6. Format for submission of final report of completed project

(Report must be for complete duration of the project)

- Title: ***Establishment of Advance Institutional Level Biotect Hub (Phase-II) at Dhing College, Nagaon (Assam)***

1. Project Investigators and address: **Dr. Manoj Kumar Saikia PI (Retd) , Dr. Sanjeeb Kumar Nath CO-PI (PI- In charge), Dr Ujjayanta Das CO-PI , Dhing College, Nagaon (Assam)**
2. Date of sanction : **01/02/2023**
3. Date of completion**: 30/04/2026**
4. Approved cost: **5784720.00**
5. Budget released: **21,10,960.00 [First Year Grant]**
6. Objectives (including targets set at the starting of the projects):

❑ **RIMARY OBJECTIVES [Capacity building programme]**

- To strengthen the laboratory infrastructure of the hub for achieving excellence in teaching and training.
- To enhance the quality of the learning through 'Hands On" exposure to experimental work and participation in Summer Schools/ Projects.
- To promote networking and strengthen ties with neighbouring institutions and other Biotech hub laboratories.
- To conduct specialized training programmes/Lecture programme /Outreach/awareness/STC for the Students, faculty & teachers to improve their skills.
- To provide access and exposure to students to R& D activities of the hub/ laboratories and industries in the NER region of India.
- To help in devising standard Operating Procedures (SOP's)/kit's for practicals.
- To conduct community programme their by linking with societal people/NGOetc.

❑ **SPECIFIC OBJECTIVES [R&D Component]:**

- ***Title: In vitro antimicrobial & antagonistic activity of Endolichenic Fungus (ELF) against pathogenic bacteria & fungus and evaluation of their bioactive compound using Thin Layer Chromatography (TLC) & HPLC"***

    i. *"Isolation, Identification & In-vitro evaluation of antimicrobial& antagonistic potentiality of Endolichenic fungus and their efficiency against some clinically significant human and plant pathogen.*

    ii. Isolation of bioactive compounds from Lichen and their identification.

7. **Detailed methodologies (full details of experimental set up, methods adopted, data collected supported by necessary table, charts, diagrams & photographs):**

[Work plan (methodology/experimental design to accomplish the stated aim]

- **Field Survey & Preparation of maps for Sample sites and Collection of Lichens**: The lichen specimens of the present study were collected from twigs of bark and stem from 5 (five) different sample station/location of Nagaon district of Assam. The healthy looking thalli were cut out from the tree bark with a sterile knife and placed into sterile plastic collection bags. The collected samples were brought to the laboratory in sterile polythene bags and processed within 24 hours of collection. The identification was done using standard key (*Awasthi, 1988, 1991, 2000a*). The species preserved in college laboratory for further studies.
- **Isolation and identification of endolichenic fungi**: The isolation procedure of endolichenic fungi was carried out following the method prescribed by *Liet al.(2007)*. Lichen thalli was washed thoroughly with Milli-Q water to remove dirt or debris from surfaces and then surface sterilized by immersing sequentially in 10% of 30% hydrogen peroxide (H_2O_2) solution for 4–5 minutes followed by rinsing with 70% alcohol for 5 seconds and 1% of 4%sodium hypochlorite(NaOCl) for 6 minutes and washed with sterile distilled water. The lichen thalli are then dried by placing over sterile filter papers and was dissected aseptically to a fragment of 1mm^2size. Each fragment was then inoculated onto Potato Dextrose Agar (PDA) medium. The plates was sealed with parafilm and incubated in BOD incubator at 30°C until growth of endolichenic fungi. The plates were observed once a day for fungal growth. After several days of incubation the colonies growing out of surface sterilized fragments was isolated, sub-cultured and maintained at 4°C in PDA slants. The isolates was then identified based on their morphological and reproductive characters using the standard identification manuals given by *Barnett Hunter (1998)&Gilman (1971).* The cultures that failed to sporulate were categorized as sterile mycelia.

- **Screening of for antimicrobial /MIC activity**: Pure cultures of endolichenic fungi were cultivated on Potato Dextrose Broth (PDB) by placing agar blocks of actively growing culture (3mm in diameter) in 250ml Erlenmeyer flasks containing100 ml of the medium. The flasks will be incubated in BOD shaking incubator for14 days at 29±1°C with periodic shaking at 150rpm. The cultures were then filtered through sterile cheese cloth to remove them mycelia mats. The liquid broth was collected and extracted with equal volume of acetate in a separating funnel by vigorous shaking for 15min. The cell masses were separated, and the ethyl acetate extracts was collected for each isolate. Ethyl acetate was evaporated, and the resultant compounds was allowed to be dried individually with magnesium sulfate ($MgSO_4$) and concentrated to yield the crude extracts. The crude extracts was then dissolved in 15% Dimethyl sulfoxide(DMSO) for anti microbial bioassay. Antimicrobial activities of the crude metabolites isolated from the endolichenic fungi was determined by agar cup diffusion method against two bacterial pathogen and two fungal pathogen obtained from KVV Kendra, AAU, Nagaon (Assam).Muller Hinton Agar (MHA) plates was inoculated with overnight culture of each bacterial suspension. Similarly for the fungal pathogens, Sabourad Dextrose Agar (SDA) plates were used for each fungal suspension. The plates with the inoculated organisms were evenly spread out with sterile cotton swabs. Agar cups were prepared by scooping out the media with a sterile cork borer (7mm diameter). The cups was then filled with 100µl of the crude metabolites that was dissolved in DMSO to get a concentration of 1mg/ml. The plates was then incubated a t36±1°C for 24h and 48h for bacterial and fungal pathogens respectively. Antimicrobial activity was determined as growth inhibition of the target organism around agar cup as appearance of clear zones. The Optical Density (OD_{600}) of crude lichenoid extract upon test pathogen was also conducted using UV-VIS spectrophotometer to determine the % inhibition on two bacterial and two fungal pathogen. The results was expressed in terms of growth of organisms (+) or inhibition of growth (-). The lowest concentration inhibiting fungal growth was noted as MIC (Rath et al., 1999).

8. Detail analysis of the Results with good quality images:

The findings of this study offer valuable insights into the lichen diversity and endolichenic fungal community in the Nagaon district of Assam. The collection of 29 lichen species across five distinct areas demonstrates the region's rich lichen flora and the associated endolichenic fungal community. Through meticulous collection efforts across five distinct areas (**Map 1&2**) namely *Dhing, Kothiatoli, Nonoi, Podumoni, and Chapanala* – a total of 29 lichen species were identified, with *crustos*e species comprising 60% and *foliose* species 40% of the total **(Table-2, Photo plate 2-7)**. Notably, a prevalence *of corticolous* lichen was observed within the sampled regions. Expert identification conducted at lichenology laboratories at Nowgong University, Nagaon, and the ICFRE-Rain Forest Research Institute, Jorhat, Assam, facilitated accurate categorization of specimens, with *Parmotrema* being the predominant genus among foliose lichens.

Following collection, surface sterilization techniques **(Photo plate-8**) were employed to isolate sporulated endolichens, leading to the successful isolation and storage of pure colonies for further analysis. Biochemical and growth pattern evaluations of the endolichens revealed consistent positive delayed *catalase* and *oxidase* activity across all endolichenic fungi (ELFs). To enhance understanding and distinction among various lichen associated ELFs, ongoing efforts include the implementation of additional biochemical and MIC test. These endeavors aim to deepen our comprehension of the diverse endolichenic fungal community within the region, paving the way for potential applications in ecological research and biotechnology. The findings of this study offer also provide us an valuable insights into the lichen diversity and endolichenic fungal community in the Nagaon district of Assam. The collection of 29 lichen species across five distinct areas demonstrates the region's rich lichen flora. The predominance of crustose species, comprising 60% of the total, suggests a preference for substrates conducive to their growth, while the presence of foliose species, particularly those belonging to the Parmotrema genus,highlights

the diversity within this group. The identification of lichen specimens was facilitated by collaboration with expert lichenology laboratories at Nowgong University, Nagaon , and the ICFRE- Rain Forest Research Institute, Jorhat, Assam. This ensured accurate taxonomic classification and laid the foundation for further investigations into the ecological roles and potential applications of these lichen. The successful isolation and storage of pure colonies of sporulated endolichens signify a crucial step towards understanding the endolichenic fungal community associated with these lichens. The consistent positive delayed catalase and oxidase activity exhibited by all endolichenic fungi (ELFs) suggest metabolic activity indicative of potential symbiotic or parasitic relationships with their lichen hosts. These findings corroborate previous studies highlighting the metabolic diversity of endolichenic fungi and their potential ecological significance.The planned implementation of additional biochemical and molecular tests aims to elucidate the diversity and genetic makeup of the endolichenic fungal community further.These tests will provide valuable insights into the functional roles of ELFs within lichen symbiotic associations and their potential biotechnological applications. Overall, this study contributes to our understanding of lichen diversity and endolichenic fungal communities in the Nagaon district of Assam. The data generated pave the way for future research endeavors aimed at exploring the ecological, evolutionary, and biotechnological significance of these fascinating organisms in natural ecosystems. The study reveals rich lichen diversity with *Parmotrema* and *Pyxine* being dominant genera, thriving due to favourable climatic conditions. Most samples were collected from rural areas having favourable annual rainfall, temperature and humidity which favours the growth of others lichen species namely *Corticolous*, *Saxicolous* and *Lignicolous* lichens in this locality. In the present study the Simson's Diversity Index **(Table- 4**) of Lichens species from 5(five)sample sites of Nagaon District was calculated as- D=0.87547 which signify the high diversity of lichen species . The study reflects both richness and evenness, a few dominant species lead to low diversity, while many species with similar number lead to high diversity.

The interpretation of the value of Simpson's indices was calculated. The value 0.87547 is likely from the most commonly used diversity index (1-D), as this range makes intuitive sense. If the value is for Simpson's Diversity Index (Gini-Simpson Index, or 1-D): The index ranges from 0 to 1. A value of 0.87547 in the present study is close to 1, which signifies a high degree of diversity (many different species with a relatively even distribution of individuals among those species).

