SWARRNIM
STARTUP & INNOVATION
UNIVERSITY
WHERE IDEAS COME ALIVE
INDIA'S FIRST UNIVERSITY FOR STARTUP

Ref: Swarrnim/RO/Letter/2025/76

Date: 06/09/2025

To

The Manager,

Spechrom Solutions.

Subject: Request for Issuance of Sanction Letters in the Name of Swarrnim Startup & Innovation University for Allocated Major Research Projects (AY 2019-2024)

Dear Sir,

We, Swarrrnim Startup & Innovation University, would like to extend our sincere thanks for providing financial support and promote industry sponsored research throughout the year.

With reference to the above subject, we would like to inform you that Swarrnim Startup & Innovation University has received 15research projectsamounting to ₹1,89,50,000 during the academic year 2019-2024.Actually, these projects were given to the University but the letters were issued in the name of Constituent departments.

As per the recent query raised by NAAC, all sanction letters are required to be issued in the name of the University. Therefore, we kindly request you to re-issue the sanction letters/clarification letter in the name of Swarrnim Startup & Innovation University for the above-mentioned projects.

We sincerely appreciate your support and cooperation in this matter.

Your prompt response is highly appreciated considering the urgency of the matter,

Thanking you,

Yours faithfully,

Registrar

Swarrnim Startup & Innovation University

Date: 12/09/2025

To,

Swarrnim Startup & Innovation University,

Bhoyan Rathod, Opposite IFFCO,

Near ONGC WSS, Adalaj Kalol Highway,

Gandhinagar, Gujarat - 382422.

Subject: Sanction Letter of Research Proiect

Dear Researcher,

I am pleased to inform you that the scrutiny committee has approved your research. The details of the Research Proposal and Sanctioned grant is as under.

Title of Research Proposal	Copper biosorption utilizing dehydrated Aspergillus biomass
Name of Principal investigator	Dr. Priti Mahla
Name of Co-investigators	Dhara Goti, Darshika Savalia, Narmatta Datta,Priyanka Shrimali, Mitesh Prajapati
Duration in months	12
Sanctioned Grant for Research Work	500000

It is further hereby informed that you will abide to follow all the guidelines/norms, terms, and conditions mentioned in the Research Scheme of company. The principal investigator may contact for any further assistance. All the best for great research work ahead.

With Regards

SPECHROM SOLUTIONS AHMEDABAD

Date: 30/3/2020

To,

Swarrnim Science colleage,

Bhoyan Rathod, Opposite IFFCO,

Near ONGC WSS, Adalaj Kalol Highway,

Gandhinagar, Gujarat - 382422.

Subiect: Sanction Letter of Research Proiect

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With Regards

SPECHROM SOLUTIONS AHMEDABAD

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SWARANIM STARTUP AND INNOVATION UNIVERSITY

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Period	:	01-04-2018 To 06-04-2021
Cust.Reln.No	:	59701131
Account No	:	9712631137
Currency	:	INR
Branch	:	AHMEDABAD - PALDI
Nominee Registered	:	N

Date	Narration	Chq/Ref No	Withdrawal (Dr)	Deposit(Cr)	Balance
16-12-2020	CLG TO VODAFONE MOBILE SERVICE CITI BANK	2075	685.00		18,897.95(Cr)
16-12-2020	CLG TO VODAFONE MOBILE SERVICE CITI BANK	2076	412.00		18,485.95(Cr)
16-12-2020	IB: FUND TRANSFER FROM 9712648883	IB		200,000.00	218,485.95(Cr)
16-12-2020	FUND TRANSFER TO JIGARKUMAR THAKKAR	2083	26,000.00		192,485.95(Cr)
16-12-2020	Sent NEFT KKBKH20351626231/ESSKSEE CONSULTANC	2082/000191804726	46,374.00		146,111.95(Cr)
17-12-2020	CLG TO SPICE HUB RESTRO CAFE INDUSIND BANK LIM	2042	17,670.00		128,441.95(Cr)
18-12-2020	IB: FUND TRANSFER FROM 9712631168	IB		300,000.00	428,441.95(Cr)
18-12-2020	IB: FUND TRANSFER FROM 9712639331	IB		950,000.00	1,378,441.95(Cr)
18-12-2020	IB: FUND TRANSFER FROM 9712648876	IB		800,000.00	2,178,441.95(Cr)
18-12-2020	IB: FUND TRANSFER FROM 9712648883	IB		1,200,000.00	3,378,441.95(Cr)
18-12-2020	Sent RTGS KKBKR52020121800652499/GYAPRASAD JA	2085/000192098664	2,000,000.00		1,378,441.95(Cr)
18-12-2020	UPI/jaypatel28./035317346591/UPI	UPI-035317882494		2,500.00	1,380,941.95(Cr)
18-12-2020	Sent NEFT KKBKH20353655202/ANAND S MASHRUWALA	2090/000192100975	7,500.00		1,373,441.95(Cr)
18-12-2020	Sent NEFT KKBKH20353655541/SWASTIK INFRASTRUC	2084/000192100463	100,000.00		1,273,441.95(Cr)
19-12-2020	Sent NEFT KKBKH20354744400/WORLDWIDE DISTRIBU	2093/000192184908	5,000.00		1,268,441.95(Cr)
19-12-2020	FUND TRANSFER TO DEEP JAYESHKUMAR MEHTA	2092	4,510.00		1,263,931.95(Cr)
19-12-2020	RTGS CR-502000496721 SPECHROM SOLUTIONS	2088/000197287211		500,000.00	1,863,931.95(Cr)
19-12-2020	Sent RTGS KKBKR52020121900794921/GYAPRASAD JA	2086/000192266117	1,500,000.00		363,931.95(Cr)
19-12-2020	UPI/jay247k@oki/035421412409/Convocation	UPI-035421567944		2,500.00	366,431.95(Cr)

