Northeast Microbial Database: a web-based databank of culturable soil microbes from North East India

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Northeast Microbial Database (NEMiD) is a first of its kind digital database on microbial diversity from North East (NE) India, which provides information on culturable microbes (bacteria, fungi and actinomycetes) isolated from soils of the region (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim and parts of North Bengal) distributed across landscape elements (LSE) spread in various ecosystems. The database is based on the primary data through survey, isolation and characterization of the microbes during 2008–2012. Details about a particular microorganism in the database cover aspects of phylogenetic information on taxonomic outline and classification, morphological, biochemical and molecular characterization, general and cultural characteristics, geographical/location information, history of cultures and preservation details. Each microbe is identified based on cultural, biochemical and molecular characteristics leading to its taxonomic position up to the species level along with information on sampling sites comprising altitude, soil type, latitude, longitude, soil temperature, ambient temperature, humidity and soil pH. The database is available on-line at http://mblabnehu.info/nemid/.

Keywords: Digital database, landscape elements, natural ecosystems, soil microbes.

MICROORGANISMS play a vital role in the maintenance of the earth's ecosystems. Microbes have mainly remained unused due to poor documentation. At the global level, databases on microbes that have been developed include Species 2000 and the Integrated Taxonomic Information System (ITIS) collaborative Catalogue of Life (www.gbif.org)[1]. Many Microbe Microarrays Database (M^{3D}) is a resource for analysing and retrieving gene expression data for microbes. MicrobeID.com is an on-line resource for microbiologists, where one can find information related to identification keys, databases, test methods (including images and video), media guides and other useful resources on microbes (http://www.microbeid.com). A database providing comprehensive information about 600 known bacteria living in human mouth can be found at http://homd.org/.

Few fungal databases are available on the World Wide Web and they include; Systematic Botany and Mycology Laboratory (SBML), US Department of Agriculture, Agricultural Research Service, Betsville, Maryland USA (http://nt.ars-grin.gov); MICH Fungal Bioinformatics: A Mycopedia Project at University of Michigan Herbarium, USA (http://www.herb.lsa.umich.edu/bioinformatics.html); Catalog of Rust Types, New York Botanical Garden (http://www.nybg.org.bsci/hcol/rust/pucci1.html); The Pen State Mycological Herbarium, USA (http://www.ma.psu.edu/pacma); and the microbial database of Virginia Bioinformatics Institute (VBI) which hosts data from a range of plant pathogenic oomycetes, fungi and bacteria primarily those under the VBI (http://www.vbi.vt.edu).

In all the above efforts, documentation has been attributed to research in the US. In India, some initiatives have been made, but overall data on Indian microbial diversity are negligible and no microbial documentation has so far been done for North East India. There is paucity of information that links microbes to various ecological systems and their potential uses in our country. In India, the Environmental Information System (ENVIS) Centre, Department of Zoology, University of Madras has developed databases on thematic areas such as reference/abstract database, experts' directory database of microbiologists, bibliographic database and database on research activities on microbes (Ph D thesis, research projects, reports, monographs/manuals). Further, the centre has created a database on the biodiversity of microbes (isolation, habitat, ecological significance), especially marine microbes (http://www.envismadrasuniv.org/index.php). The Department of Biotechnology in Presidency College, Chennai has developed a database on the bioinformatics of antibiotics from microbes and another on vaccines is being developed (http://www.bifcpresidency.tn.gov.in/database.html). The Alagappa University, Karaikudi, Tamil Nadu generated a database for the 16S rRNA sequences of marine bacteria from the Gulf of Mannar for biotechnological prospects (http://www.alagappabiotech.org/biobank/biobank%20index%20page.htm). The Bioinformatics Center of the Institute of Bioresources and Sustainable Development, Imphal is developing a biodiversity database on cyanobacteria of NE India[2].

The present web-based NEMiD database is based on data generated for culturable microbes (Figure 1) from surface and subsurface soils collected across different altitudinal zonations of NE India and parts of North Bengal. The sampling regions were located between 20°N and 32°N lat. and 87°E and 100°E long. and occupy an area of 262,230 sq. km. The database accessible at http://mblabnehu.info/nemid/. Soil samples were collected from different microhabitats, mixed thoroughly to make a composite sample for microbial analysis (Table 1).

