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# Diversity and Cellulase Activity of *Chaetomium globosum* (Kunze), A Destructive Cellulolytic Fungus

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**Abstract**: Fungi invading objects containing cellulose are called cellulolytic fungi. These fungi produce ''cellulolytic enzymes or cellulases'', which decompose cellulose (a polysaccharide) into first oligosaccharide and then monosaccharides, and ultimately to glucose molecules. Chaetomium globosum (Kunze)is reported to be a destructive cellulolytic fungus causing damage to our cultural heritage of library books, monuments, paintings, archival materials etc. In the present investigation, diversity of C. globosum in different library books of District - Gorakhpur (located in North- Eastern Uttar Pradesh, India) has been studied. Cellulase activity of C. globosumisolated and cultured has been assayed using Carboxyl Methyl Cellulose (CMC) Agar medium technique. Gram's iodine solution is used as indicator. The Enzyme Index of C.globosum has been reported as 3.6, which shows that it is industrially important fungus, which may be exploited for the production of cellulase enzyme at industrial level. Therefore, this research work strongly supports the concept that screening of cellulase producing ability of C. globosum and other microorganisms is very important.

**Keywords:** Cellulolytic Fungi, Biodeterioration, Cellulase Activity, Chaetomium globosum, Mesophilic, Enzyme Index (EI).

## Introduction

*Chaetomium globosum* (Kunze) is a mesophilic cellulolytic fungus. It has a vast range of substratum for its growth including plants, soils, debris of plants and animals, papers, textiles and clothes *etc.* (Sharma *et al.* 2025). In addition to its saprophytic nature, strain of *Chaetomium globosum* has been reported to be ''Endophytic'', assisting in cellulose decomposition of plant cells (Chapman *et al*. 1975). Its habitat ranges from forest plants to soils of various biomes (Domsch *et al*. 1980; Liu *et al*. 2007); to indoor environment including books and wood (Provost *et al*. 2013). Rarely

some strains of *Chaetomium globosum* are reported to be human allergens, causing Mycosis and neurological infections (Kim *et al*. 2008; Provost *et al*. 2013).

In humid tropical and sub-tropical countries of the world, biodeterioration of various cultural commodities in textiles, papers, wood and leather is a very common phenomenon (Tiano, 2009; Ortega - Morales *et al*. 2019).
Our cultural heritages are heavily damaged and destroyed by these micro-organisms (Koestler and Vedral, 1991). The two most important microbes responsible for this biodeterioration are fungi and bacteria. Fungi of various groups play most active role and cause maximum damage to these important objects (Arroyo, 2007).

District Gorakhpur is situated in North - Eastern Uttar Pradesh, India, in foot hills of Himalayas at the bank of Rapti river (coordinates; 26.7637152° N; 83.4039116° E), with average annual temperature of 26°C (79°F); elevation- 75m (246ft). Its high relative humidity and moderate temperature from July to March are very suitable for growth of Mesophilic microbes including fungi (Srivastava, 2007).

Fungi having ability to hydrolyse cellulose (a polymer of glucose) into its simpler units are called cellulolytic fungi (Arnthong *et al*. 2020). Twenty-six species of these cellulolytic fungi belonging to 15 genera have been reported causing biodeterioration of Webster's Dictionary in Gorakhpur (Srivastava *et al*. 2011). These fungi by producing cellulase enzymes, cause biodegradation of our cultural heritage containing cellulose, including important library books *etc*. (Mesquita *et al*. 2009; Sterflinger *et al*. 2013). Their activities are supported by high moisture content, moderate light intensity and temperature (Garg *et al.* 1995; Sterflinger*et al.* 2012; Coronado-Ruiz *et al.* 2018).

Biodeterioration of papers and archival material caused by fungi is very common in India (Agrawal, 1995). Lignocellulosic biomass is heavily decomposed by these cellulolytic fungi (Anwar *et al*. 2014). These fungi cause biodegradation of cellulose containing objects by producing three types of cellulases - "Endo 1,4-β-D-glucanase (EG), Cellobiohydrolase (CBH) or exo 1,4, β-D-glucanse and β-glucosidase" (Teeri, 1997; Bayer *et al.*1998; Zhang and Lyund 2004; AL-Kharousi *et al*. 2015). Degradation of cellulose is achieved by the combined effects and actions of these three cellulase enzymes (Qin *et al*. 2010).

*Chaetomium globossum* with other cellulolytic fungi has been reported to degrade cellulose, causing damage of important documents. (Pinzari *et al*. 2006; Michaelsen *et al.* 2009).