CERTIFICATE FROM THE INVESTIGATOR

PROJECT Title : Copper Biosorption Utilizing Dehydrated Aspergillus Biomass

Name(s) of the PI's and Co-PI's:

Principal Investigator: Dr. Priti Mahla, Swarrnim Science College

Co-investigator: Dhara Goti, Darshika Savalia, Narmatta Datta ,Priyanka Shrimali, Mitesh Prajapati

1. I/We agree to abide by the terms and conditions of the grant.

2. I/We did not submit this or a similar project proposal elsewhere for financial support. I/we have explored and ensured that equipment and basic facilities will actually be available as and when required for the purpose of the project.

3. I/We shall not request financial support under this project for procedure for procurement of these items.

4. I/We undertake that spare time on permanent equipment and will be made available to other Researchers/ users.

5. I/We undertake to submit progress reports, Statement of Expenditure (SE)/ accounts, Utilisation Certificates (UC) etc covering upto 31st March every year till completion of the project as prescribed by DST.

6. I/We have enclosed the following materials:

a. Endorsement from the Head of the Institution (on letter head)

b. Certificate from Investigator (s)

c. Completed Proposal one hard copy

Date:

Signature of PI/PI's

Place: SSIU, Gandhinagar

ENDORSEMENT FROM THE HEAD OF THE INSTITUTION

PROJECT TITLE: Copper Biosorption Utilizing Dehydrated Aspergillus Biomass

Name(s) of the PI's and Co-PI's:

Principal Investigator: Dr. Priti Mahla, Assistant Professor, Swarrnim Science College

Co-investigator: Dhara Goti, Darshika Savalia. Narmatta Datta ,Priyanka Shrimali, Mitesh Prajapati

It is certified that the Institute welcomes participation of above as the Principal Investigator(s) and/or Co-PI(s) for the project. The research proposal falls in line with the normal research activities of the Institution.

27. Certified that the equipment other basic facilities and such other administrative and accounting facilities as per terms and conditions of the grant will be extended to the investigator throughout the duration of project. In case of PI/Co-PI leaving the institution or proceeding on a long leave during the project period, a prior permission will be sought from DST before relieving/sanctioning.

28. Institute assumes the financial and other management responsibilities of the project including timely submission of Progress Reports, UC's and SE's and facilitate in conducting external audit, if required.

Name of the Head of Institution

Signature with stamp

Date:

Place: SSIU, Gandhinagar

Declaration by Principal Investigator

I Dr. Priti Mahla hereby declare that the **major research Project Copper Biosorption Utilizing Dehydrated Aspergillus Biomass** is supported by Spechrom Solutions is submitted to Swarrnim Startup and Innovation University. This is my original work and my indebtedness to other work publications, references, if any, have been duly acknowledged. If I am found guilty of copying from any other report or published information and showing as myoriginal work, I understand that I shall be liable and punishable by the university.

Signature:

Name of PI: Dr. Priti Mahla

Designation: Assistant Professor

Name of Department: Microbiology

Name of Institute with code: Swarrnim Science College

Stamp of Institute

Verified By

Principal:
Signature

Stamp of University

Copper biosorption utilizing dehydrated Aspergillus biomass

Research Project Report Submitted to

Spechrom Solution Pvt Lmt.

SWARRNIM
STARTUP & INNOVATION
UNIVERSITY
WHERE IDEAS COME ALIVE.

Submitted by:

Principal Investigator: Dr. Priti Mahla, Head, Assistant Professor, Swarrnim Science College

Co-investigator: Dhara Goti, Darshika Savalia, Narmatta Datta,Priyanka Shrimali, Mitesh Prajapati

INDEX

1. Introduction:

The issue of environmental contamination has become a primary concern for all the nations on a global scale, as it affects and causes suffering in both developed and developing countries. The pollution of water resources is a significant concern among all environmental pollutants. The presence of heavy metals in sewage water is a result of the increased use of these substances in industrial processes. (Amorim, et al., 2018) (Andreazza, et al., 2010) Heavy metals are the most hazardous type of pollution since they don't biodegrade and remain for long in the environment. (Lebron, Moreira, Santos, & Jacob, 2018) (Gupta, Rastogi, Saini, & Jain, 2006) (de Carvalho, et al., 2003) The presence and accumulation of metallic ions in industrial effluent are a cause for major concern due to their deleterious effects on living organisms (Areco & dos Santos Afonso, 2010) (Baltazar, et al., 2018).