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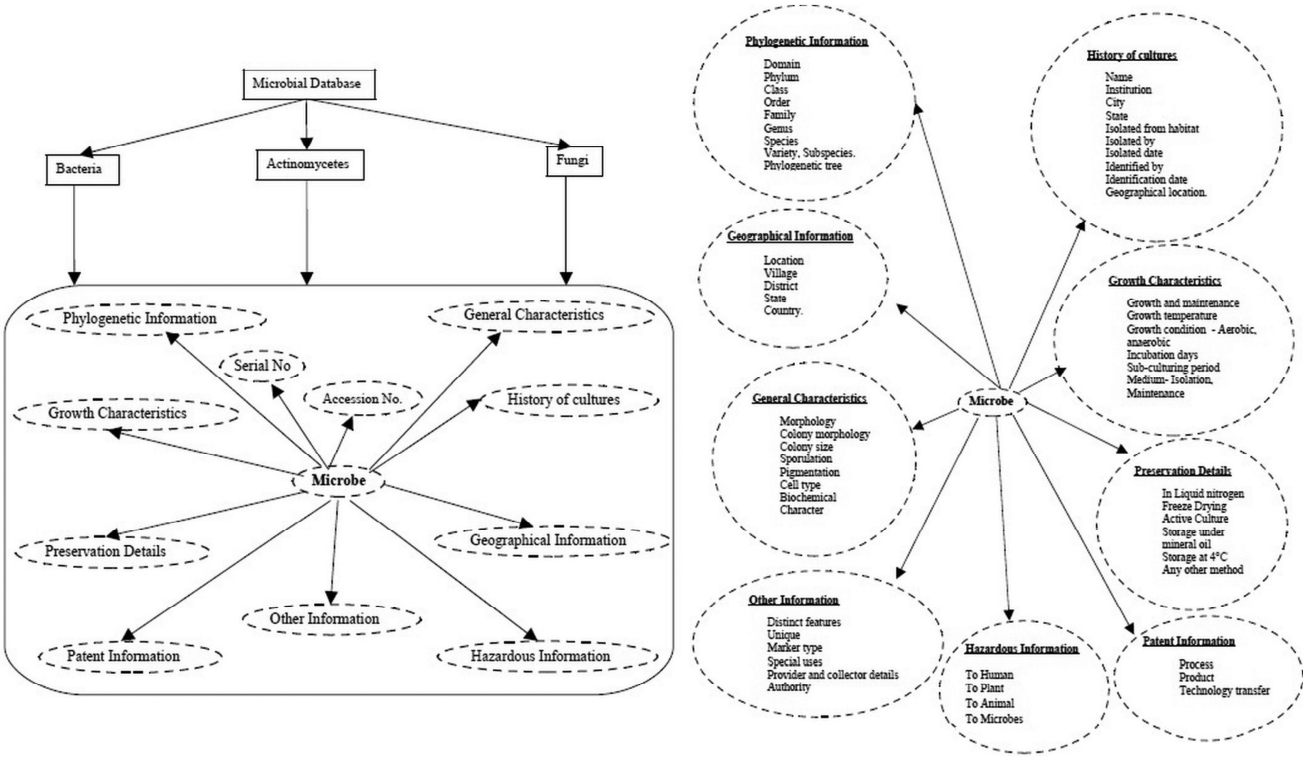

Figure 1. Interface of database parameters.

Table 1. Parameters used for identifying the microbes incorporated in the database

Identification characteristics	Parameters/tests
Morphological	Fungi: Colony morphology, hyphae, asexual spores, sexual spores, reproductive bodies and arrangement of conidia. Bacteria: Cultural characteristics (colour, form, margin, elevation, appearance), Gram-staining. Actinomycetes: Colony characteristics (colour, margin, elevation, presence of substrate/aerial mycelium), staining (simple stain, Gram-stain, acid alcohol fast stain), pleomorphism, endospore detection and motility.
Biochemical	Bacteria: IMViC, catalase, oxidase, amylase, lipase, gelatinase, nitrate reduction, triple sugar iron test, urease, casein hydrolysis, cellulase, protease, H_2S production, N_2 gas production, coagulase test, sugar utilization (mannitol, arabinose, dextrose, sucrose, xylose, rhamnose, lactose, maltose), arginine dihydrolase, phenylalanine deaminase, amino acid decarboxylase (lysine, ornithine), O/F test. Actinomycetes: Allantoinase, nitrate reduction, nitrite reduction, phosphatase, oxidase, urease, indole, Voges–Proskauer, methyl red, catalase, starch hydrolysis, gelatin hydrolysis and casein utilization.
Molecular	Phylogenetic analysis based on 18S rRNA/5.8S rRNA/16S rRNA/ITS/IGS sequences.

Microbial identification is an intensified process to include all the NE states on uniform basis. Various parameters like latitude and longitude, altitude, ambient temperature, humidity, soil temperature, vegetation and soil types were noted for further references (Table 2). The data collection on microbes is an ongoing process carried out uniformly across all the states of NE India and the microbes are incorporated in the database as and when the new isolates are characterized from the sites. The diversity is expected to vary significantly with an increase in the number of samples, which is being documented and updated in the database.