A value between approximately 0.7 and 1.0 is often considered high diversity. If the value is for Simpson's Index (D, or Dominance Index): The index also ranges from 0 to 1, but the interpretation is counterintuitive: higher values indicate *lower* diversity (or higher dominance by one or two species). In this case, 0.87547 would suggest very low diversity/high dominance (a value > 0.7 is typically very low diversity). The high diversity index indicates a robust ecosystem, suggesting potential for discovering n Further the antimicrobial activity of the lichen extracts was evaluated against two bacterial pathogens*, Ralstonia solanacearum (MTCC 13168)* and *Pseudomonas syringae (MTCC 673),* and two fungal pathogens, *Fusarium oxysporum (MTCC 12994)* and *Alternaria alternata (MTCC 13407),* using agar well diffusion assay. The extracts prepared using *acetone, methanol, petroleum ether* and *diethyl ether* exhibited varying degrees of antimicrobial activity against the tested pathogens (**Table-5, Photoplate-1& Figure-1**). Among the tested microorganisms, the bacterial pathogens showed greater susceptibility to the lichen extracts than the fungal pathogens. The highest antibacterial activity was observed against *R. solanacearum and P. syringae,* with petroleum ether and acetone extracts producing comparatively larger zones of inhibition. Methanol and diethyl ether extracts also exhibited inhibitory activity, although the zones were relatively smaller. Streptomycin, used as the positive control, produced the largest inhibition zones against both bacterial pathogens. In contrast, the fungal pathogens exhibited lower sensitivity to the lichen extracts.

Only weak to moderate inhibition was observed against *F. oxysporum and A. alternata,* irrespective of the solvent used for extraction. Carbendazim, used as the positive control, showed superior antifungal activity compared to the lichen extracts. ew species in future studies to come which may contribute ICBN. The comparatively lower inhibition observed against the fungal pathogens may be attributed to differences in cell wall composition and inherent resistance mechanisms. The results indicate that the lichen extracts possess promising antibacterial activity, particularly against phytopathogenic bacteria.

The variation in antimicrobial activity among the solvent extracts may suggests that the extraction efficiency of bioactive secondary metabolites depends on the polarity of the solvent employed. The MIC test of lichenoid extract upon selected bacterial pathogen *Ralstonia solanacearum &Pseudomonas syringae* and two fungal pathogen *F. oxysporum and A. alternate* as identified in the ELF list (**Table-3**) from the study sites. the above said pathogens (bacteria and ELF) was also conducted in laboratory using VIS-UV spectrophometer (**Table-7**) which also confirm that lichen extracts has greater inhibition effect on bacterial pathogen than fungal pathogen which need further investigation for biotechnological application .These tests will provide valuable insights into the functional roles of ELFs within lichen symbiotic associations and their potential biotechnological applications.Overall, this study contributes to our understanding of lichen diversity and endolichenic fungal communities in the Nagaon district of Assam. The data generated pave the way for future research endeavors aimed at exploring the ecological, evolutionary, and biotechnological significance of these fascinating organisms in natural ecosystems.

Results and Tables with good quality images

- **Table: 1. No. of workshop/symposia/brainstorming meeting/ trainings organized in financial year 2023-2026.**

[Outcome Indicators of CAPACITY DEVELOPMENT PROGRAMME]

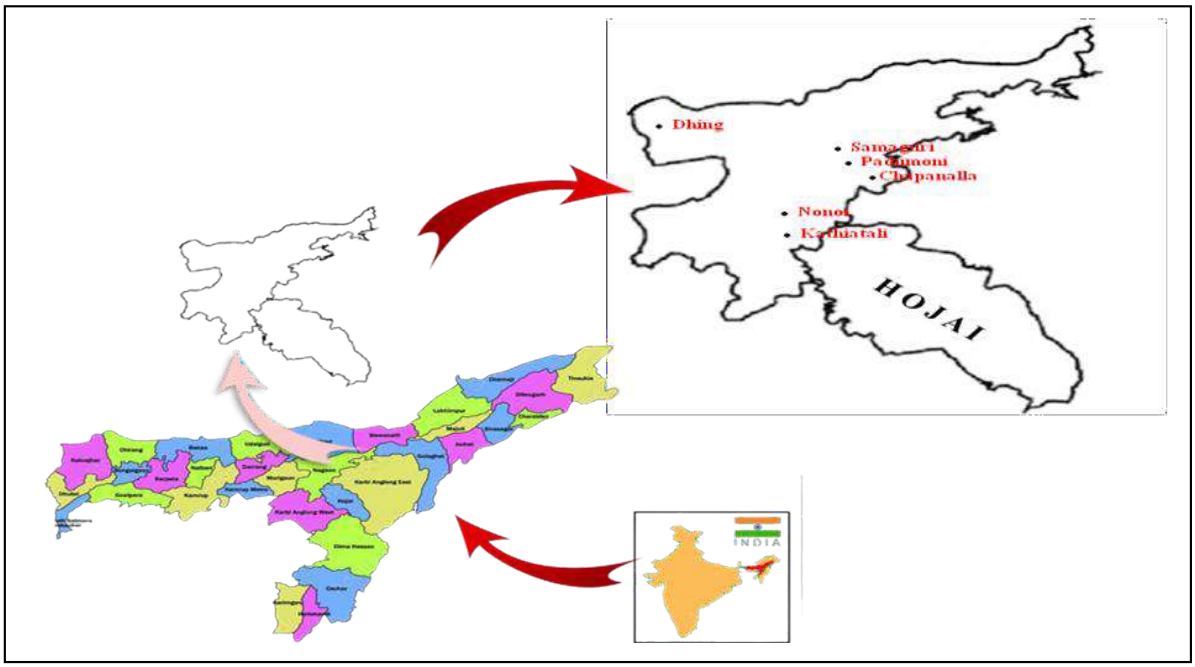
Year	1st Year		2nd Year		3rd Year		Total	
Target (T)/ Achievements (A)	**A**	**T**	**T**	**A**	**T**	**A**	**T**	**A**
No. of manpower supported/ trained				287		141	**428**	**428**
No. of female beneficiaries in the DBT funded project						20	**20**	**20**
No. of publications					01	01	**02**	**02**
No. of Patents filed/ granted/commercialized						01	**Granted 01 Filed 01**	**Granted 01 Filed 01**
No. of products or technologies developed/ transferred/commercialized								
Others (Training/STC/ wprkshop/ OP)	3			4		3	**10**	**10**
Patents				01		01(A/F)	**02**	**02**

Table 2: List of Identified Lichens from various sample sites [R&D PROGRAMME]

Lichen Samples	Site	Scientific Name	Figures
Sample 1	Kathiatoli (Nagaon)	*Parmotrema tinctorum*(Nyl.)Hale	Figure1-3
Sample 2	Dhing (Nagaon)	*Oxneriopsisbassiae* (Ach.)S.Y. Kondr.Upreti &Hur	Figure4
Sample 3	Padumoni (Nagaon)	*Dirinariaaegiliata* (Afzel.ExAch.) Moore	Figure5-6
Sample 4	Dhing (Nagaon)	*Cryptotheciastriata*Thor.	Figure7
Sample 5	Padumoni (Nagaon)	*Parmotrematinctorum*(Nyl.)Hale	Figure1-3
Sample 6	Chapanala (Nagaon)	*Dirinariapapillulifera*(Nyl.)D.D. Awasthi	Figure8-9
Sample 7	Chapanala (Nagaon)	*Pyxinesubcinerea*Stirton	Figure10-11
Sample 8	Kathiatoli (Nagaon)	*Lecanoraachroa*Nyl.	Figure12
Sample 9	Chapanala (Nagaon)	*Graphisscripta*(L.) Ach.	Figure13-14
Sample 10	Chapanala (Nagaon)	*Phaeographiscaesioradians* (Leight.) Archer	Figure15-16
Sample 11	Dhing	*Parmotrematinctorum*(Nyl.)Hale	Figure1-3
Sample 12	Bordua	*Pyxinesorediata*(Ach.)Mont.	Figure17-18
Sample 13	Chapnala	*Bacidiaconnexula*(Nyl.) Zahlbr.	Figure19-20
Sample 14	Chapnala	*Lecanoraachroa*Nyl.	Figure12
Sample 15	Padumoni	*Thelotrema*sp.	Figure21-22
Sample 16	Dhing	*Pyxinecocoes*(Sw.)Nyl.	Figure23
Sample 17	Dhing	*Pyxinereticulate*(Vain.)Vain.	Figure24
Sample 18	Dhing	*Parmotremapraesorediosum*(Nyl.) Hale	Figure25
Sample 19	Chapnala	*Parmotremapraesorediosum*(Nyl.) Hale	Figure25
Sample 20	Chapnala	*Pyxinecocoes*(Sw.)Nyl.	Figure23
Sample 21	Chapnala	*Pyxinefarinose* Kashiw.	Figure26
Sample 22	Bordua	*Dirinariapapillulifera* (Nyl.)D.D.aWAwasthi	Figure8-9
Sample 23	Bordua	*Graphisnigroglauca* Leighton	Figure27-28

Sample 24	Bordua	*Bacidia incongruens*(Stirton) Zahlbr.	Figure29
Sample 25	Chapnala	*Parmotremacrinitoides*J.C. Wei	Figure30
Sample 26	Chapnala	*Graphis*sp.	Figure31-32
Sample 27	Dhing	*Graphinarufopallida*(Vainio) Zahlbr.	Figure33-34
Sample 28	Dhing	*Chrysothrixcandelaris*(L.) Laundon	Figure35
Sample 29	Chapanala (Nagaon)	Sampleisnotalichenbutprobably **[A wooddecayingfungus]**	Figure36
Sample 30	Dhing	(FruticoseLichen)[unidentified]	Figure37

Map1: Geographical Map of Lichen Collection Sites:



Map2: Location, GPS Details of Lichen Collection Sites:-

Sample site	Name	Nature	Latitude& Longitude
1	Dhing	Plain area	Lat:26.457140,Long: 92.487541
2	Chapanala	Foot hills	Lat:26.339437,Long: 92.894914
3	Padumoni	Foot hills	Lat:26.369124,Long: 92.844875
4	Kathiatoli	Foot hills	Lat:26.225751,Long: 92.808177
5	Bordua	Plain area	Lat:26.402127,Long: 92.536625