Copper is one of the most widespread environmental contaminants, which can be toxic to living organisms. Copper is released into the environment during the mining of copper and other metals, as well as from enterprises that produce or utilize copper metal. Additional entry points include wood production, natural sources, and home waste water and fossil fuel ingestion. (Mathew & Krishnamurthy, 2018)

Toxic metals such as copper is removed from waste waters using a variety of physico-chemical techniques, like reverse osmosis, Ion exchange, Ultrafiltration, Precipitation, Adsorption, Absorption, Activated carbon absorption, Membrane filtration, Bioleaching, Membrane bioreactor, Biosorption. Among them Biosorption inexpensive biomaterials to sequester environment pollutants from aqueous solutions by a wide range of Physico-chemical mechanism, including; ion exchange, chelation, complexation, physical adsorption and surface microprecipitation. Biosorption is a quick, mainly reversible, passive absorption mechanism that doesn't depend on the vitality of the cell. (Nazari, Cox, & Waters, 2014). As metal ions can accumulate and cause cancer in living things, there has been a lot of research done on the bio-adsorption technique for discharging metal ions from industrial wastewater. (Baltazar, et al., 2018) (Barquilha, Cossich, Tavares, & Silva, Biosorption of nickel (II) and copper (II) ions by Sargassum sp. in nature and alginate extraction products, 2019).

Fungi are another type of microorganisms that have been efficiently exploited in the preparation of biosorbent for metal ions removal from polluted soil. Fungi are easy to grow, provide significant quantities of biomass and at the same time can be altered genetically and morphologically (Kapoor et al..1995). Different types of fungi can break down different levels of pollutants because they can release extracellular enzymes that help with the assimilation of complex carbohydrates for earlier hydrolysis. The benefit lies in the easy separation of fungal biomass by filtration, facilitated by its filamentous structure. Fungal biomass maybe utilized by biosorptive processes as it often exhibits marked tolerance towards metals and other factors such as low pH (Gadd, 1990; Zafar et al., 2007; Kapoor and Viraraghavan, 1997). Fungal cell walls and their components have a major role in biosorption. Many fungal species such as Rhizopus arrhizus, Penicillium spinulum and Aspergillus niger have been extensively studied for heavy metal biosorption and the mechanism seems to be species dependent (Zhou and Kiff, 1991; Hafez et al., 1997). (Nur Liyana Iskandar1 Tolerance and biosorption of copper (Cu) and lead (Pb) by filamentous fungi isolated from a freshwater ecosystem).

In this study fungi were isolated from different samples such as soil, leaves and decayed food collected from Ahmedabad and Aqueous copper waste collected from Vatva GIDC. The maximum biosorption capacity based on dry weight was determined by varying the concentrations of Cu ions in the aqueous solution.

2. Literature Review

Treatability studies have indicated that wastes often contain toxic and non-biodegradable matter (such as metals), which generally limits the implementation of a conventional biological treatment process. The mining, mineral processing and metallurgical industries are known to generate annually billions of tons of wastes. Some of the metal and mineral constituents of these wastes have potential economic value and their recovery can augment our primary mineral and metal resource supply base. The important of pollution prevention by clean technologies instead of remediation has also been recognized.

The U.S. Environmental Protection Agency (EPA) is evaluating technologies for their ability to recover metals from sludges and wastewater.Dilute aqueous solutions, generated or used by industry, can contain a variety of different metal ions. Various processes are suitable for reclamation of toxic metals and among them, attention is paid here to biosorption. The ability of microorganisms to remove metal ions from solution is a well-known phenomenon.

Industrial applications of biosorption often make use of dead biomass, which does not require nutrients and can be exposed to environments of high toxicity. Experimental laboratory batch experiments are described for fungi and for activated sludge, as the metal biosorbents, providing insight into copper biosorption. Non-living biomass showed greater binding capacities for copper (a priority pollutant) than living biomass. Engineering considerations are central in decisions concerning the commercial future of biosorption and a practical solution is needed for certain problems, such as the efficient separation of metal-loaded biomass.

Pollution of surface and ground water caused by human and industrial activities has been recorded as a major problem in the global context (Satya et al.,2011) water pollution considered as the leading universal cause of 80% of diseases (OECD, 2006).The presence of inorganic pollutants such as metal ions in the ecosystem causes a major environmental problem. Toxic metal compounds coming to the earth's surface, it contaminate earth's water as well as underground water in trace amounts by leaking from the soil after rain and snow(Kilic et al.).

Metal ions are reported as priority pollutants due to their mobility, in natural water ecosystems and due to their toxicity (Demirbas A.,2008). The problem associated with metal ion pollution is that they are not biodegradable and are highly persistent in the environment. Thus, they can be accumulated in living tissues, causing various disease and disorders (Wan Ngah WS, 2008). Heavy metal toxicity can result in damage or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs (Ahmaruzzaman M.,2011).