Microorganisms inhabit virtually every niche in the biosphere and they are the most adaptable group of organisms that are able to survive almost all conditions. They form a vast community with a diversity of protozoa, algae, fungi, bacteria and viruses that are associated with all plants and animals, also being responsible for their well-being[3]. Many of them are beneficial to human beings, and are used in health-care products, drug industry, food industry and agriculture[4–8].

Soil is the natural habitat for all organisms involved in important ecological processes. Soils are excellent cultural media for the growth of many types of organisms, including bacteria, fungi, algae, protozoa and viruses. In addition, various nematodes and insects are also present in the soil[9]. A spoonful of soil contains billions of microorganisms. In general, majority of microbial population is found in the upper 12 inches of soil and their number decreases with depth[10]. Majority of bacteria, however, are heterotrophic and utilize large amounts of organic matter. The development of fungi is especially favoured by soils

Table 2. Interface for landscape elements and data search in NEMiD

Landscape elements/ physiographic factors	Latitude, longitude, altitude, relative humidity, ambient temperature, soil temperature, soil pH, soil depth, vegetation type, soil organic content.
Species distribution map	Geographical locations of microbial isolates on the map of North East India using Google Maps.
Isolate details	Classification of the isolates under the domain Actinomycetes, Bacteria, Fungi, which includes parameters like phylogenetic information covering the taxonomic outline and classification, morphological, biochemical and molecular characterization, general and cultural characteristics, geographical/location information, history of cultures, preservation details, hazardous information, patent information, detailed identification, phylogenetic information covering the taxonomic outline, morphological, biochemical and molecular characterization, general and cultural characteristics, geographical/location information, history of cultures, preservation details, hazardous information, patent information.
Score sheet details	State, district, sampling site name, sampling site code, soil temperature, ambient temperature, humidity, moisture content, soil pH, soil depth, soil type, soil texture, vegetation, longitude, latitude, altitude, collection time (IST), collection date, season, nearest village, landmark collector(s).

Figure 2. Snapshot of user interfaces available in the database.

having an acidic reaction and an aerobic condition near the surface. As fungi exist in both the mycelial and spore stages, it is difficult to enumerate them[11,12].

Microorganisms have opened vistas for biotechnological applications and have been explored for the discovery of new pharmaceutical products, synthesis of new enzymes, chemicals and new organisms that carry out novel processes[13]. A study of the biodiversity of microorganisms and their potential applications provides scope for development of new strains through genetically engineered microbes/recombinant DNA technology. These unique combinations may be able to degrade complicated pollutants prevalent in the environment[14].

NEMiD is unique and is specific to the microbial diversity of NE India (Figure 2), which is likely to open avenues for its exploration for human well-being. Further, NE India being one of the mega biodiversity hotspots of the world, has natural ecosystems still prevalent in pristine conditions offering scope for bioprospection of novel organisms hitherto unknown to the scientific world. Further, the sacred groves in this region are rich patches of undisturbed virgin forests and serve as a natural habitat for many endemic, rare and economically valuable species[15]. There have been efforts to document the fauna and flora of the region, but documentation of microbes from the region has been scarce. Therefore, a comprehensive database on microbes of NE India is complementary to the development of such a database at the country level in future. The present database incorporates data on microbes isolated from soil samples collected uniformly from the NE states of India (Figure 3).

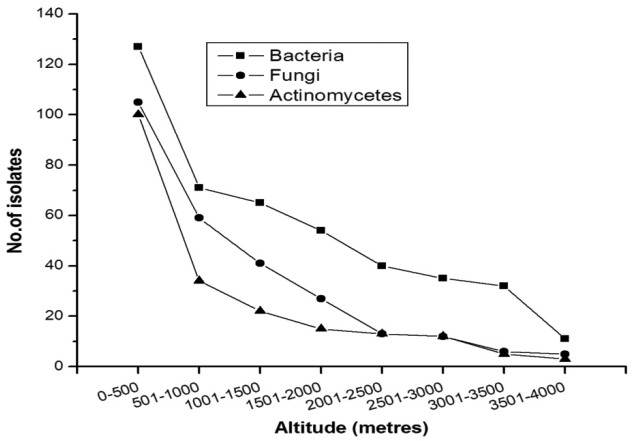

Figure 3. Variation in the number of isolates (bacteria, fungi, actinomycetes) with altitude.

