Extrinsic allergic alveolitis-causing actinomycetes in indoor and farm environments

Suspended airborne particles, of biological origin, can constitute bioaerosols\(^1,2\) and they can be of different origin ranging from farm environments dealing with hay, sugar cane, tobacco, mushroom and cotton to refuse disposal sites to military equipment test chambers. These bioaerosols might carry allergenic and pathogenic agents like viruses, spore forming bacteria and fungi, excreta of insects and mites, moss and fern spores, algal and plant cells; enzymes, antibiotics, endotoxins, mycotoxins and fungal glucans\(^1\). Although infections from pathogenic viruses, bacteria and fungi may occur in these work environments the commonly reported symptoms relate to allergic rhinitis and asthma, allergic alveolitis (granulomatons pneumonitis) or organic dust toxic syndrome (inhalation fever or toxic pneumonitis)\(^1,2\). This article will only provide an overview on the non-infectious lung diseases resulting from long-term exposure to the spores of thermoactinomycetes of the order Bacillales and thermophilic actinomycetes of the order Actinomycetales in indoor and farm environments.

Early reports on the above-mentioned non-infectious diseases resulting from the allergenic and/or immunotoxic properties of airborne biological agents dates to 1877 by the recognition of byssinosis (brown-lung disease) associated with cotton, hemp and flax farming\(^3,4\). The cause of this disease has later been associated with the exposure to endotoxins from Gram-negative bacteria in 1981\(^5\). Another similar disease, the Farmer’s Lung Disease was linked to ‘white dust arising from mouldy hay’ in 1932\(^6\) and the causative agent was only identified in 1963 as the airborne spores of actinomycetes\(^7\). Since then such diseases have been frequently reported from many different countries including Finland, Germany, Poland, Switzerland, Sweden, India, Canada, Argentina and Costa Rica due to the storage of substrates prone to infestations by spore forming and Gram-positive bacteria (e.g. farm environments, mills and compost facilities)\(^8-13\). These diseases can be more prevalent in tropical and sub-tropical environments where thermophilic actinomycetes and fungi thrive due to elevated temperatures and humidity. Farmer’s lung is also highly prevalent in regions with high rainfall, such as Doubs, France, during the haymaking season\(^14\).

In this article causative bacterial genera or species associated with the above-listed diseases and belonging to the order Actinomycetales (http://www.bacterio.net/actinomycetales.html) will be termed as thermophilic actinomycetes, whereas the ones belonging to the family of Thermoactinomycetaceae of the order Bacillales (http://www.bacterio.net/thermoactinomycetaceae.html) will be termed as thermoactinomycetes covering the 21 genera currently listed under this family, including Thermoactinomyces, Laceyella, Seinonella and Thermo flavimicrobium.

Genera of the thermophilic actinomycetes implicated in hypersensitivity pneumonitis or extrinsic allergic alveolitis (EAA)\(^15\) include Faenia, Streptomyces, Thermomonospora, Saccharopolyspora, Saccharomonospora and Nocardiosis. Thermophilic members of these actinomycete genera are capable of growth at elevated temperatures due to diploniconic acid containing spores that are responsible for their survival at elevated temperatures. Whereas, genera belonging to thermoactinomycetes produce highly heat-resistant endospores\(^7\) and such spores can easily be disseminated through bioaerosols\(^1,2,13,16\), Thermoactinomyces species can survive in organic materials, such as soil, for up to 100 years as well as at 100°C for 30–40 minutes. Improper storage of large bales of
organic substrates (in airtight buildings) when temperatures reach 50–60°C with a moisture content of >30% can result in the growth and proliferation of endospore forming thermoactinomycetes. Thermoactinomyces species were reported to infest home humidifiers and buildings where humid conditions may be present. Thermoactinomyces vulgaris and Thermoactinomyces intermedius were isolated from hot water and heating systems of homes and Thermoactinomyces vulgaris from the household air. Thermophilic actinomycetes are also reported to occur in the condensate of refrigerators and air conditioners.

The above-mentioned non-infectious lung diseases associated with different occupational environments are termed accordingly: farmer’s lung disease, mushroom worker’s lung disease and hagassosis (sugarcane mills/farms) and their occurrence may differ in work places but present with similar symptoms that include cough, fever, malaise, weight loss, chills and shortness of breath. Eye and nose irritation may also be experienced. Susceptible workers that are exposed to the organic dust clouds from disrupted overheated materials, due to storage rooms with inadequate ventilation, may be at risk of acquiring the acute, subacute or chronic form of extrinsic allergic alveolitis. The different forms of the disease (acute, subacute or chronic) depend on the exposure concentrations of these bacteria and length of the exposure time. Workers may inhale anywhere between 500,000 to 750,000 spores per minute during a concentrated exposure and this may ultimately lead to pulmonary inflammation. Extrinsic allergic alveolitis is a T-lymphocyte dependent granulomatous inflammatory reaction of the alveoli of the lungs. Although a clear dose-response relationship for extrinsic allergic alveolitis and concentration of thermoactinomycetes and thermophilic actinomycetes is yet to be determined symptoms increase in a dose-dependent way.

Hypersensitivity pneumonitis has also been described in highly sensitised animals. When animal feed, made up of hay and grain, becomes damp in environments with elevated temperatures (e.g. in a storage unit that may not be completely isolated from rain or other water entry), thermoactinomycete spore concentrations increase thus putting the animals at risk of inhaling antigens of Thermoactinomyces species. Cattle have been known to develop hypersensitivity pneumonitis during the winter period when they are confined to their stables. Growth of Thermoactinomyces species occurs in their feed and other organic material resulting in inhalation of high concentrations of spores. Hypersensitivity pneumonitis may also develop when cattle are moved from a dry stable to lush pastures at the end of summer, where these bacteria may be present. When cattle eat feed containing thermoactinomycetes they excrete viable spores that are spread on fields and within soil that can remain there for many years until suitable germination conditions arise.

So far, the limited research that has been done in Australia has mixed results. A report by McNeill around Queensland sugar mills...
These preventative measures are essential for the maintenance of healthy farm environments via ensuring the elimination of EAA causing bacteria.

References


Biographies
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Mixed community biofilms and microbially influenced corrosion

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Metals are used in most marine infrastructures for energy extraction and production. Metal corrosion is a serious concern, due to the environmental, safety, and replacement costs associated with it. Microbially influenced corrosion (MIC) contributes to the overall corrosion process, through several chemical, electrochemical and biochemical...