The term bioremediation has been introduced to describe the process of using biological agents to remove toxic waste from environment. Bioremediation is most effective management tool to manage the polluted environment, and recover contaminated soil a water. Bioremediation has been used at a number of sites worldwide with varying degrees of success.(Kumar. A 2011).Intensification of agriculture and manufacturing industries has resulted in increased release of a wide waste has been led to scarcity of clean water and disturbances of hazardous waste has been led to scarcity of clean water and distribution of soil thus limiting crop production (Kumaluden et al.,2003).

This technology relies on promoting the growth of specific microflora or microbial consortia that are indigenous to the contaminated sites that are able to perform desired activities (Agarwal,1998). Mycoremediation is a form of bioremediation in which fungi-based technology is used to decontaminate the environment. Phrase coined by Paul Stamets.Fungi have been proven to be a very cheap, effective and environmentally sound way for helping to remove a wide array of toxins (heavy metals) from damage environment like soil.

Biosorption is a physico-chemical process, simply defined as the removal of substances from by biological material. Biosorption uses inexpensive biomaterial to sequester environment pollutants from aqueous solutions by a wide range of physico-chemical mechanism, including; ion exchange, chelation, complexation, physical adsorption and surface microprecipitation. The biomaterials used in this process are termed biosorbent (flores-Garnica JG et al.,2013).

Fungi represent another group of microorganisms that have been efficiently used in the preparation of biosorbent for metal ions removal from contaminated soil. Fungi are easy to grow, produce high yields of biomass and at the same time can be manipulated genetically and morphologically (Kapoor et al..1995). Therefore, the aim of this review is to discuss about the heavy metal removal from contaminated sources and aqueous solutions by fungi of different groups. The capability of many type of fungi to produce extracellular enzymes for assimilation of complex carbohydrates for former hydrolysis makes capable the degradation of various degrees of pollutants. Benefit is easy separation of fungal biomass by filtration because of its filamentous structure.

The bio-sorptive capacity of dead fungal biomass has been studied by several authors during the last few years. A.Kapoor & T. Viraraghavan* reported a high biosorption capacity of Aspergillus sp. Javaid et al.explored the adsorption potential of Pleurotus ostreatus to remove copper from water and achieved maximum biosorption capacities of 8.06 mg g^{-1} .

3. Rationale:

The rationale behind selecting Aspergillus biomass lies in its filamentous structure, which provides a large surface area for biosorption and allows for easy separation from the treated water. The study's focus on dehydrated biomass is particularly important, as it explores the potential for long-term storage and reusability of the biosorbent, thus enhancing the practical applicability of this method in real-world scenarios.

The use of FTIR analysis to identify the functional groups involved in the biosorption process provides a deeper understanding of the mechanisms at play, which can further inform the development of more efficient biosorbents in the future. By demonstrating the effectiveness of Aspergillus biomass in copper biosorption, this study contributes to the growing body of research on sustainable and cost-effective methods for heavy metal removal, with potential implications for improving water quality and protecting public health.

4. Aim and Objectives

The study was aimed to provide a practical view of the process involved in biosorption dealing with the copper contaminated water using *Aspergillus.*

1. Collection of aqueous waste
2. Isolation of Fungus
3. Screening of fungi for copper sorption
4. Optimization of system using different parameters

5. Methodology:

5.1 Sample collection:

Aqueous Copper sample was collected from Industry named Selex, G I D C, Phase 2, Vatva, Ahmedabad, Gujarat, 382445.

5.2 Isolation and Characterization

Sterile Potato Dextrose Agar plates were used for the isolation of various fungi from sources like soil, decay food, leaf. The Streak plate method was performed and plates were incubated for 6/7 days at room temperature. Lactophenol blue was used for mounting of fungus.

5.3 Biomass production

Biomass production was done in 100ml sterile PDA broth by keeping the flasks under shaking conditions at 150 rpm or a week.

5.4 Process of Biosorption

Batch experiment was done. Biosorption study were performed in 250 ml Erlenmeyer flask by addition of adsorbent to 50 ml copper solution. The pH was adjusted with 1 N HCL and 1 N NaOH before addition of biosorbent(biomass). In all the experiments, the flask was shaken at 150 rpm on a rotary shaker. Contact time was 2 hours. At different interval of time, the samples were withdrawn and filtered. The residual metal ion in the filtrate was extracted using solvent extraction method and was determined spectrophotometrically. Control system was prepared without adding the biomass.

5.5 Optimization of Process Parameter

The optimization of various parameters was done like the effect of biomass concentration, pH, agitation. For agitation, amount of bio-sorbent and pH were constant (pH 4.5, biosorbent concentration 80 mg). The effect of bio-sorbent was determined using adsorption of Cu (II) 10-80 mg/100 ml and other experimental conditions were fixed (copper solution concentration 100 ppm / 100 mg pH 4.5). The effect of pH on the copper adsorption was studied at different pH values (2.5-5.5) at constant copper concentration (100 ppm/100 ml), amount of bio-sorbent (80 mg/100 ml).