- **Table 3: Isolation of ELF corresponding to Lichen Species**

Genus	Identified Lichen Species	ELF identified
Bacidia	Bacidia connexula (Nyl.) Zahlbr.	Colletotrichum
	Bacidia incongruens (Stirton) Zahlbr.	Trichoderma Sp
Chrysothrix	Chrysothrix candelaris (L.) Laundon	Phomopsis
Cryptothecia	Cryptothecia striata Thor.	Trichoderma Sp
Dirinaria	Dirinaria aegiliata (Afzel. Ex Ach.) Moore	Alternaria spp
	Dirinaria papillulifera (Nyl.) D.D. Awasthi	Cladosporium sp.,
Graphina–	Graphina rufopallida (Vainio) Zahlbr.	Fusarium Sp
Graphis	Graphis scripta (L.) Ach.	Aspergillus
	Graphis scripta (L.) Ach.	Alternaria spp
	Graphis spp.	Fusarium Sp
Lecanora	Lecanora achroaNyl.	Cladosporium sp.,
Oxneriopsis	Oxneriopsis bassiae (Ach.) S.Y. Kondr.Upreti& Hur	Trichoderma Sp
Parmotrema	Parmotrema tinctorum (Nyl.) Hale	Alternaria spp
	Parmotrema praesorediosum (Nyl.) Hale	Alternaria spp
	Parmotrema crinitoides J.C. Wei	Fusarium Sp
Phaeographis	Phaeographis caesioradians (Leight.) Archer	Alternaria spp
Pyxin	Pyxine cocoes (Sw.) Nyl.	Xylaria sp
	Pyxine farinosaKashiw.	Fusarium Sp
	Pyxine subcinerea Stirton	Daldinia
	Pyxine reticulata (Vain.) Vain.	Fusarium
	Pyxine sorediata (Ach.) Mont.	Aspergillus
Thelotrema	Thelotrema sp.	Trichoderma Sp

Table 4: Simpsons Diversity Index of Lichen Species of Nagaon District:

Diversity Index=$1-\sum(n/N)^2$
n=Total Number of organisms of a particular species
N= Total number of organisms of all species
D=Diversity Index

- **Data Collection:**

Lichen samples	Total species identified
Parmotrema	6
Oxneriopsis	1
Dirinaria	3
Cryptothecia	1
Pyxine	6
Lecanora	2
Graphis	3
Phaeographis	1
Bacidia	2
Thelotrema	1
Graphina	1
Chrysothrix	1
FruticoseLichenspp	1
	Total=29

- **Calculation of $(n/N)^2$ for each species:**

Lichen samples	$(n/N)^2$	
Parmotrema	$(6/29)^2$	0.042849
Oxneriopsis	$(1/29)^2$	0.001156
Dirinaria	$(3/29)^2$	0.010609
Cryptothecia	$(1/29)^2$	0.001156
Pyxine	$(6/29)^2$	0.042849
Lecanora	$(2/29)^2$	0.004761
Graphis	$(3/29)^2$	0.010609
Phaeographis	$(1/29)^2$	0.001156
Bacidia	$(2/29)^2$	0.004761
Thelotrema	$(1/29)^2$	0.001156
Graphina	$(1/29)^2$	0.001156
Chrysothrix	$(1/29)^2$	0.001156
FruticoseLichenspp	$(1/29)^2$	0.001156
Sum the squared proportions ($\Sigma(n/N)^2$):		**0.12453**
Calculation of D(1-Sum)1-0.12453		**0.87547**

Table 5 : Qualitative antimicrobial activity of lichen extracts against selected plant pathogens

Pathogen	Acetone	Methanol	Petroleum Ether	Diethyl Ether	Positive Control
Pseudomonas syringae (MTCC 673)	+++	++	+++	++	++++ (Streptomycin)
Ralstonia solanacearum (MTCC 13168)	+++	++	+++	++	++++ (Streptomycin)
Alternaria alternata (MTCC 13407)	-	-	±	-	++ (Carbendazim)
Fusarium oxysporum (MTCC 12994)	±	-	±	-	++ (Carbendazim)

Scale: ++++very strong inhibition,+++Strong,++Moderate, + Weak, -No inhibition.

TABLE 6: STATION WISE COLLECTION OF DATA:

❑ Sample Station (L-01): Dhing Area (Campus and nearby forest):

Code	Habitat	GPS	Type	Location
D-01	Corticolous	Lat. 26.457140, Long. 92.487541	Crustose	Dhing College Campus
D-02	Corticolous	Lat. 26.457747, Long. 92.485705	Crustose	Dhing College Campus
D-03	Corticolous	Lat. 26.457747, Long. 92.485705	Foliose	Dhing College Campus

❑ Sample Station (L-02): Chapanala and Samaguri Area (Nearby forest):

Code	Habitat	GPS	Type	Location
C-01	Saxicolous	Lat. 26.339437, Long. 92.894914	Crustose (White and orange)	Chapanala
C-02	Corticolous	Lat. 26.339251, Long. 92.894884	Crustose (Whitish green)	Chapanala
C-03	Ramicolous	Lat. 26.369144, Long. 92.844882	Foliose	Chapanala
C-04	Corticolous	Lat. 26.339251, Long. 92.894884	Foliose	Champawati falls area
C-05	Corticolous	Lat. 26.321012, Long. 92.904060	Crustose (Whitish green)	Champawati falls area
C-06	Corticolous	Lat. 26.368863, Long. 92.845258	Foliose	Champawati falls area
C-07	Corticolous	Lat. 26.320604, Long. 92.904717	Crustose (Green)	Champawati falls area
C-08	Corticolous	Lat. 26.320604, Long. 92.904717	Crustose (Whitish)	Champawati falls area
C-09	Ramicolous	Lat. 26.340091, Long. 92.894852	Foliose (Green)	Champawati falls area
C-10	Corticolous	Lat. 26.340091, Long. 92.894852	Crustose (Whitish green)	Champawati falls area

❑ Padumoni area (L-03) nearby forest

Code	Habitat	GPS	Type	Location
P-01	Corticolous	Lat. 26.369128, Long.92.844901	Crustose (Whitish green)	Podumoni Village
P-02	Corticolous	Lat. 26.369058, Long. 92.844810	Foliose (Green)	Podumoni Village

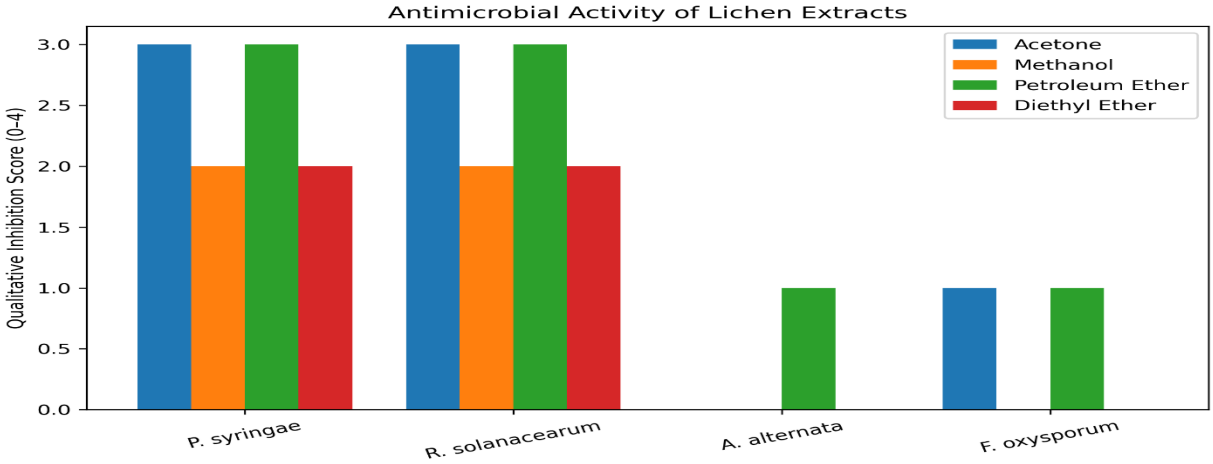
❑ Kothiatoli area (L-04) nearby forest

Code	Habitat	GPS	Type	Location
K-01	Corticolous	Lat. 26.225755, Long.92.808166	Crustose (white)	Kothiatoli Foothills
K-05	Ramicolous	Lat. 26. 225746, Long.92.808177	Foliose	Kothiatoli Foothills

❑ Nonoi area (L-05) nearby forest

N-01	Corticolous	Lat. 26.225750, Long.92.808167	Crustose	Nonoi Area
N-02	Corticolous	Lat. 26. 225760, Long.92.808182	Crustose	Nonoi Area

➢ **Fig 1 : Antimicrobial activity of Lichen Extract.**



➢ **Photo Plate 1: : Antimicrobial activity of Lichen Extract.**

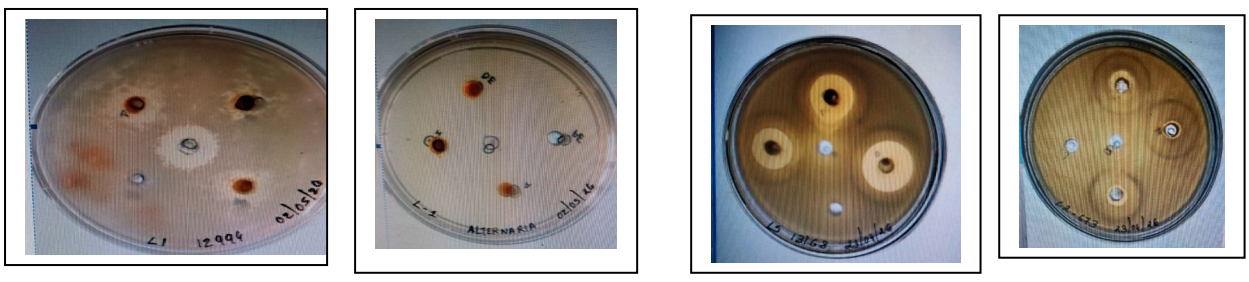
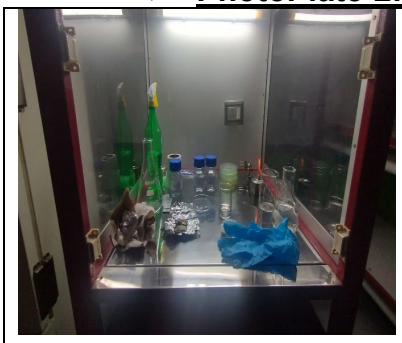
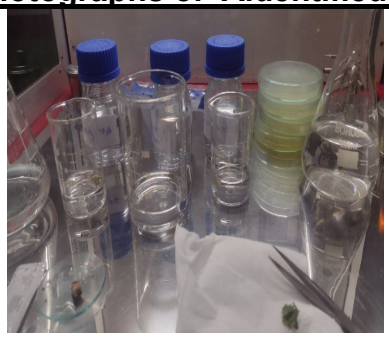
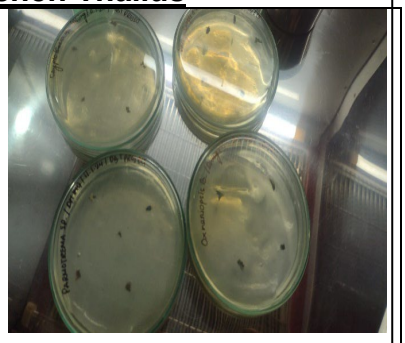


