

Health problems caused by actinomycetes and moulds in the industrial environment

LARS BELIN

Astma- och allergisektionen, Med klin I, Sahlgrenska sjukhuset, S-413 45 Göteborg, Sweden

Inhalation of low doses of allergenic non-pathogenic microbes particularly moulds can produce IgE responses in atopic hosts. High doses of these allergens will stimulate an IgG response and a lymphocyte response, resulting in an immunopathological reactivity in which combined type-III and type-IV reactions interact without requirement for this atopic hostfactor. Clinically

allergic asthma and allergic alveolitis are the disease expressions of these immunopathological mechanisms.

Inhalation of high concentrations of non pathogenic microbial dust occurs in certain occupational environments. Consequently allergic alveolitis (AA) is often an occupational disorder (table I). The etiologic microbes are opportunistic, saprophytic moulds

Table I
Examples of allergic alveolitis.

Sources of antigen	Environmental exposure	Disease
Micropolyspora faeni Thermoactinomyces vulgaris, other thermophilic actinomycetes and moulds	Mouldy hay	Farmer's lung
T vulgaris	Mouldy sugar cane	Bagassosis
Avian proteins	Bird droppings or dusts	Bird fancier's lung
M faeni, T vulgaris	Mushroom dust	Mushroom worker's lung
Cryptostroma corticale	Mouldy maple bark	Maple bark stripper's disease
M faeni, T vulgaris, Penicillium frequentans	Oak bark, cork dust	Suberosis
Complex microbial flora incl. bacteria, moulds, Thermophilic actinomycetes and amoebas	Humidifiers, air con- ditioners	Humidifier and air conditioner pneumonitis
Aspergillus fumigatus, A clavatus	Mouldy malt	Malt worker's lung
Alternaria	Mouldy logs	Wood pulp worker's lung
Rhizopus, Paecilomyces, Asp. fum.	Mouldy wood	Wood trimmer's disease
Asp. fum. and other moulds	Mouldy wood chips	Wood chip burning disease

COMPOST REACTION

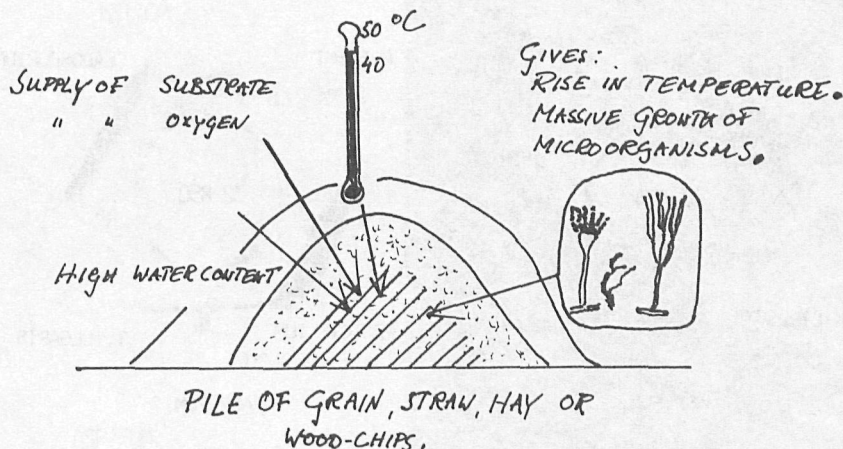


Fig. 1. Schematic drawing of a compost reaction.

and actinomycetes. They are ubiquitous and normal participants of many common ecological systems. When supplied with the proper nutrients (substrate), water, suitable temperatures pH and O_2 they will grow rapidly. Excellent growth conditions for these organisms are often found in farming and forestry.

FARMING

Hay straw and grain are excellent substrates for microbes. Only under very dry conditions will these materials stay free of microbial growth. Stacking or piling will prevent drying and in a short time a wet pile of hay can be overseeded by so many microbes that a compost reaction starts with considerable heat production. Fast-growing moulds like *Aspergillus* species, actinomycetes such as *M. faeni*, *T. vulgaris* and *Streptomyces* species will finally dominate the microbial population in such compost piles. They may generate an abundance of spores (fig 1). Before this stage is reached several other types of moulds may also have produced significant amounts of spores into the air.