5.6 Calculation of The efficiency of adsorbed copper was calculated as follows:

Efficiency of adsorption(%) = Eo - E x 100/E [Where, Eo = Initial metal ion concentration (O.D.) E = Final metal ion concentration (O.D.)]

5.7 Solvent extraction

Working solution of cupric sulphate pentahydrate was prepared from the stock solution by diluting it to get desired concentration and then biomass was added to it. 1.0 ml from the experimental system was added into beaker.10.0 ml of distilled water and 5.0 ml of 25% aqueous citric acid solution was added to it. It was rendered slightly alkaline with ammonia solution, alternatively adjusted to pH 8.5. Then, it was added with 15 ml of 4% EDTA solution and was transferred to a separatory funnel. 0.2% aqueous SDDC (sodium diethyldithiocarbamate) solution was added and then shaken well for 45 second or given 90 strokes, a yellow brown color developed in the solution. Further 10.0 ml of n-Butyl acetate was added into the funnel and shaken for 45 second again or given 90 strokes. The phases were allowed to get separated, the lower aqueous layer was removed.10 ml of 10% sulfuric acid was allowed to get separated and the lower aqueous layer was discarded. The optical density was determined at 560 nm spectrophotometrically.

5.8 FTIR Analysis:

Functional groups of the adsorbent material were confirmed by performing FTIR.

6. Result and Discussion

6.1 Fungal Isolation

Total five isolates of fungi were obtained from soil, decayed food, leaves, etc., and they were named Aspergillus, Curvularia, Fusarium, Rhizopus, and Penicillium. Aspergillus fungal biomass was used for further work. The cultural characters of the Aspergillus showed dry, powdery growth with shades like black, green, brown, and yellow, which is consistent with previous reports on its growth pattern (Klich, 2002). The morphological characteristics of Aspergillus included septate mycelia, with conidiophores that were long, unbranched, and ending in vesicles, on which sterigmata were radially arranged in chains, as described by Moss and Cheadle (2000) and Klich (2002).

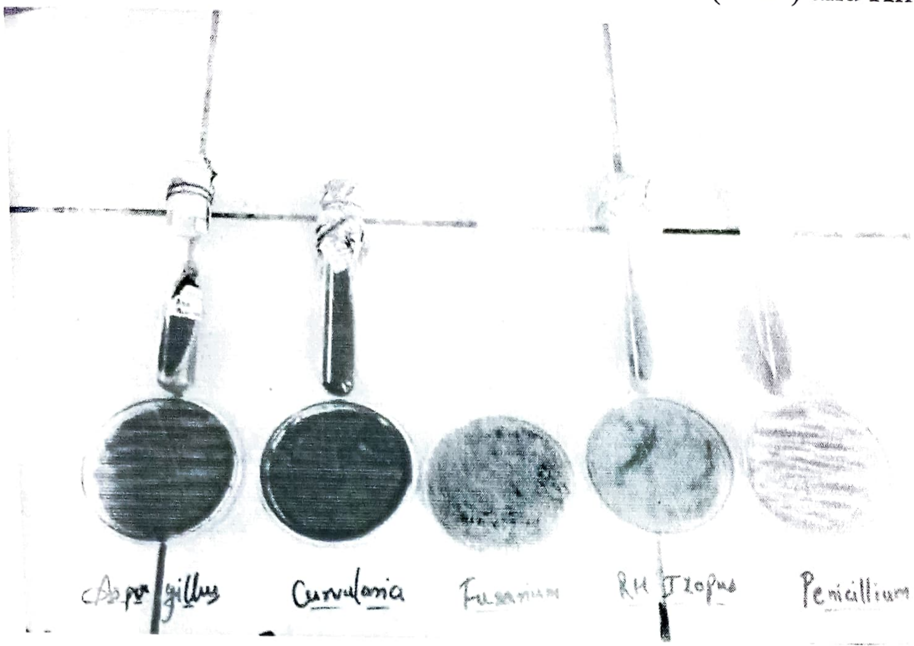


Figure: different five types of fungal isolates in PDA plate and pure culture in PDA slant.

Figure: microscopic observation of *Aspergillus* sp.

6.2 EFFECT OF BIOSORBENT (BIOMASS)

The removal of Cu (II) ions from aqueous solution was significantly dependent on the amount of biosorbent. The result shown in the graph indicates that the sorption increased up to a certain limit and then decreased. The increased biosorption with the biosorbent concentration can be attributed to greater surface area and the availability of more biosorption sites (Volesky, 2007). At biosorbent concentrations greater than 40 mg, the surface Cu (II) concentration and the solution Cu (II) concentration came to equilibrium with each other. However, the biosorption capacity decreased with an increase in biosorbent concentration. This may be attributed to overlapping or aggregation of biosorbent sites, resulting in a decrease in the total biosorbent surface area available to Cu (II) ions (Aksu & Tezer, 2005).