The cellulase producing and decomposing ability of various cellulolytic fungi including*Chaetomium*is reported by several workers (Ames, 1961; Aranyanak, 1995; Al-Kharousi *et al*. 2015).

Exploitation of these cellulolytic fungi and their enzymes at industrial scale is the need of time (Arif *et al*. 2024). Control of these cellulytic fungi and protection of our cultural heritage in papers and cloths/textiles is a challenging job (Sequeira *et al*. 2017). However, isolation of these cellulolytic fungi from deteriorated objects and their identification is the initial step. Pure cultures of these fungi are then used to evaluate their cellulolytic activities by calculating their enzyme index (EI).

In the present research work, isolation of cellulolytic fungi from deteriorated samples of papers and cloths/textiles has been done to study the presence of *C. globosum.* Cellulase activity of isolated *C. globosum* has been determined by calculating its enzyme index (EI).

## Materials and Methods

### 1. Isolation of Test Fungus - *Chaetomium globosum* Kunze

Various sites of District Gorakhpur (such as Government District Library; Central Library of D.D.U. Gorakhpur University and Central library of St. Andrew's Post-Graduate College; Buddha Museum and whole sale market of clothes/textiles) were visited and infested samples of papers and cloths/textiles were collected from these sites.

For isolation, 3 techniques were used – Direct Observation, Standard Blotter Method and Czapek Dox Agar Method.

Six species of *Chaetomium*were isolated and reported from deteriorated samples of papers and cloths/textiles, which were given Isolate/Culture Numbers (**Table – 1**).

**Table – 1**
**Frequencies of Species of *Chaetomium* Kunze Isolated from Deteriorated Samples of Papers and Cloths/Textiles**

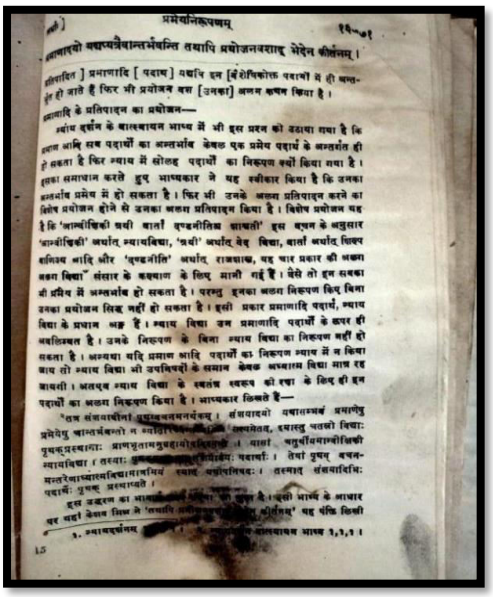
| S. No. | Species of *Chaetomium* Isolated | Isolate/Culture No. | DO | SBM | CDA |
|---|---|---|---|---|---|
| 1. | *Chaetomium dolichotrichum* Ames | SP/AML/0122 | + | + | ++ |
| 2. | *C. funiculosum* Corda | SP/AML/0123 | + | + | |
| 3. | *C. globosum* Kunze | SP/AML/0124 | +++ | ++ | +++ |
| 4. | *C. strumarium*Minter | SP/AML/0125 | + | + | ++ |
| 5. | *Chaetomium* sp. (US) - 1 | SP/AML/0126 | + | - | + |
| 6. | *Chaetomium* sp. (US) - 2 | SP/AML/0127 | + | - | - |

| | | | | | |
|---|---|---|---|---|---|
| +++ | : | Most Frequent | DO | : | Direct Observation |
| ++ | : | More Frequent | SBM | : | Standard Blotter Method |
| + | : | Less Frequent | CDA | : | Czapek Dox Agar |
| - | : | Absent | US | : | Unidentified Species |

As it is evident from **Table – 1**, maximum frequency observed was of *C. globosum*, which was selected as the test fungus. It was cultured on Potato Dextrose Agar (PDA) Medium.