The prevailing microorganisms are related to the particular farming habits and can be evaluated by an immunodiffusion analysis. As seen in fig 2 Icelandic farmers mostly produce precipitating antibodies to the classical Farmer's lung antigen *M. faeni*, while the antibodies of Swedish farmers usually are directed against a number of mould species. In Finland *Thermoactinomyces vulgaris* seems to be the main Farmer's lung antigen (1) and microbiological air analyses have clearly revealed higher spore levels in farms where AA have occurred than in farms without such cases.

Severely mouldaffected grain has generated the highest concentrations ($>10^{10}$) according to the experience of Malmberg and Palmgren from a recent study in Sweden. They have chosen to sample air on nucleopore filters and then to count the microbes with an epifluorescence microscope after staining with acridine orange. Mouldy hay and grain are the main sources of microbial air pollution in a farm and table II shows the very high levels that have been noted in Swedish farms when farmers have handled such material (2).

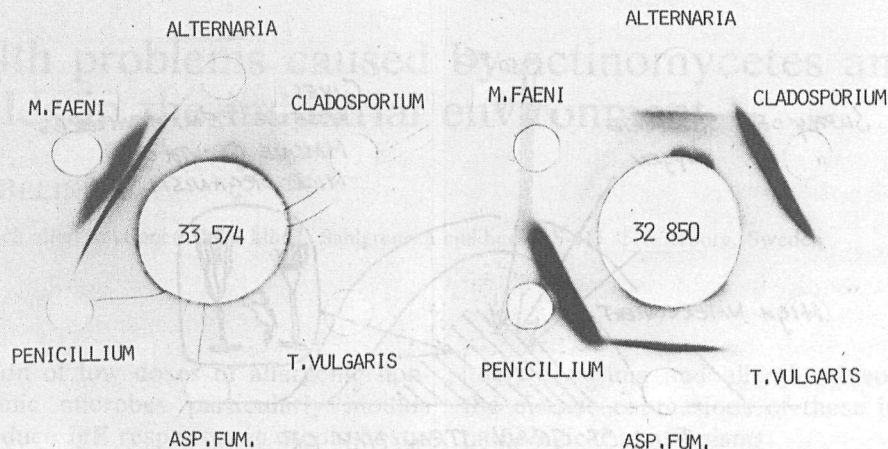


Fig. 2. Results of immunodiffusion analysis of serum from an Icelandic farmer (left) and a Swedish farmer (right) suffering from AA.

FOREST INDUSTRY

Wood also furnishes attractive nutrition to moulds. As an acute form of AA we have frequently recognized in Swedish sawmill workers over the last 15 years, repeated attacks of chills, fever, malaise, cough and dyspnea. A survey in 1976–78 revealed that in 10 out of 17 Swedish sawmills about 50 % of the wood trimmers had precipitating antibodies, mainly to *Rhizopus* antigens, and 10–20 % had suffered the symptoms given above (3). Usually the affected wood trimmer displays symptoms in the afternoon on days when he has trimmed or sorted planks which have been subjected to an unusually intense superficial mould growth in the

kilns where the wood material has been artificially dried (fig 3).

In order to study these exposures, continuous air monitoring by means of a Burkard spore trap (fig 4) have been carried out in trimming departments. By direct microscopy, culturing and protein staining of the trapped dust, we have confirmed that the exposure to the organic mould material is clearly intermittent with wide peak variations during the work day and between workdays. Air samples collected on Millipore filters over 2–4 hours have revealed average values from 10^6 to 10^9 colony forming units of *Rhizopus*, *Paecilomyces* and *Aspergillus* species/ m^3 in the trimming units with significant occurrence of this disorder. Recently a dust sample which consisted almost entirely of spores was removed from one of these departments and the number of spores amounted to 10^7 /mg of the dust.

Table II

Microbial air pollution in farming. Numbers of spores per m^3 as collected on Nucleopore filters are given. Data kindly provided by dr Urban Palmqvist and dr Per Malmberg (3).

