culture	1.517	1.384	64.20	32	5.20–4.00

IV. Conclusion

The issue of hazardous waste that contains chromium (VI) has emerged as a significant worry across the nation. The proper treatment of tannery waste in the industry prior to its discharge is of the utmost importance for public usage, particularly when it is intended to be used for drinking and irrigation purposes. The objective of the current research that is being carried out is to reduce the amount of chromium (VI) that is present in tannery waste water to the lowest level of the acceptable limit of 0.05 mg/l that was established by the World Health Organisation in 1998. This is done in order to ensure the continued existence of microbes, plants, and human life. As a result, the bioremediation process was carried out by utilising locally accessible agricultural waste, specifically modified rice husk medium (MRHM), in conjunction with tannery effluent that contained chromium ion along with varying volumes of sterile media and resistant or tolerant filamentous fungi, specifically *Aspergillus niger*, *Rhizopus nigricans*, and *Penicillium* sp.

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