

## Editorial

### Emerging role of saprobic fungi in human and animal health

Fungi are a versatile group of living heterotrophic, achlorophyllous eukaryotic organisms, which are responsible for many diseases in humans, animals, and plants. It is estimated that about 5 million species of fungi are prevalent in the universe, of which only 600 have been found to be associated with infections in humans and animals. In India, about 27,000 species of fungi are reported by several researchers. Fungi are part and parcel of our environment as are frequently isolated from soil, air, water, and other natural substrates. It is stated that about 25 % of world's cereals (food crops) are contaminated by fungal toxins annually. The loss of animal protein, viz. milk, meat, fish, and egg because of mycotic infections, directly cause great financial losses to the dairy, fish, and poultry industries throughout the world. Fungal diseases are important from public health and economic point of view, and are reported from developed as well as developing nations of the world. As mycotic diseases are not notifiable, the exact data on their prevalence and incidence is grossly inadequate. However, it is presumed that at least 800 million people in world have suffered from one or other types of fungal diseases indicating the growing significance of mycoses in human health. Currently, there are over 600 species of *Aspergillus*, of which 30 are implicated in human and animal infections. There are around 200,000 million cases of invasive aspergillosis each year in the world. Fungal infections can occur in sporadic and epidemic form, resulting in high morbidity and mortality. It is pertinent to mention that 90% of the invasive fungal infections have been encountered in immune compromised patients. The high mortality due to invasive fungal infections is of great concern.

A large number of fungi, such as *Absidia corymbifera*, *Acremonium falciforme*, *A. kiliense*, *Alternaria alternata*, *A. chlamydospora*, *A. tenuissima*, *Aphanoascus fulvescens*, *Apophysomyces elegans*, *Aspergillus candidus*, *A. clavatus*, *A. chevalieri*, *A. deflectus*, *A. flavus*, *A. fumigates*, *A. glaucus*, *A. niger*, *A. ochraceous*, *A. sydowii*, *A. tamarii*, *A. terreus*, *A. ustus*, *A. versicolor*, *A. wentii*, *Aureobasidium pulluans*, *Bipolaris hawaiiensis*, *B. spicifera*, *Blastomyces dermatitidis*, *Chaetomium fumicolium*, *Cladophialophora carionii*, *Coccidioides immitis*, *Cryptococcus neoformans*, *C. gatii*, *Curvularia geniculata*, *C. lunata*, *Exophiala jeanselmei*, *E. rostratum*, *Fonsecaea compacta*, *F. pedrosoi*, *Fusarium moniliformis*, *F. oxysporum*, *F. proliferatum*, *F. solani*, *F. verticillioides*, *Geotrichum candidum*, *Helminthosporium spiciferum*, *Histoplasma capsulatum*, *Madurella grisea*, *M. mycetomatis*, *Microsporium gypseum*, *Mucor circinelloides*, *Paecilomyces lilacinus*, *P. variotii*, *Paracoccidioides brasiliensis*, *Penicillium citrinum*, *Phaeoannellomyces elegans*, *P. werneckii*, *Philophora bubakii*, *P. parasitica*, *P. repens*, *P. richardsiae*, *P. verrucosa*, *Phoma hiberica*, *P. upyrena*, *Pesudoallescheria boydii*, *Rhinocladiella aquaspera*, *Rhizomucor pusillus*, *Rhizopus arrhizus*, *R. microsporus*, *Rhodotorula glutinis*, *Saksenaia vasiformis*, *Sarcinomyces phaemuriformis*, *Schizophyllum commune*, *Scopulariopsis brevicaulis*, *Scytalidium dimidiatum*, *S. hyalinum*, *Trichophyton verrucosum*, *Trichosporon beigilii*, *Ulocladium chartarum*, *Veronaea botryose*, *Verticillium serraе*, *Wangiella dermatitis*, and *Xylohypha emmonsii* are from recovered from many sources, such as soil, litter, bat guano, pigeon droppings, avian excreta, manure, sewage, maize, wheat, oat, rice, pea, cottonseed, potato, onion, tomato, cucumber, sugarcane, sorghum, groundnut seed, soybean, apple, banana, orange, grape, milk, bread, paper, leather, hay, straw, rye grass, and wood etc. Fungi are cosmopolitan in distribution, and may enter the susceptible host by inhalation of infectious fungal cells/conidia through respiratory tract. Traumatic implantation of the fungus into the skin results in infection to the host. Occasionally, ingestion of fungi in contaminated foods may also cause infection. Fungus can affect any organ of the body, such as skin, nail, ear, eye, sinus, mouth, lung, heart, kidney, brain, and bone. The fungi can cause infections in immune competent as well as immune compromised persons. Many species of *Alternaria*, *Aspergillus*, *Fusarium* are known plant pathogen and can also produce disease in humans and animals including birds. It is recommended to study the impact of saprobic fungi on the health of humans, animals, and plants.