Material	Grain	Hay
Severely affected	10^{10}	10^9
Moderate damage	10^9	10^8
Normal material	10^{7-8}	10^7

ARTIFICIALLY HUMIDIFIED INDUSTRIES

Artificial indoor humidification is another industrial development that has caused mi-

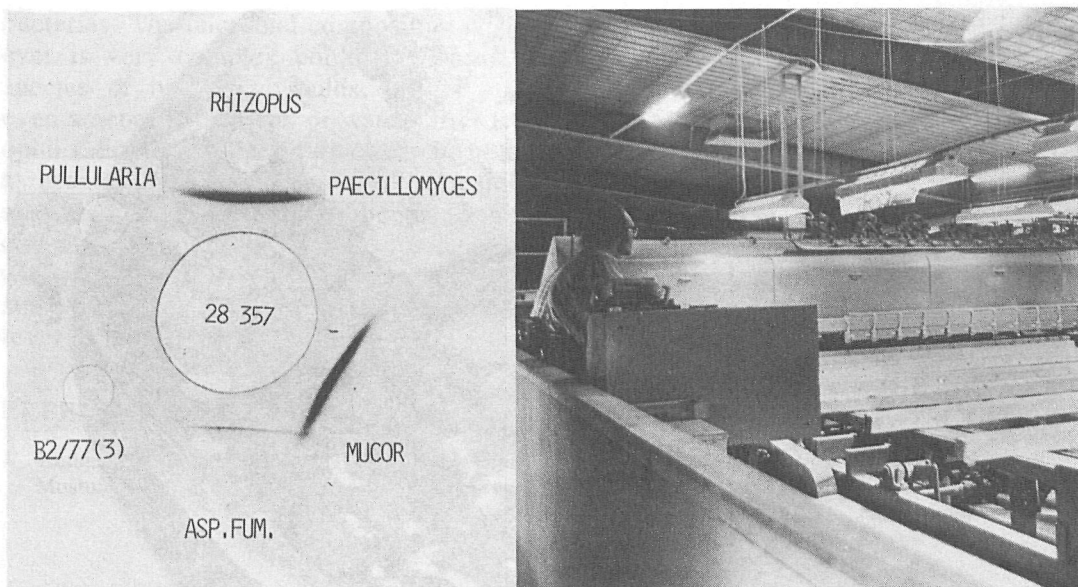


Fig. 3. An immunodiffusion analysis (left) showing precipitating antibodies to *Rhizopus* and *Mucor* antigens in the serum of a wood trimmer exposed to these mould species in his job (right).

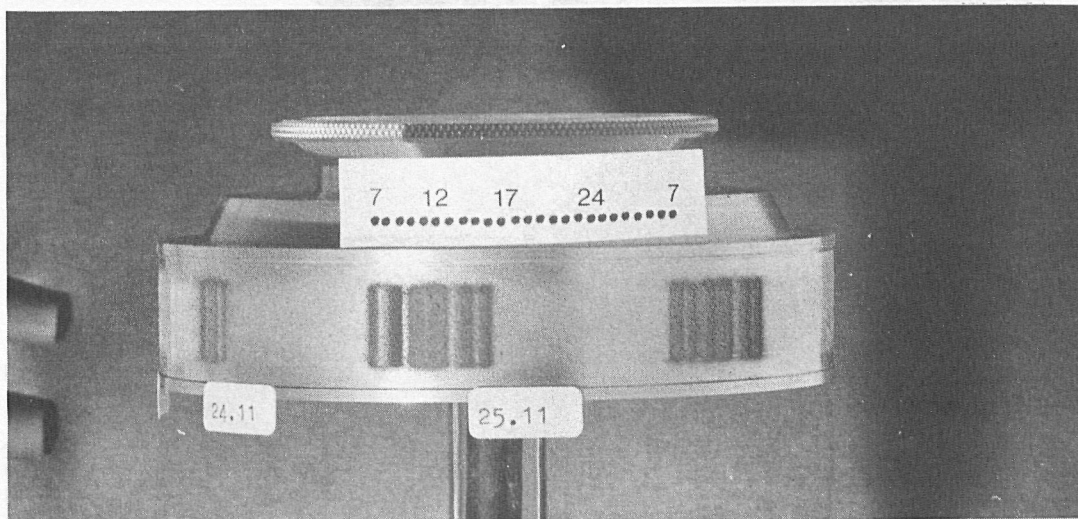


Fig. 4. Airborn dust deposits from a trimming department sampled continuously on sticky tape of a Bukard pollen and spor trap.