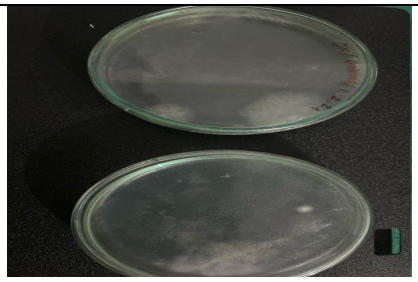
Table 7: Percent Inhibition (%) of bacterial and fungal pathogen treated with lichen extract at OD $_{600nm}$ using UV-VIS spectrophotometer [mean value of 3 replicas in petroleum and ethanol extract]

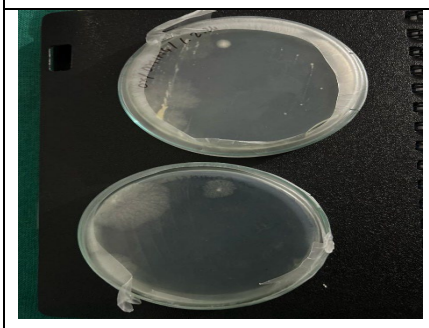
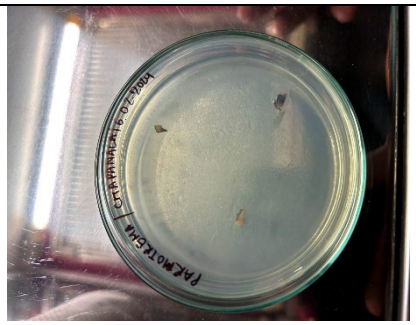
Pathogen/Test organism	ppm	OD $_{Control}$	OD $_{Sample}$	% Inhibition (mean of 3 replica)
Pseudomonas syringae	25	0.625	0.489	21.76
	75	0.634	0.464	26.81
	50	0.649	0.455	29.89
	100	0.697	0.408	**41.46**
Ralstonia solanacearum	25	0.615	0.478	22.27
	75	0.629	0.455	27.66
	50	0.640	0.452	29.37
	100	0.678	0.425	**37.31**
Alternaria alternata	25	0.630	0.621	0.90
	50	0.645	0.640	0.77
	75	0.650	0.649	0.15
	100	0.670	0.666	**0.59**
Fusarium oxysporum	25	0.623	0.620	0.48
	50	0.639	0.635	0.62
	75	0.657	0.651	0.91
	100	0.662	0.659	**0.45**

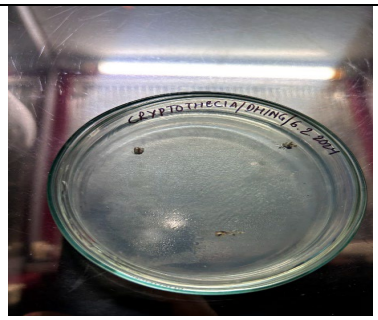
- **Perform calculation:**
- A control= Brooth+ Test organism [Absorbance before adding extract]
- A sample= Brooth+ Test organism+ extracts [Absorbance after adding extract]
- Apply Formula:
  - % Inhibition = [A control – A sample] X100 / A control

➢ PhotoPlate-2: Photographs of Aidentified Lichen Thallus





➢ PhotoPlate-2: Photographs of identified Lichen Thallus

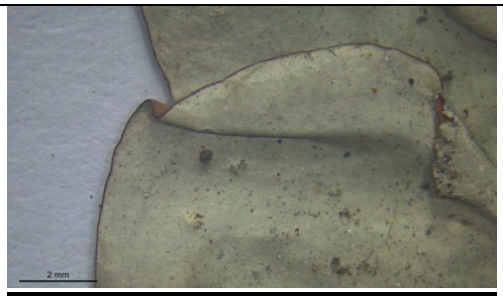


Figure 1: Dorsal surface of thallus of *Parmotrema tinctorum* (Nyl.) Hale

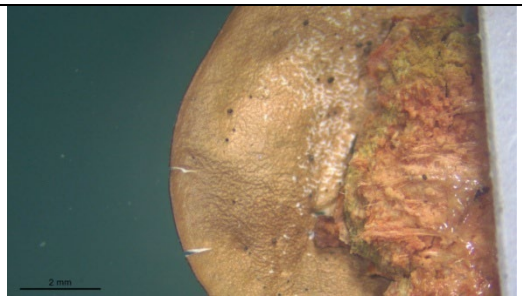


Figure 2: Ventral surface of thallus of *Parmotrema tinctorum* (Nyl.) Hale

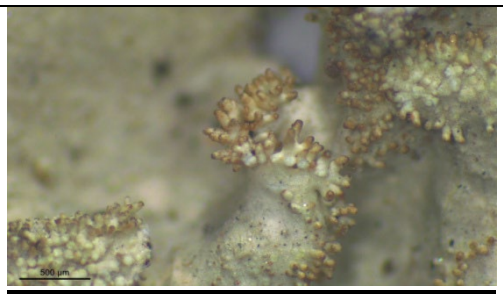


Figure 3: Isidia of *Parmotrema tinctorum* (Nyl.) Hale

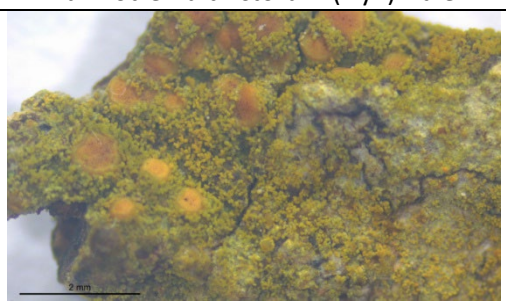


Figure 4: Thallus of *Oxneriopsis bassiae* (Ach.) S.Y. Kondr.Upreti &Hur

Figure 5: Thallus of *Dirinaria aegiliata* (Afzel. Ex Ach.) Moore

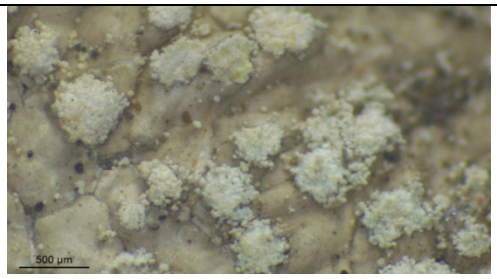


Figure 6: Soralia of *Dirinaria aegiliata* (Afzel. Ex Ach.) Moore

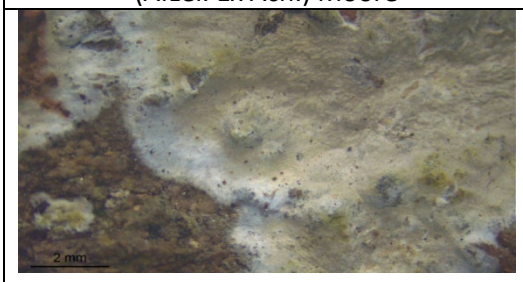


Figure 7: Thallus of *Cryptothecia striata* Thor.

Figure 8: Thallus of *Dirinaria papillulifera* (Nyl.) D.D. Awathi

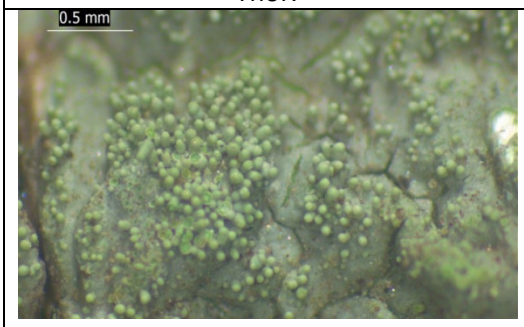


Figure 9: Isidiaof *Dirinaria papillulifera* (Nyl.) D.D. Awathi

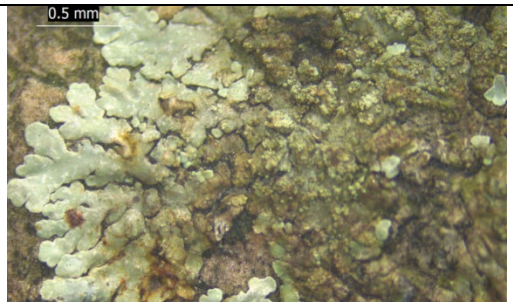


Figure 10: Thallusof *Pyxine subcinerea*Stirton

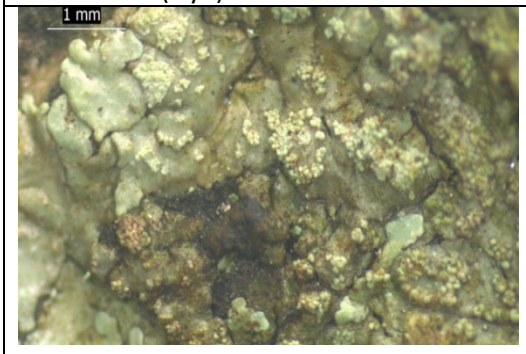


Figure 11: Soraliaof *Pyxine subcinerea* Stirton

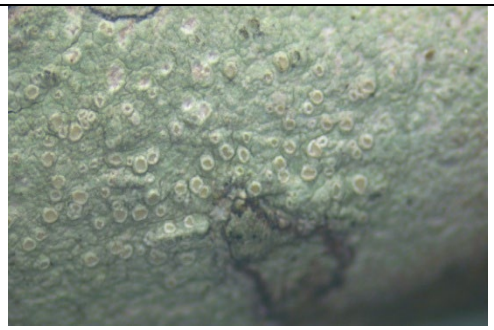


Figure 12: Thallusof *Lecanora achroa* Nyl.