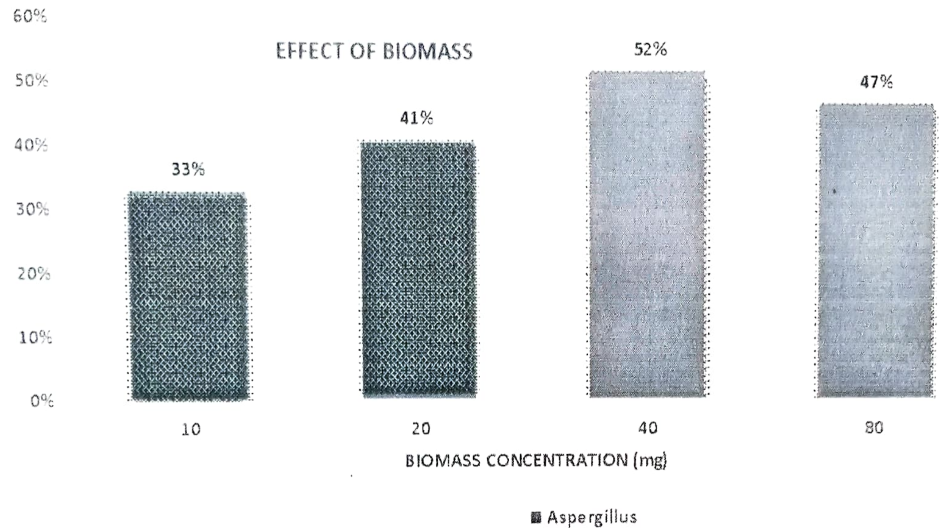
Biomass Concentration (mg)	Copper Removal Efficiency (%)
10	33%
20	41%
40	52%
80	47%

The efficiency of copper ion removal was observed to vary significantly with changes in the biomass concentration of dehydrated *Aspergillus* used in the biosorption process. The data showed a positive correlation between biomass concentration and biosorption efficiency up to a certain point, after which a slight decline was noted. At a biomass concentration of 10 mg, the copper removal efficiency was recorded at 33%. Increasing the biomass to 20 mg led to a noticeable increase in biosorption, achieving 41% efficiency. The highest removal efficiency was obtained at 40 mg, where copper biosorption peaked at 52%. This enhancement in metal uptake can be attributed to the increased availability of active binding sites on the fungal cell wall as more biosorbent was introduced into the system (Volesky, 2007). However, further increasing the biomass concentration to 80 mg resulted in a reduction of biosorption efficiency to 47%. This slight decrease may be due to overlapping or aggregation of biosorbent particles at higher concentrations, which causes a reduction in the effective surface area available for copper ion binding (Aksu & Tezer, 2005). Additionally, excess biomass in a fixed volume of solution may lead to saturation of binding sites and hinder optimal mass transfer between the solute and biosorbent (Anand et al., 2020).

These findings suggest that there is an optimum biomass concentration (around 40 mg) for achieving maximum biosorption efficiency. Beyond this point, additional biomass does not contribute proportionally to metal ion removal and may even interfere with the process. This trend is consistent with biosorption behaviors reported in the literature, where optimal biosorbent dosage balances the availability of functional groups and mass transfer dynamics (Meena et al., 2008). The functional groups (e.g., hydroxyl, carboxyl, and amino groups) on the surface of *Aspergillus* biomass are primarily responsible for metal ion uptake through ion exchange, chelation, or physical adsorption mechanisms (Pino et al., 2006).

The experimental results demonstrate that biomass concentration is a critical factor influencing the efficiency of copper biosorption. 40 mg of biomass was found to be the most effective dosage under the studied conditions, highlighting the need to optimize biosorbent amounts for practical applications in wastewater treatment.

Graph: Effect of concentration of biomass at pH 4.5



At 40 mg of biomass concentration, maximum sorption (52%) was achieved. (A.verma et 2013). Increase in biosorbent concentration is linked with the decrease in biosorbent capacities.This may be due to aggregation sites on fungi, causing a decrease in total adsorbent surface area available to Cu (II) (Din and Mirza, 2013).

EFFECT OF AGITATION

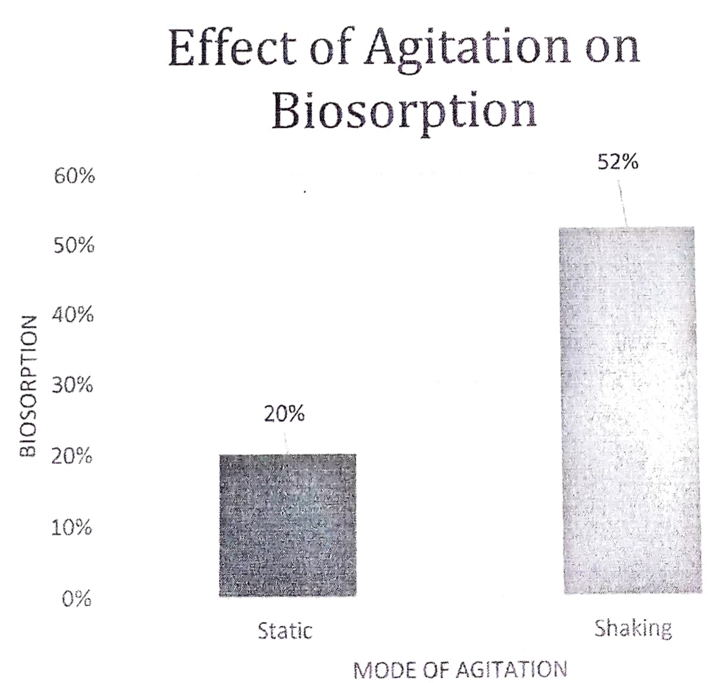
Results of the experiments showed that biosorption is increased in shaking condition compared to static condition.