crobial health problems in some industries, particularly the printing industry. These mechanical humidifiers can easily be infected by microbes if they are designed with water containers where water is intermittently stagnant (fig 6, 7). Humidifier fever

disease has been recognized in several countries including Sweden, (4) but it is uncertain if the reaction to these aerosolized microbes is caused by an immunological reaction or by an endotoxin action (5), since many of the microbes are gram negative

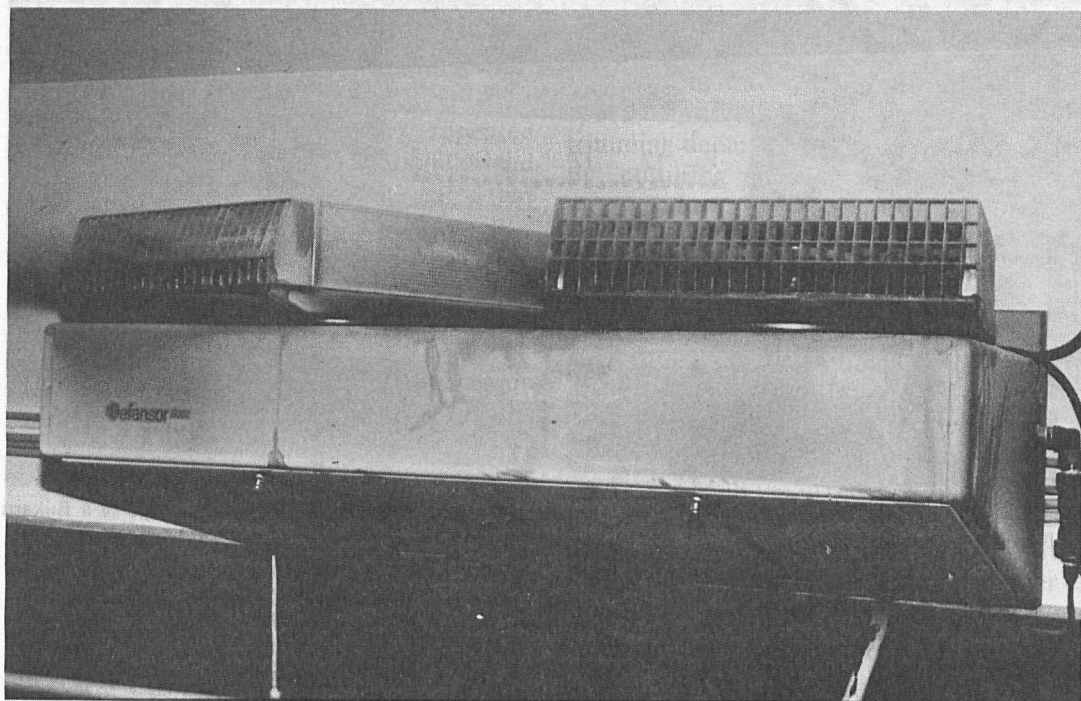


Fig. 5. A typical mechanically operating humidifier (top). The water reservoir was heavily infected by microbes which produced a black slime (bottom). Several cases of humidifier fever were caused by the aerosolized antigens.

bacterias. The microbial composition however is very complex containing various species of bacteria, moulds, yeasts and even amebas. The slime or water (after lyophilization and reconstitution) can be used as a test reagent in a simple gel diffusion analysis and precipitating antibodies to this complex microbial antigen has indicated widespread immunostimulating exposure in some of these outbreaks of »humidifier fever».

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