➢ PhotoPlate-3: Photographs of identified Lichen Thallus

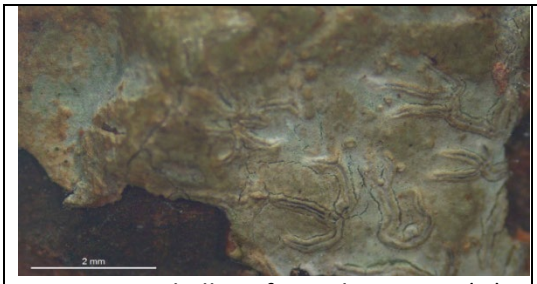


Figure 13: Thallus of *Graphis scripta* (L.) Ach.

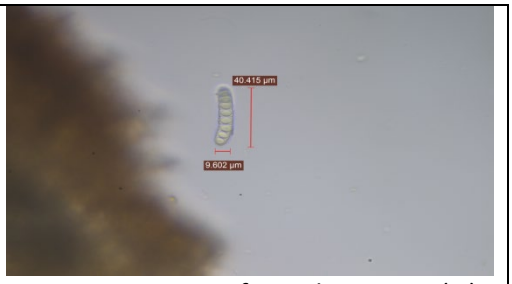


Figure 14: Spore of *Graphis scripta* (L.) Ach.

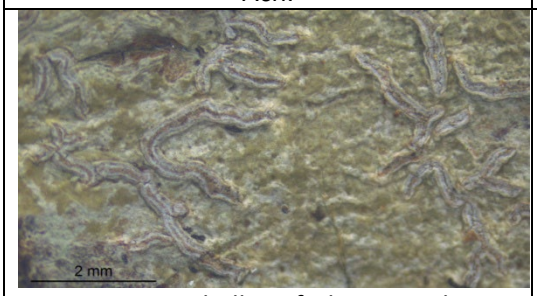


Figure 15: Thallus of *Phaeographis caesioradians* (Leight.) Archer

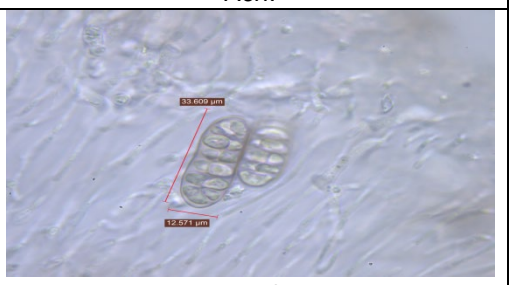


Figure 16: Spore of *Phaeographis caesioradians* (Leight.) Archer

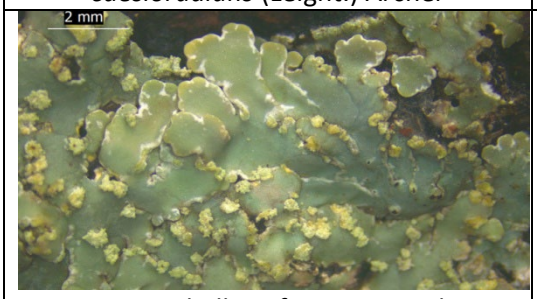


Figure 17: Thallus of *Pyxine sorediata*

Figure 18: Spores of *Pyxine sorediata*

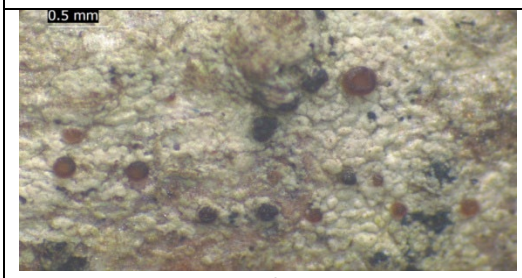


Figure 19: Thallus of *Bacidia connexula* (Nyl.) Zahlbr.

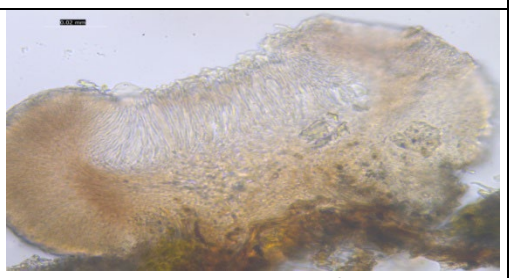


Figure 20: Apothecia of *Bacidia connexula* (Nyl.) Zahlbr

➢ PhotoPlate-4: Photographs of identified Lichen Thallus

Figure 21: Thallus of *Thelotrema* sp.

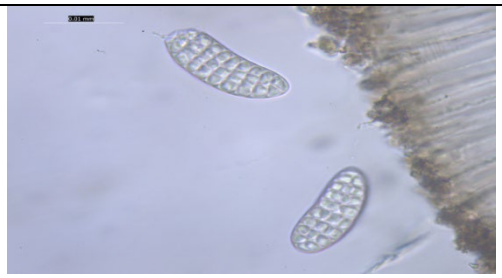


Figure 22: Spores of *Thelotrema* sp.

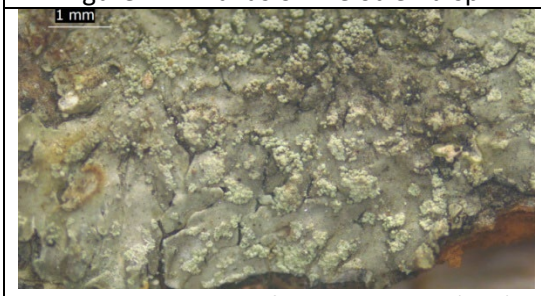


Figure 23: Thallus of *Pyxine cocoes* (Sw.) Nyl.

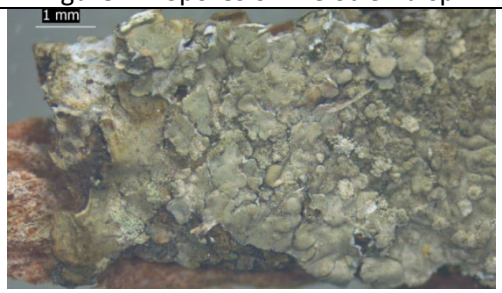


Figure 24: Thallus of *Pyxine reticulate* (Vain.) Vain.

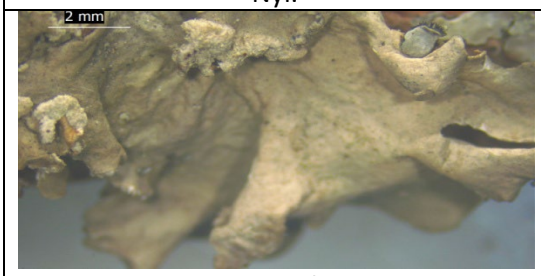


Figure 25: Thallus of *Parmotrema praesorediosum* (Nyl.) Hale

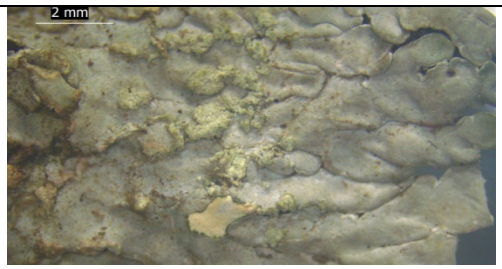


Figure 26: Thallus of *Pyxine farinose* Kashiw.

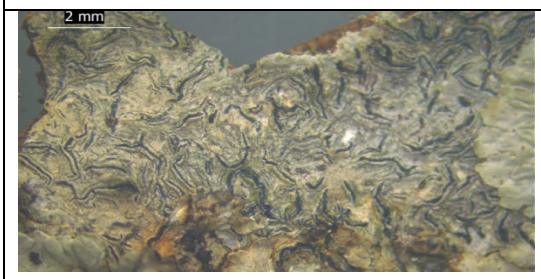


Figure 27: Thallus of *Graphis nigroglauca* Leighton

Figure 28: Spore of *Graphis nigroglauca* Leighton.

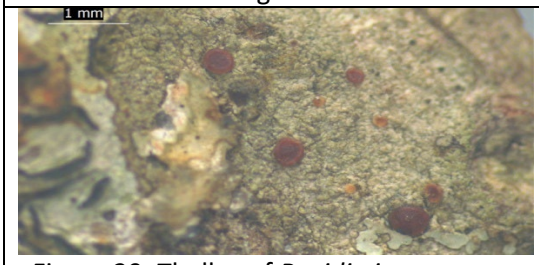


Figure 29: Thallus of *Bacidia incongruens* (Stirton) Zahlbr.

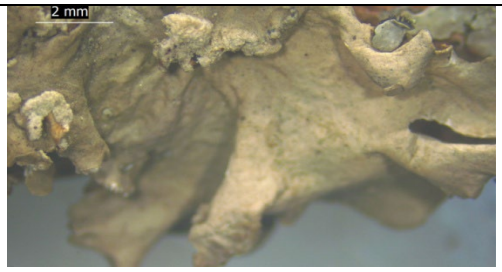


Figure 30: Thallus of *Parmotrema crinitoides* J.C.

➢ PhotoPlate-5: Photographs of identified Lichen Thallus

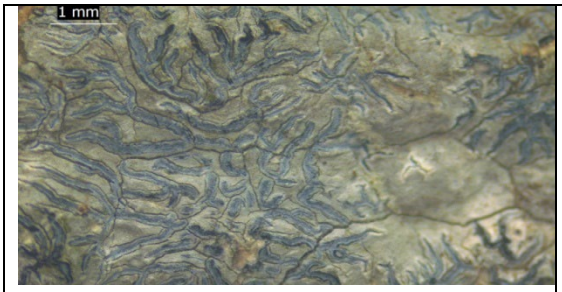


Figure 31: Thallus of *Graphis* sp.

Figure 32: Spore of *Graphis* sp.