The pure culture of isolated *C.globosum* **(Isolate/Culture No. SP/AML/0124)** was deposited in NFCCI (National Fungal Culture Collection of India), Pune, Maharashtra, India to get Accession No. **(Accession. No. – NFCCI5963)**. Also, the pure culture of *C. globosum* was procured from ITCC (Indian Type Culture Collection), Indian Agricultural Research Institute (IARI), New Delhi **(ITCC. No. - 3680).**

**Shakya Buddha, Thanka (1875 AD, TIBBET) infested by Cellulolytic fungi**



प्रमेयनिरूपणम्

प्रमाणादयो पदार्थान्तर्भवन्ति तथापि प्रयोजनवशाद् भेदेन कीर्तनम्।

तीयादि ] प्रमाणादि [ पदार्थ ] यद्यपि इन [प्रदेशिकोक्त पदार्थों में ही अन्त-र्हो जाते हैं फिर भी प्रयोजन वश [उनका] अलग कथन किया है।

प्रमाणादि के प्रतिपादन का प्रयोजन—

न्याय दर्शन के वात्स्यायन भाष्य में भी इस प्रश्न को उठाया गया है कि प्रमाण आदि सब पदार्थों का अन्तर्भाव केवल एक प्रमेय पदार्थ के अन्तर्गत ही हो सकता है फिर न्याय में सोलह पदार्थों का निरूपण क्यों किया गया है। इसका समाधान करते हुए भाष्यकार ने यह स्वीकार किया है कि उनका अन्तर्भाव प्रमेय में हो सकता है। फिर भी उनके अलग प्रतिपादन करने का विशेष प्रयोजन होने से उनका अलग प्रतिपादन किया है। विशेष प्रयोजन यह है कि 'आन्वीक्षिकी त्रयी वार्ता दण्डनीतिश्च शाश्वती' इस वचन के अनुसार 'आन्वीक्षिकी' अर्थात् न्यायविद्या, 'त्रयी' अर्थात् वेद विद्या, वार्ता अर्थात् शिल्प शास्त्र आदि और 'दण्डनीति' अर्थात् राजशास्त्र, यह चार प्रकार की अलग अलग विद्या" संसार के कल्याण के लिए मानी गई हैं। वैसे तो इन सबका भी प्रमेय में अन्तर्भाव हो सकता है। परन्तु इनका अलग निरूपण किए बिना उनका प्रयोजन सिद्ध नहीं हो सकता है। इसी प्रकार प्रमाणादि पदार्थ, न्याय विद्या के प्रधान अङ्ग हैं। न्याय विद्या उन प्रमाणादि पदार्थों के ऊपर ही अवलम्बित है। उनके निरूपण के बिना न्याय विद्या का निरूपण नहीं हो सकता है। अन्यथा यदि प्रमाण आदि पदार्थों का निरूपण न्याय में न किया जाय तो न्याय विद्या भी उपनिषदों के समान केवल अध्यात्म विद्या मात्र रह जायगी। अतएव न्याय विद्या के स्वतंत्र स्वरूप की रक्षा के लिए ही इन पदार्थों का अलग निरूपण किया है। भाष्यकार लिखते हैं—

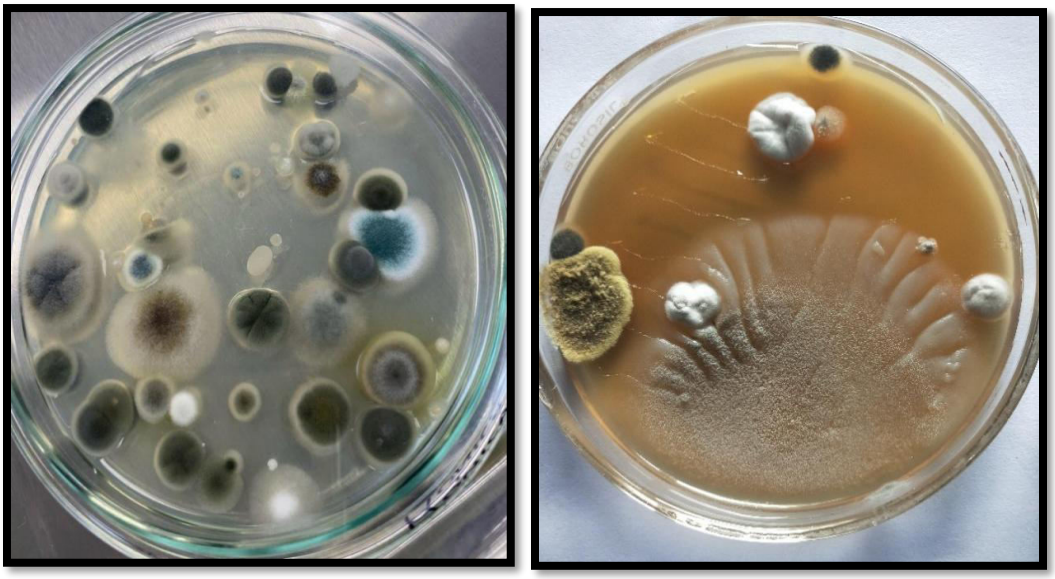
"तत्र संशयाधीनो [illegible] संशयादयो यथासम्भवं प्रमाणेषु प्रमेयेषु चान्तर्भवन्तो न स्वतंत्रेण [illegible] तत्त्वमेतत्, इयत्तु पृथग्विद्याः पृथक्प्रस्थानाः प्राणभृतामनुग्रहायोपदिष्टाः। यावां चतुर्थीसमान्वीक्षिकी न्यायविद्या। तस्याः [illegible] पदार्थाः। तेषां पृथग् वचनमन्तरेणाध्यात्मविद्यामात्रमियं स्यादुपनिषदः। तस्मात् संशयादिभिः पदार्थैः पृथग् प्रस्थाप्यते।