Mode of Agitation	Biosorption (%)
Static	20%
Shaking	52%

The mode of agitation significantly influenced the biosorption efficiency of copper ions using dehydrated *Aspergillus* biomass. Two different conditions were analyzed: static (no shaking) and shaking (agitated). Under static conditions, the copper biosorption efficiency was relatively low, recorded at 20%. In contrast, when the system was subjected to shaking, the biosorption efficiency increased markedly to 52%. This substantial improvement can be attributed to enhanced contact between the metal ions and the biosorbent surface (Aksu & Tezer, 2005).

Agitation facilitates better dispersion of the biomass in the solution, thereby reducing boundary layer resistance and increasing the rate of mass transfer of copper ions from the bulk solution to the biosorbent surface (Volesky, 2007). This results in improved accessibility of active binding sites on the fungal biomass. Shaking ensures that the solution remains homogeneous, preventing localized saturation of metal ions around biomass particles and promoting more uniform uptake (Pino et al., 2006). On the other hand, in static conditions, the lack of movement limits the interaction between the biosorbent and the metal ions, resulting in lower biosorption efficiency. The reduced diffusion of copper ions toward the biosorbent surface leads to a slower uptake rate and fewer ions being adsorbed within the given contact time (Anand et al., 2020).

The experimental results clearly demonstrate that agitation (shaking) enhances biosorption efficiency significantly, making it a vital operational parameter to consider for optimizing the removal of heavy metals such as copper from aqueous solutions using fungal biomass (Meena et al., 2008). These findings underscore the importance of agitation in biosorption processes. Proper agitation not only improves the kinetics of biosorption but also ensures that the maximum number of binding sites are utilized effectively. This is particularly relevant for large-scale applications where achieving high efficiency in a shorter time is critical.



Graph: Effect of Agitation at pH 4.5; where, efficiency of sorption is 20% in static condition and 52% in shaking condition

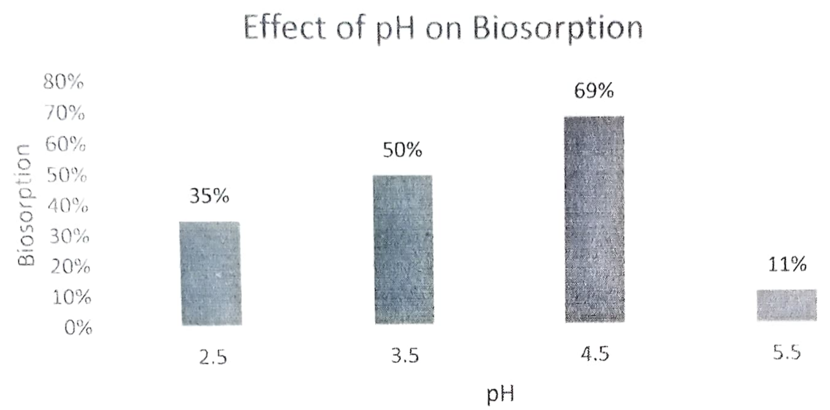
6.3 Effect Of pH

The result of the experiment showed that biosorption was low in a strong acidic medium, and adsorption capacity increased with an increase in pH values, up to a certain pH level. Biosorption was enhanced between pH 2 and 5. The results are shown in the graph. At the optimal pH of 4.5, 59% of Cu(II) ions were removed. At pH values above 5, copper ions in the solution precipitated, as shown in the graph. At low pH, the H+ ions competed with metal cations (Cu(II)) for the exchange sites on the biosorbent, thereby partially hindering metal uptake under conditions of extreme acidity (Aksu & Tezer, 2005). The competition between H+ ions and Cu(II) ions for the binding sites on the biosorbent is a well-known phenomenon that reduces biosorption efficiency at lower pH levels (Volesky, 2007)

pH	Biosorption (%)
2.5	35%
3.5	50%
4.5	69%
5.5	11%

The result of the experiment showed that biosorption was low in a strong acidic medium, and adsorption capacity increased with an increase in pH values, up to a certain pH level. Biosorption was enhanced between pH 2 and 5. The results are shown in the graph. At the optimal pH of 4.5, 59% of Cu(II) ions were removed. At pH values above 5, copper ions in the solution precipitated, as shown in the graph. At low pH, the H+ ions competed with metal cations (Cu(II)) for the exchange sites on the biosorbent, thereby partially hindering metal uptake under conditions of extreme acidity (Aksu & Tezer, 2005). The competition between H+ ions and Cu(II) ions for

the binding sites on the biosorbent is a well-known phenomenon that reduces biosorption efficiency at lower pH levels (Volesky, 2007).