Figure 33: Thallus of *Graphina rufopallida* (Vainio) Zahlbr

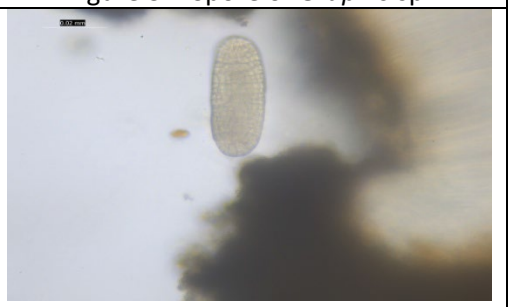


Figure 34: Spore of *Graphina rufopallida* (Vainio) Zahlbr.

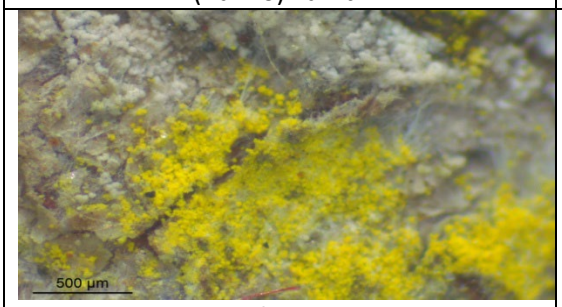


Figure 35: Thallus of *Chrysothrix candelaris* (L.) Laundon

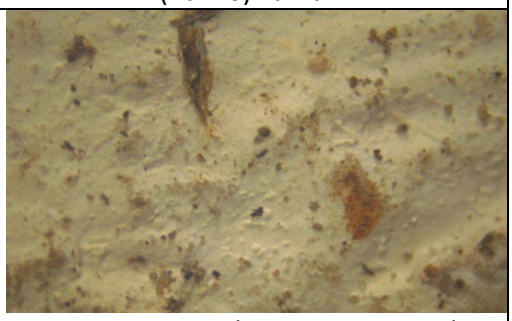
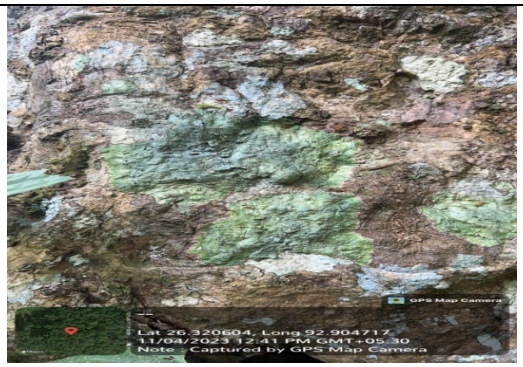
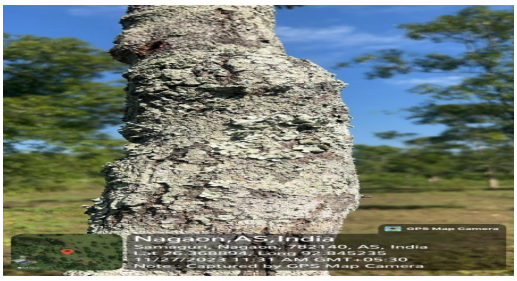


Figure 36: Sample no. 29 is a wood decaying fungus

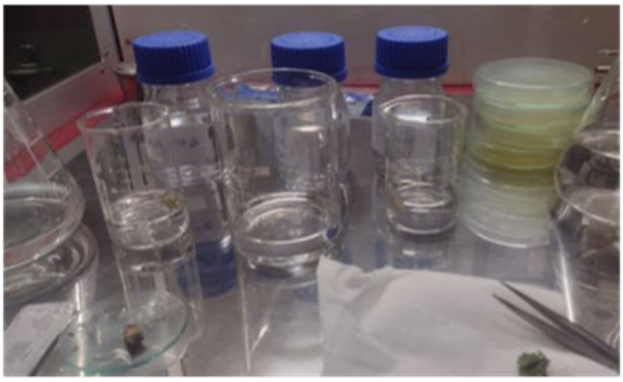
Figure 37: Is a Fruticose Lichen species

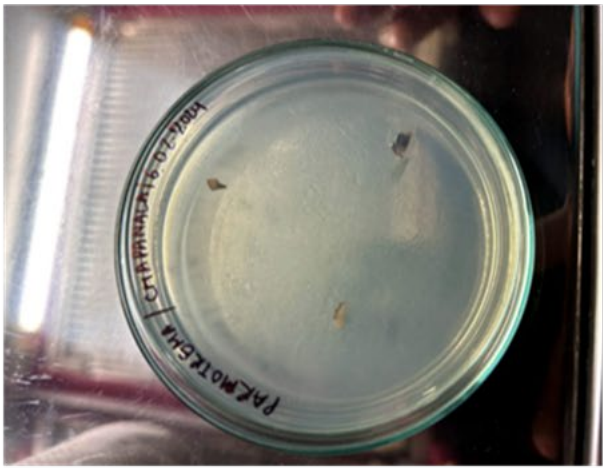
Total identified=29

➢ Photopplate 6: Location wise collection of Lichens

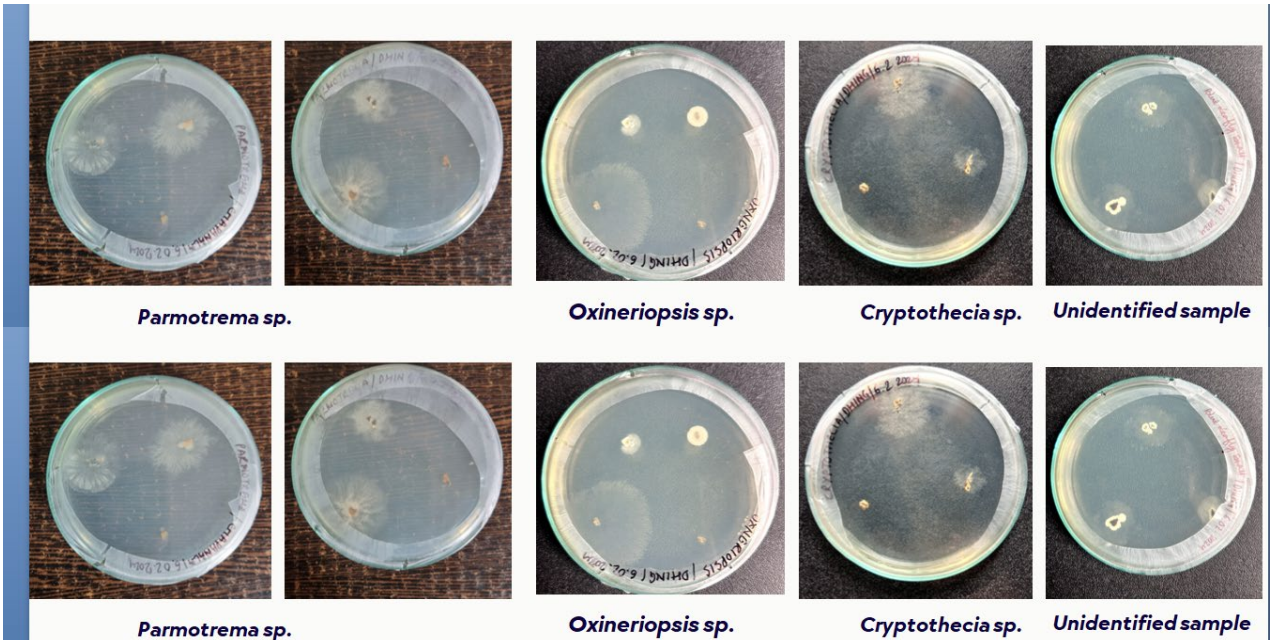
L1		
L2		
L3		
L4&L5		

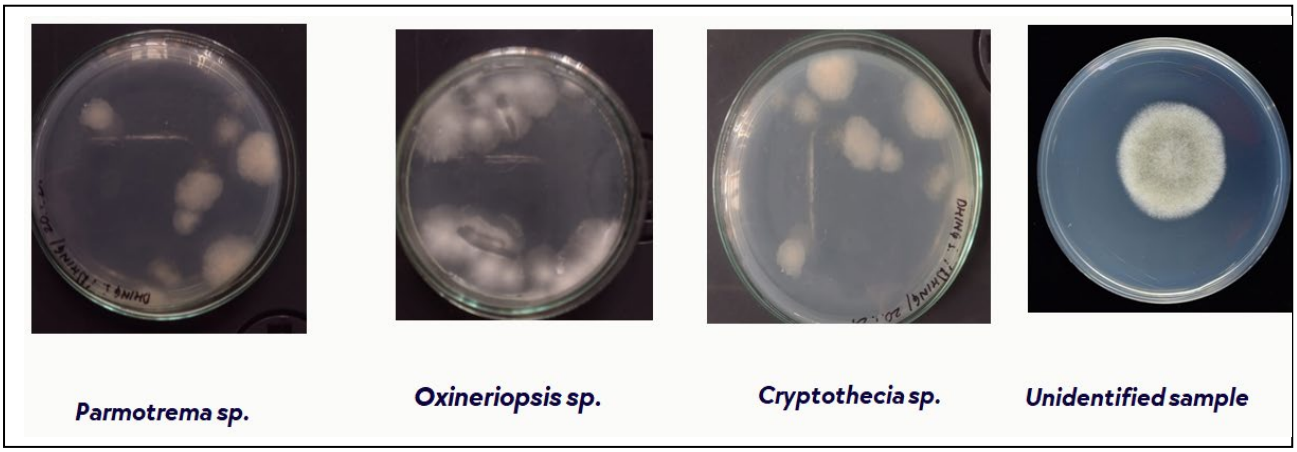
➢ **Photo Plate: 7 Collection and Surface Sterilization of collected Species:**