इस उद्धरण का आशय [illegible] पर यहाँ केवल सिद्ध ने 'तत्त्वमेतत्' यह पंक्ति लिखी

१. न्यायदर्शनम् [illegible] वात्स्यायन भाष्य १,१,१।

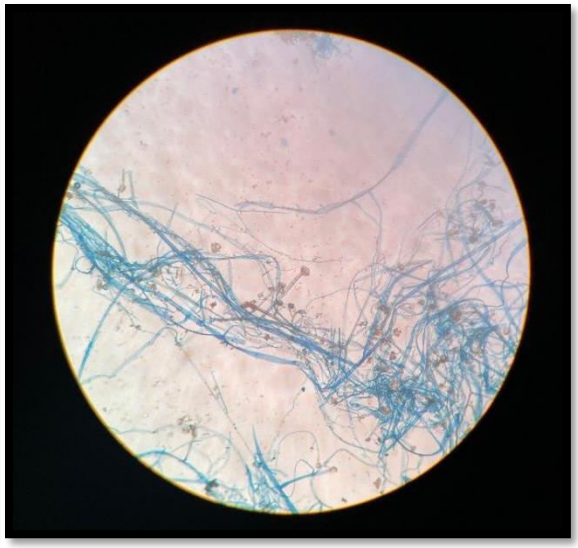
**Infested page of "Hindu Dharmkosh"**


**Damaged Book entitled "SUKH SAGAR" Isolation of Cellulolytic Fungi (1856)**



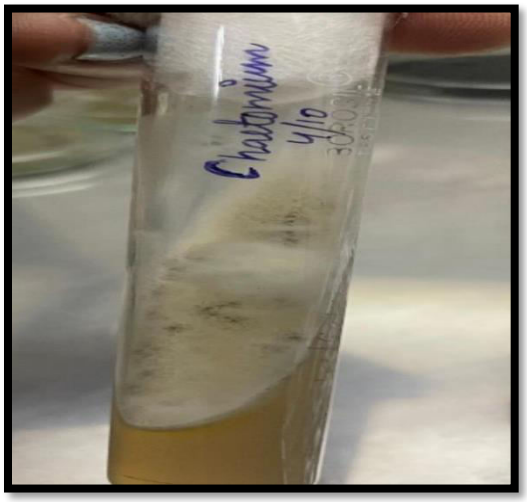
**Mixed Culture of Cellulolytic Fungi Isolated**