Fungi can be cultured from diverse types of samples on several mycological media, such as Sabouraud dextrose agar, potato dextrose agar, oat meal agar, Pal sunflower seed medium (pulverized sunflower seed 4.5 g, agar 2 g, chloramphenicol 10 mg, distilled water 100 ml) (Pal, 1980), APRM (Anubha, PratiBha, Raj, Mahendra) medium (Dried Mary gold flower 4.0 g, agar 2.0 g, chloramphenicol 50 mg, distilled water 100 ml) (Dave and Pal, 2015). The morphology of fungal isolates can be easily studied in *Narayan* stain developed by Pal in 1998. It contained

0.5 ml of methylene blue (3 % aqueous solution), 6 ml of dimethyl sulfoxide, and 4 ml of glycerine. The gross cultural and microscopic morphology help in the identification of fungi. It is recommended that Pal sunflower seed agar, APRM medium, and *Narayan* stain, which are simple to prepare and less expensive than other media and stains, should be routinely used in public health and microbiology laboratories for the study of fungi, which are implicated in human and animal mycoses. The development of safe, potent, and cheap chemotherapeutic agents are imperative for the management of mycoses, which cause life threatening diseases in humans and animals. Further work on the ecological niche, pathogenesis, molecular epidemiology, and diagnostics will be rewarding. It is emphasized to build a group of enthusiastic and devoted scientists who are willing to promote education, teaching, and research in fungal diseases. As Medical and Veterinary Mycology in many developing countries including India is still a tip of ice berg, there is an urgent need to undertake comprehensive and systematic studies to elucidate the growing role of saprobic fungi in various clinical disorders of humans and animals.

**Prof. Mahendra Pal**

Narayan Consultancy on  
Veterinary Public Health and Microbiology,  
Anand, Gujarat  
([palmahendra2@gmail.com](mailto:palmahendra2@gmail.com))

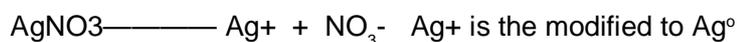
## Fungal Marvels 3. Fungi and Nanotechnology

**Nanoscience** is concerned with science at the scale 1-100 nanometers – larger than atoms or molecules – but still very small objects. Things this small have unusual properties. Nanotechnology is the study of synthesis, properties and application of nanoparticles that can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. In recent time Nanoparticles are widely used in various fields such as electronics, cosmetics, biomedical, and biotechnology. Basically, four types of nanoparticles have been synthesized: Carbon Based Materials, Metal Based Materials, Dendrimers and Composites. The large surface-to-volume ratio of nanoparticles, their ability to easily interact with other particles, and several other features make them attractive tools in scientific research.

Nanoparticles can be synthesized by physical methods such as attrition, pyrolysis, and using some wet chemical methods. The physical and chemical methods have serious drawbacks such as high cost of production; require high energy input and generation of toxic by-products. To overcome this, several biological methods are employed in the synthesis of nanoparticles. The biological methods are generally cost effective, nontoxic, and ecofriendly. Of the biological methods (plant, algae, bacteria and fungi including yeasts), **yeast and filamentous fungi are most useful because they are most cost effective and majority of them produce and secrete the nanoparticles extracellular and therefore easier for isolation and purification.** Filamentous fungi are preferred because they grow in the form of mycelial mesh which helps them to bear flow pressure and agitation and other conditions to which microbes are subjected to in a bioreactor used for large scale production.

Of all the nanoparticles silver nanoparticles (AgNP) and gold nanoparticles (AuNP) are of great interest to science for their multifarious application in molecular biology and biotechnology. Fungus produced AgNPs are now used as antibacterial, antifungal, antiviral, anti-inflammatory, anti-angiogenic, and anti-cancer agents. A large number of fungi are now used for synthesis of AgNPs in the lab. and industry. Different species of genera like *Trichoderma*, *Fusarium*, *Aspergillus*, *Penicillium*, *Rhizoctonia*, *Pleurotus*, *Phoma* produce AgNPs extracellularly, while *Verticillium* sp. And *Neurospora crassa* produce intracellularly. Different species of *Verticillium*, *Neurospora*, *Aspergillus* and yeasts produce AuNPs extracellularly.

The basic principle is that many fungi when exposed to metal salts such as  $\text{AgNO}_3$  or  $\text{AuCl}_4^-$  produce extracellular nitrate or nitrite reductase enzyme and other reducing substances like naphthaquinone and anthraquinone. The reductase enzyme causes ionization of  $\text{AgNO}_3$  as shown below:



The nutrient broth for culturing the fungus is supplemented with  $\text{AgNO}_3$  for AgNPs and with  $\text{AuCl}_4^-$  for AuNPs. Since the useful application of NPs is dependent on their size shape and stability, and NPs produced by different fungi are diversely variable, **many more fungi are to be tested for the production of newer and more useful NPs of different types.** Uncontrolled use of Ag NPs in biomedicine may lead to severe toxicity to humans and animals. Nanoparticles of Cd, Pb, Hg, and Ti, however, are highly toxic and harmful for animals, especially mammals and plants. (Bioterrorism with NPs should be under deep surveillance system, especially unrestricted production of NPs in unlicensed production centers if any.)