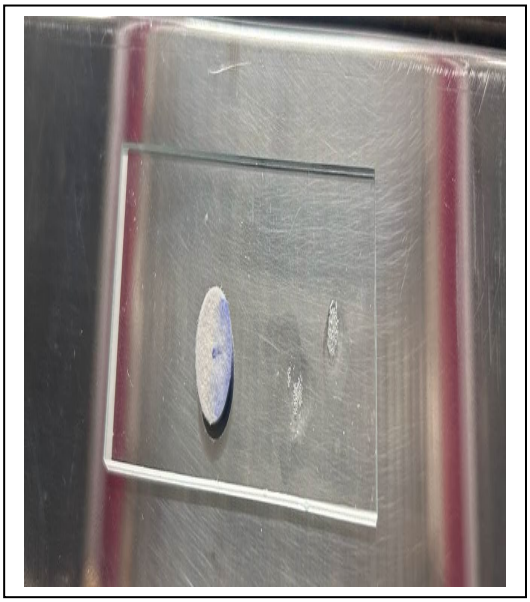




➢ **Photo Plate 8: Surface Sterilization.**







9. CONCLUSIONS SUMMARIZING THE ACHIEVEMENTS:

- A total of 29 lichen species were collected from 5 sampling stations namely Dhing*, Kothiatoli, Nonoi, Podumoni, Chapanala area*. A dominance of *corticolous* lichen was observed during the collection process.
- Corresponding to lichens species about 10 ELF were identified from five sample sations. The highest number of ELF was isolated from genus permotrema and pyxine.
- All the collected samples have been identified with the help of lichenology laboratory of Nowgowng University, Nagaon and ICFRE- Rain Forest Research Institute, Jorhat, Assam.
- The collected samples were surface sterilized*, sporulated endolichens* were isolated by streaking and pure colonies were isolated and stored.
- Biochemical and growth patterns of the endolichens showed similar results. All the ELFs are catalase and oxidase positive.
- Further the antimicrobial activity & MIC of the lichen extracts was evaluated against two bacterial pathogens*, Ralstonia solanacearum (MTCC 13168)* and *Pseudomonas syringae (MTCC 673),* and two fungal pathogens, *Fusarium oxysporum (MTCC 12994)* and *Alternaria alternata (MTCC 13407),* using agar well diffusion assay and recording their Optical Density(OD_{600}) using UV-VIS Spectrophotometer . The highest antibacterial activity and percent(%) inhibition was observed against *R. solanacearum and P. syringae,* with petroleum ether and acetone extracts producing comparatively larger zones of inhibition. In contrast, the fungal pathogens exhibited lower sensitivity to the

lichen extracts. Only weak to moderate inhibition was observed against *F. oxysporum and A. alternata,* irrespective of the solvent used for extraction.

- The comparatively lower inhibition observed against the fungal pathogens may be attributed to differences in cell wall composition and inherent resistance mechanisms.
- The results indicate that the lichen extracts possess promising antibacterial activity, particularly against phytopathogenic bacteria. The variation in antimicrobial activity among the solvent extracts suggests that the extraction efficiency of bioactive secondary metabolites depends on the polarity of the solvent employed.
- To conclude the project has yielded significant insights into the local lichen diversity and the associated endolichenic fungal community leading to the successful isolation and storage of pure colonies for further analysis. To enhance understanding and distinction among various ELFs further study is required paving the way for future potential applications in ecological research and biotechnology.

10. SUMMARY (IN 200 WORDS ONLY):

The findings of this study offer valuable insights into the lichen diversity and endolichenic fungal community in the Nagaon district of Assam. The isolation and taxonomic classification of ELF will laid the foundation for further investigations into the ecological roles and potential applications of these lichens. The successful isolation and storage of pure colonies of sporulated endolichens signify a crucial step towards understanding the endolichenic fungal community associated with these lichens. The consistent positive

delayed catalase and oxidase activity exhibited by all endolichenic fungi (ELFs) suggest metabolic activity indicative of potential symbiotic or parasitic relationships with their lichen hosts. These findings corroborate previous studies highlighting the metabolic diversity of endolichenic fungi and their potential ecological significance.

The study of antimicrobial activity of the lichen extracts evaluated against bacterial and fungal pathogens, is an indicate that the lichen extracts possess promising antibacterial activity, particularly against phytopathogenic bacteria, while exhibiting limited antifungal potential. The variation in antimicrobial activity among the solvent extracts suggests that the extraction efficiency of bioactive secondary metabolites depends on the polarity of the solvent employed. The planned implementation of additional biochemical and molecular tests in future will elucidate the diversity and genetic makeup of the endolichenic fungal community further. These tests will provide valuable insights into the functional roles of ELFs within lichen symbiotic associations and their potential biotechnological applications. Overall, this study contributes to our understanding of lichen diversity and endolichenic fungal communities in the Nagaon district of Assam. The data generated pave the way for future research endeavors aimed at exploring the ecological, evolutionary, and biotechnological significance of these fascinating organisms in natural ecosystems.

11. Any new product/ process developed : **Nil**

12. Any new lead: **Nil**

13. Any technology developed: **Nil**

14. Any patent taken: **Yes**

[01 Design Patent granted and 01 Design patent applied for]

1. Design Patent Certificate: Glass Chamber for Surface Sterilization

पेटेंट कार्यालय, भारत सरकार | The Patent Office, Government Of India
डिज़ाइन के पंजीकरण का प्रमाण पत्र | Certificate of Registration of Design

डिज़ाइन सं. / Design No. : 432610-001
तारीख / Date : 03/10/2024
पारस्परिकता तारीख / Reciprocity Date* :
देश / Country :

प्रमाणित किया जाता है कि संलग्न प्रति में वर्णित डिज़ाइन जो *GLASS CHAMBER FOR SURFACE STERILIZATION* से संबंधित है, का पंजीकरण, क्लास 24-01 में 1.Dr. Sanjeeb Kumar Nath 2. Chandamita Goswami 3.Dr. Monjit Saikia 4.Isha Bodhe 5.Mousumi Terangpi 6.Dr. Monoj Kr. Saikia के नाम में अनुक्रम संख्या और तारीख में अंकित किया गया है।

Certified that the design of which a copy is annexed hereto has been registered as of the number and date given above in class 24-01 in respect of the application of such design to *GLASS CHAMBER FOR SURFACE STERILIZATION* in the name of 1.Dr. Sanjeeb Kumar Nath 2.Chandamita Goswami 3.Dr. Monjit Saikia 4.Isha Bodhe 5.Mousumi Terangpi 6.Dr. Monoj Kr. Saikia.

डिज़ाइन अधिनियम, 2000 तथा डिज़ाइन नियम, 2001 के अध्यधीन प्रावधानों के अनुसरण में।
In pursuance of and subject to the provisions of the Designs Act, 2000 and the Designs Rules, 2001.

जारी करने की तिथि Date of Issue : 10/12/2024

नियंत्रक महा पेटेंट, डिज़ाइन और व्यापार चिह्न
Controller General of Patents, Designs and Trade Marks

2. Patent applied: Portable Herbarium Preservation Chamber for Lichens

FORM 1

Application for Registration of Design

[See section 5 and 44]

You are requested to register the accompanying design in:

Sr.	Class	Sub Class	Articles
1	24-00-Medical and laboratory equipment	24-01-APPARTUS EQUIPMENT FOR DOCTORS, HOSPITALS AND LABORATORIES	PORTABLE HERBARIUM PRESERVATION CHAMBER FOR LICHENS

In the name of :

Sr.	Name	Nationality	Address
1	Dr. Sanjeeb Kumar Nath	India	Co-PI, Advanced Institutional Level Biotech Hub (Phase II) & Associate Professor & HOD, Department of Botany, Dhing College, Dhing, Nagaon, Assam 782123
2	Dr. Monoj Kumar Saikia	India	PI, Advanced Institutional Level Biotech Hub (Phase II) & Rtd Associate Professor Department of Botany, Dhing College, Dhing, Nagaon, Assam 782123
3	Chandamita Goswami	India	Project Associate , Advanced Institutional Level Biotech Hub (Phase II), Dhing College Dhing, Nagaon, Assam 782123
4	Uddhab Talukdar	India	Laboratory Assistant , Department: Advanced Institutional Level Biotech Hub (Phase II), Dhing College, Dhing, Nagaon, Assam 782123
5	Mousumi Terangpi	India	Assistant Professor, Department of Botany, Dhing College, Dhing, Nagaon, Assam 782123

who claim(s) to be the proprietor(s) thereof.

Four exactly similar representations of the design accompanying this request.

The design is to be applied to **PORTABLE HERBARIUM PRESERVATION CHAMBER FOR LICHENS,**

INTELLECTUAL PROPERTY INDIA
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सत्यमेव जयते
GOVERNMENT OF INDIA

Controller General of Patents,Designs and Trademarks
Department of Industrial Policy and Promotion
Ministry of Commerce and Industry

Design Application Details

Application Number:	454312-001
CBR Number:	207280
CBR Date:	04/04/2025 17:57:45
Applicant Name:	**1. Dr. Sanjeeb Kumar Nath** **2. Dr. Monoj Kumar Saikia** **3. Chandamita Goswami** **4. Uddhab Talukdar** **5. Mousumi Terangpi**

Design Application Status

Application Status: Application Under Process(awaiting for Technical Examination)

Back

- **Journal Publication:**

1]. Title: Lichens of Dhing, Nagaon District, Assam

Authors: Sanjeeb Kumar Nath, Manoj Kumar Saikia, Uddhab Talukdar, Mousumi Terangpi

Published in December 2025

Name of Journal: Himalayan Journal of Basic and Applied Sciences (ISSN 3107-9113) Vol. 1, Issue 2 Page 133-138

[An open-access, peer-reviewed Journal]

2]. Applied for Publication on Cryptogam Biodiversity and Assessment. (Receive letter is enclosed)

- **PUBLICATION AND CONFERENCE PRESENTATION**

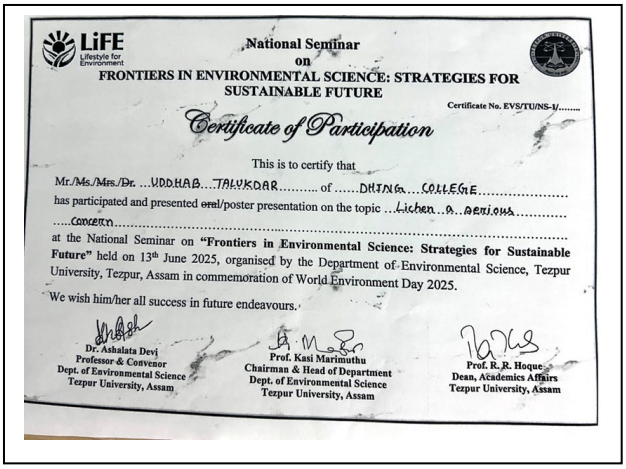
1. Abstract titled “Screening of antimicrobial properties of endolichenic fungi against certain bacterial species” was presented in International conference “International Conference on Plant science & Sustainable Agriculture” organized by SARPS.