Pure Culture of *Chaetomium globosum*



Mycelium of *Chaetomium globosum*

Spores of *Chaetomium globosum*



Slant of *Chaetomium globosum* for

Pure Culture of *Chaetomium globosum*

**Deposition in NFCCI, Pune procuredfrom ITCC, IARI, New Delhi**

## 2. Cellulase Assay of *Chaetomium globosum*

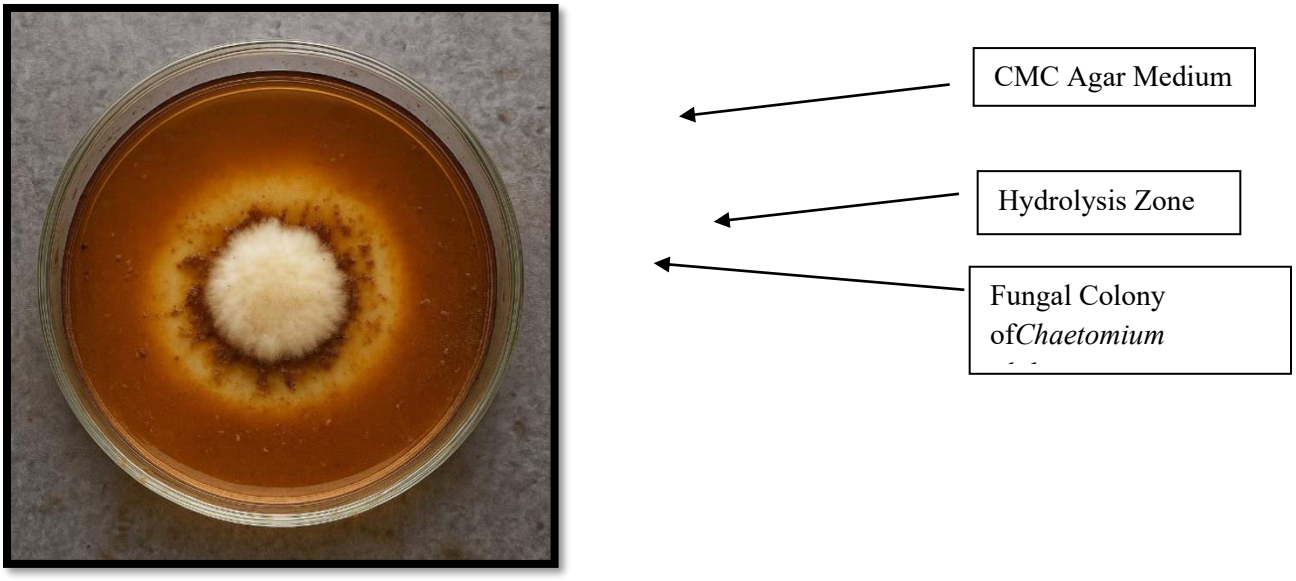
Cellulase assay of the test fungus *C.globosum* was done by using 1% Carboxyl Methyl Cellulase Agar medium (CMC AM).

Carboxyl Methyl Cellulose serves as source of carbon and Gram's iodine solution as indicator to observe cellulose hydrolysis zone (Coronado - Ruiz *et al.* 2018). In this process of qualitative determination of cellulase activity, the Gram's iodine, react with cellulose as well as its decomposed components. The unhydrolyzed and intact cellulose holds the colour of Gram's iodine solution. However, that cellulose which is hydrolysed by fungal cellulase enzymes reflects 'clear zone' (seen as pale-yellow zone). The enzymatic index of *C.globosum* was calculated as-

$$\textbf{EI of } \boldsymbol{C.\,globosum} = \frac{\textbf{Diameter of Hydrolysis Zone}}{\textbf{Diameter of Colony Growth of } \boldsymbol{C.\,globosum}}$$

To evaluate E.I., 6mm. diameter disc of pure culture of *C. globosum* was cultured on 1% CMC Agar Medium and was incubated for 7 days at 28 ± 2 ℃ temperature. The antibiotic used was Streptomycin. Gram's Iodine solution was used as indicator. Afterwards, this culture was washed with water. Colony diameter of *C.globosum*and clear zone around the fungal disc were measured to calculate enzyme index (Coronado- Ruiz; 2018).

**Observations**



**Cellulase Assay of *Chaetomium globosum***

1. Diameter of hydrolysis zone (Diameter of colony + clear zone) = 36mm.
2. Diameter of colony growth of *C. globosum* = 10mm

Therefore;

$$\textbf{EI of } \boldsymbol{C.globosum} = \frac{\textbf{36 mm.}}{\textbf{10 mm.}} = \textbf{3.60}$$

**Result and Discussion**

Six species of *Chaetomium*have been isolated and cultured from deteriorated samples of papers and clothes/ textiles. Of these 6 species, 4have been identified as*Chaetomium dolichotrichum* Ames,*C. funiculosum*Corda,*C. globosum*Kunze and *C. strumarium*Minter. However, two unidentified species (US) were also isolated and were given culture numbers for future studies. Of all these 6 species, *C. globosum*was reported to be the most frequent species collected from all the samples.

**Enzymatic index (EI)** of***C. globosum*** has been calculated as **3.60**

The results of present work clearly shows that *C.globosum* is efficient in cellulase enzyme production and cellulase producing ability of this species can be exploited at industrial level. Also, the objects containing cellulose, such as books, archives, cloth and textiles *etc*. could be a good source to explore and isolate cellulase producing fungi like *C.globosum etc.*

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**Authors Contributions**

All authors contributed significantly to the final manuscript.

**Statements and Declarations:** Authors declares no conflict of Interest.

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