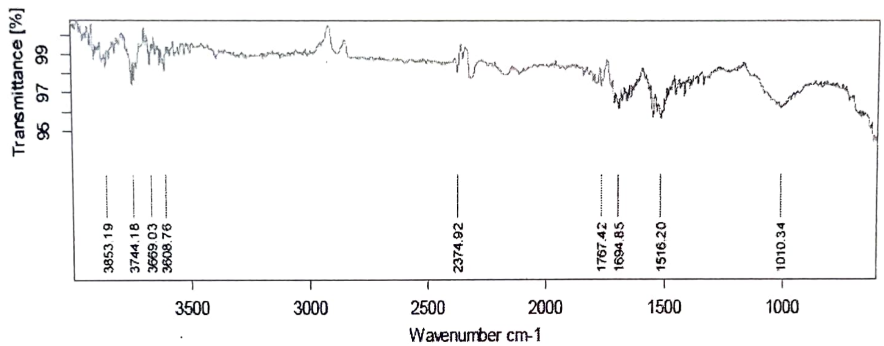
Graph: Effect of pH at Cu(II) ion concentration of 50 ppm and biosorbent concentration of 80 mg.

6.4 FTIR Analysis

In order to determine the characteristic functional groups responsible for biosorption of copper ions, FTIR spectroscopy was applied. The bonding mechanism between copper and biomass can be determined by interpreting the infrared absorption spectrum (Volesky, 2007). These results revealed that a chemical interaction between the copper ions and the hydroxyl groups occurred on the biomass surface (Aksu & Tezer, 2005). From the analysis of the IR spectra, it can be seen that the mechanism of copper uptake by fungal biomass involves interactions between copper ions and hydroxyl, amino, carboxyl, and carbonyl groups from the fungal biomass surface, depending on the types of fungal strain (Pino et al., 2006; Meena et al., 2008).

Wavenumber (cm^{-1})	Probable Functional Group / Vibration
385	O–H stretching (alcohols/phenols, hydrogen bonding)
3744.18	Free O–H stretch (possibly alcohol or water)
3696.03	O–H/N–H stretching (weak hydrogen bonding)

3680.76	O–H stretching vibrations
2374.92	C≡N stretching (nitriles), CO_2 overtones (less likely)
1767.42	C=O stretching (esters, anhydrides)
1694.85	C=O stretching (carboxylic acids, amides)
1516.20	N–O asymmetric stretch (nitro compounds) or aromatic C=C stretch
1010.34	C–O stretching or polysaccharide region (alcohols, ethers)



D:\FTIR\Aspergillus.0 Aspergillus Instrument type and / or accessory

Hit No	Hit Quality	Compound Name	Entry No.	Lib. Index	Molecular formula	Molecular weight	CAS number
1	233	Amides - Tertiary	31	1			
2	112	Ethers - Aromatic	19	1			
3	34	Nitriles - Aromatic	39	1			
4	23	Alcohols - Instmol str	15	1			
5	13	Amides - Secondary	30	1			
6	9	Nitriles - Aliphatic	38	1			
7	8	Amides - Primary	29	1			
8	7	Alkyles-Disub	6	1			
9	7	Nitro Compounds - Nitrites	45	1			
10	3	Isonitriles Aromatic	41	1			

BUDGET UTILIZED:

Category	Item Description	1 Year	2 Year	3 Year	Total (INR)
Chemicals & Reagents	Copper sulfate, acids, buffers, and other reagents	9000		6000	15,000
Biomass Preparation	Aspergillus culture, growth media,	50000		10000	60,000

	dehydration setup				
Laboratory Equipment		15000			15,000
Instrumentation	AAS/ICP for copper analysis	55000	105000		160,000
Microbial Culturing	Incubators, autoclave usage, agar plates	50000			50,000
Utilities & Consumables	Distilled water, electricity, gloves, disposable items	14000		10000	24,000
Data Analysis Software	MATLAB/SPSS/ Excel for statistical analysis	15000			15,000
Contingency Fund	Unforeseen expenses	10000		10000	20,000
Total (INR)		**309000**		**50000**	**359000**

7. **Conclusion:**

Hence, from the study it was concluded that the fungi are more helpful for sorption of copper from aqueous copper solution as compared to all other biomasses. Bio-sorption is rapid and achieved at small time interval within an hour of experiment. Many problems arise from copper contaminated water. Therefore, an economically viable and easy method for bio-sorption of copper from aqueous solution is highly desirable.

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Date: 13/12/2021

Statement of Expenditure/Utilization certificate

This is to certify that the seed money sanctioned to **Dr. Priti Mahla, Assistant Professor, Swarrnim Science College** in the academic year 2021-22 has been utilized as per the following details:

Title of Project	Amount Sanctioned in (Rs)	Amount disbursed in (Rs)		Actual Expenditure in (Rs)
		1-6 months	6-12 months	
Copper biosorption utilizing dehydrated Aspergillus biomass	500000	309000	50000	359000

Accounts/Finance officer

Swarrnim Startup and Innovation University