2.Abstract titled “Evaluation of Endolichenic Fungi as Antibacterial Agents: Screening for Antibiotic Potential” was presented in International conference “International Conference on Traditional Knowledge Exploring Traditional Knowledge: Bridging Past and Future” organized by Internal Quality Assurance Cell, Nowgong College (Autonomous) In Association with Research and Development Cell (RDC), Nowgong College (Autonomous)

3. Talukdar, U. (2024) “107- Survey of Lichens of Nagaon, Assam”. International Conference on Traditional Knowledge (Exploring Traditional Knowledge: Bridging Past and Future), Zenodo. doi: 10.5281/zenodo.10841908.

4. Goswami, C. (2024) “106- Evaluation of Endolichenic Fungi as Antibacterial Agents: Screening for Antibiotic Potential”. International Conference on Traditional Knowledge (Exploring Traditional Knowledge: Bridging Past and Future), Zenodo. doi: 0.5281/zenodo.10841883x.

Certificates of participation and presentation:



LiFE Lifestyle for Environment

National Seminar
on
FRONTIERS IN ENVIRONMENTAL SCIENCE: STRATEGIES FOR SUSTAINABLE FUTURE

Certificate No. EVS/TU/NS-V/.....

Certificate of Participation

This is to certify that

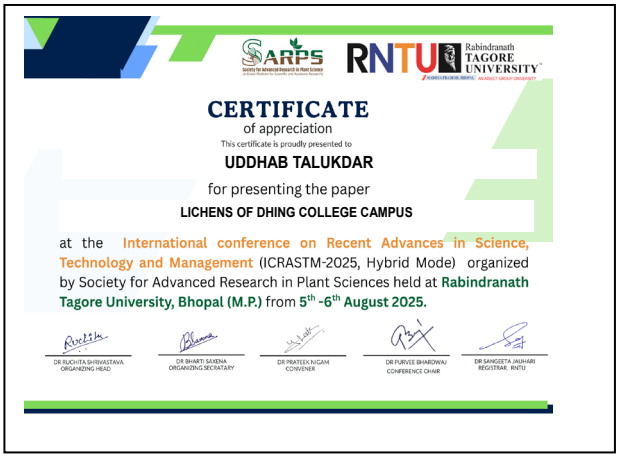
Mr./Ms./Mrs./Dr. ...UDDHAB...TALUKDAR..... of .....DHING...COLLEGE.....
has participated and presented ~~oral~~/poster presentation on the topic ...Lichen...A...serious.....
.....concern.....
at the National Seminar on **"Frontiers in Environmental Science: Strategies for Sustainable Future"** held on 13th June 2025, organised by the Department of Environmental Science, Tezpur University, Tezpur, Assam in commemoration of World Environment Day 2025.

We wish him/her all success in future endeavours.

Dr. Ashalata Devi
Professor & Convenor
Dept. of Environmental Science
Tezpur University, Assam

Prof. Kasi Marimuthu
Chairman & Head of Department
Dept. of Environmental Science
Tezpur University, Assam

Prof. R. R. Hoque
Dean, Academics Affairs
Tezpur University, Assam



SARPS Society for Advanced Research in Plant Science

RNTU Rabindranath TAGORE UNIVERSITY

CERTIFICATE
of appreciation
This certificate is proudly presented to
UDDHAB TALUKDAR
for presenting the paper
LICHENS OF DHING COLLEGE CAMPUS
at the International conference on Recent Advances in Science, Technology and Management (ICRASTM-2025, Hybrid Mode) organized by Society for Advanced Research in Plant Sciences held at Rabindranath Tagore University, Bhopal (M.P.) from 5th -6th August 2025.

DR RUCHITA SHRIVASTAVA ORGANIZING HEAD | DR BHARTI SAXENA ORGANIZING SECRATARY | DR PRATEEK NIGAM CONVENER | DR PURVEE BHAROWAJ CONFERENCE CHAIR | DR SANGEETA JAUHARI REGISTRAR, RNTU

SARPS

CERTIFICATE OF
PRESENTATION

SOCIETY FOR ADVANCED RESEARCH IN PLANT SCIENCE

This certificate is proudly presented to
Ms. Chandamita Goswami
for Presenting the Paper
SCREENING OF ANTIMICROBIAL PROPERTIES OF ENDOLICHENIC FUNGI AGAINST CERTAIN BACTERIAL SPECIES
at the International Conference held at Dubai
INTERNATIONAL CONFERENCE ON PLANT SCIENCE &
SUSTAINABLE AGRICULTURE
(ICPSSA - 2024)
10-11 February, 2024
DUBAI,UAE

Dr. Ruchita Shrivastava
President, SARPS

Dr. Sahab Malik
Convenor, Dubai Conference

ICSSR Sponsored International Conference
On
Traditional Knowledge
(Exploring Traditional Knowledge: Bridging Past and Future)
Date: 22nd & 23rd of March, 2024
Organized by
Internal Quality Assurance Cell (IQAC)
In collaboration with
Research and Development Cell (RDC)
NOWGONG COLLEGE (AUTONOMOUS)
Upgraded to NAGAON UNIVERSITY
Nagaon, Assam- 782001, India

CERTIFICATE OF MERIT

This is to certify that Ms. Chandamita Goswami affiliated with Dhing College has successfully presented the paper titled "Screening of Antimicrobial Properties of Endolichenic Fungi against certain Bacterial Species" at the ICSSR Sponsored International Conference on Traditional Knowledge (Exploring Traditional Knowledge : Bridging Past and Future) held on 22nd and 23rd of March, 2024 at Nowgong College (Autonomous).

The Nowgong College (Autonomous), hereby acknowledges the significant contribution through this presentation to the field of study and scholarly discourse at the conference.

ICSSR Sponsored International Conference
On
Traditional Knowledge
(Exploring Traditional Knowledge: Bridging Past and Future)
Date: 22nd & 23rd of March, 2024
Organized by
Internal Quality Assurance Cell (IQAC)
In collaboration with
Research and Development Cell (RDC)
NOWGONG COLLEGE (AUTONOMOUS)
Upgraded to NAGAON UNIVERSITY
Nagaon, Assam- 782001, India

CERTIFICATE OF MERIT

This is to certify that Uddhab Talukdar affiliated with Dhing College has successfully presented the paper titled "Lichens of Nagaon (Assam)" at the ICSSR Sponsored International Conference on Traditional Knowledge (Exploring Traditional Knowledge : Bridging Past and Future) held on 22nd and 23rd of March, 2024 at Nowgong College (Autonomous).

The Nowgong College (Autonomous), hereby acknowledges the significant contribution through this presentation to the field of study and scholarly discourse at the conference.

EASTERN | Sahari Foundation

INTERNATIONAL CONFERENCE
On Emerging Challenges in Sustainable Development and Environmental Conservation (ICECSDEC 2025) 25TH -27TH May 2025

Certificate

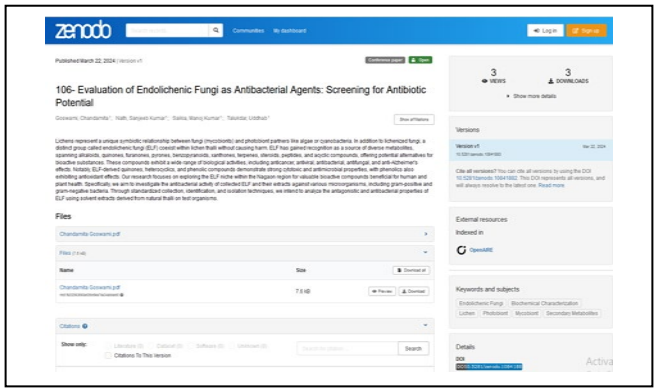
This is to certify that Prof. / Dr. / Mr./Ms. **Uddhab Talukdar, Laboratory Assistant, Biotech Hub, Dhing College**

of **Advanced Institutional Level Biotech Hub Phase II , Dhing College** has successfully Participated/ Presented a paper in the three-day International Conference on **Emerging Challenges in Sustainable Development and Environmental Conservation (ICECSDEC 2025), organized by the Department of Environmental Sciences, Maharaja Ganga Singh University, Bikaner, Rajasthan, India held from 25th to 27th May 2025.**

Prof. Manoj Dixit
Patron, ICECSDEC' 2025
Vice Chancellor, MGSU, Bikaner

Prof. Anil Kumar Chhangani
Chairperson, ICECSDEC' 2025
Head, Dept. of Envt. Science, MGSU, Bikaner

Prof. Mamta Sharma
Org. Secretary, ICECSDEC' 2025
Professor, RR College, Alwar



zenodo

106- Evaluation of Endolichenic Fungi as Antibacterial Agents: Screening for Antibiotic Potential

Files

Chandamita Goswami.pdf

Versions

External resources

Keywords and subjects

Details

16. Financial progress. Viz. equipments purchased, manpower, copies of UCs/SEs of various financial year, etc.

[Enclosed all financial documents]

❑ **List of Enclosers:**

- ✓ 1.UC & SOE [2023-2026]
- ✓ 2.Capital assets certificate [2023-2026]
- ✓ 3.Consolidated Statement of Accounts [2023-2026]
- ✓ 4.Complete Progress report [2023-2026]
- ✓ 5.Format of final completion Report [2023-2026]
- ✓ 6.Target & Achievement for completed report [2023-2026]
- ✓ 7.Objective wise achievement table [2023-2026]
- ✓ 8 Format of manpower and staffing [2023-2026]
- ✓ Letter of retention of equipments.

Sanjeeb Kr. Nath
.....

(Dr. Sanjeeb Kumar Nath CO-PI [PI-In-charge]
(Dr. Manoj Kumar Saikia, PI (Retd)

Coordinator & PI
Biotech Hub
Dhing College

RNeog
.....

(RanjonNeog, Accountant)
UDA cum Accountant
Dhing College
Dhing: Nagaon(Assam)

(Dr. Biman Hazarika)
Principal

Principal
Dhing College