As the enormity of microbial diversity becomes apparent, the dilemma of how to preserve microorganisms and their gene pools asserts itself ever more forcibly[16]. *Ex situ* preservation in culture collections can never be expected to hold more than a small fraction of the genetic diversity of microorganisms. Consequently, *in situ* conservation is as crucial for the protection of microbial diversity as it is for macrobiological diversity, as conserving biodiversity equals conserving ecosystems[17]. In recent years, the frequency of recommended strategies for the conservation of biodiversity has increased swiftly; few, however, pay attention to microorganisms. The characterized microbes are preserved by freezing at –80°C to maintain viability and reuse. Majority of the representative isolates have been deposited at Institute of Bioresources and Sustainable Development (IBSD), Imphal, India.

The occurrence of life forms in a region can be linked to many ecological factors. The factors and habitats in NE India are well known to be decisive in microbial diversity distribution[18–35]. The present database holds data on soil microbes generated through primary data collection undertaken for various niches of NE India. This is an ongoing project and data on additional microbes are being documented and incorporated into the database as and when new isolates are characterized.

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The May 21st, 2014 Bay of Bengal earthquake: implications for intraplate stress regime

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The northeastern part of the Indian Ocean, i.e. the Bay of Bengal (BoB) is located near some of the most complicated tectonic zones on the Earth. An earthquake of magnitude ~6.0 occurred on 21 May 2014 near the coast of Odisha. Occasional moderate to large earthquakes in BoB highlight the need to study precise hypocentre locations, and focal mechanisms to understand the cause of intraplate seismicity in BoB. It is also important for seismic hazard and tsunami risk evaluation along the eastern coast of India. We present an analysis of the digital data of this earthquake recorded by regional and global networks of seismic stations. Our analysis of travel-times of *P*- and *S*-waves indicates that the epicentre of the earthquake is located between the Eighty Five East and Ninety East ridges. The focus of this earthquake was at a depth of ~61 km, well below the lower boundary of the oceanic crust. The focal mechanism determined by modelling long period *P*- and *SH*-waveforms suggest an strike–slip motion along a NW–SE or NEE–SWW-directed fault or fracture. We interpret that the upper part of the BoB lithosphere is abnormally strong and brittle.

Keywords: Earthquake location, focal mechanism, intraplate seismicity, tectonic zones.

THE Indian Ocean is one of the most seismically active oceanic regions where intraplate seismicity is observed frequently[1] (Figure 1). The northeastern part of Indian

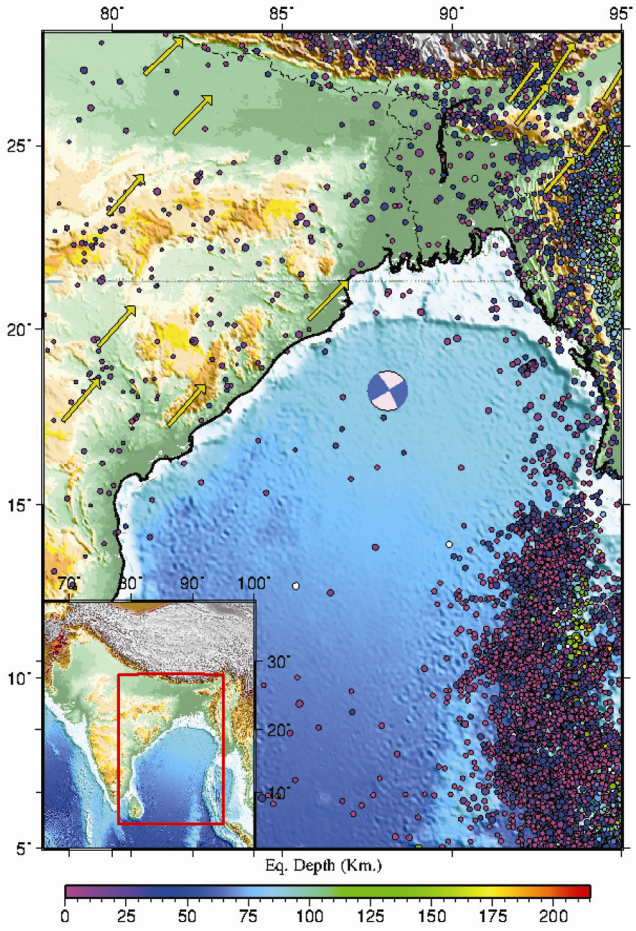

Figure 1. The location map and regional seismicity of the Bay of Bengal. The coloured circles represent earthquakes, where colour and size of a circles correspond to the depth, and magnitude of the earthquakes. Location of the 21 May 2014 earthquake is shown by beachball. Arrows show GPS velocity vectors[33].

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