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AEROBIOLOGY AND SPREAD OF MICROBIAL DISEASES

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ABSTRACT

The different steps in spread of micro-organisms through the atmosphere causing diseases have been detailed. Case studies of a variety of disease outbursts have been correlated with the source and spread of causative agents. These micro-organisms also flourish in certain work environments causing an occupational hazard.

KEYWORDS: *micro-organisms , certain work environments , biological effects.*

1. INTRODUCTION

Aerobiology as a term was coined in the 1930's to describe a multi-disciplinary research area with the aim of increasing the knowledge of how biological particles in the atmosphere are transported, become airborne, deposited and their biological effects. The biological particles considered in aerobiology covers both micro-organisms, for example bacteria, fungi, algae and viruses, as well as spores, pollen, seeds, insects and other biological material. This review mainly deals with micro-organisms, their transmission in the atmosphere and their negative effects on humans, animals and plants. Reports and reviews that cover other aerobiological particles are numerous and will only briefly be dealt with here.

2. AEROBIOLOGICAL PROCESS

The aerobiological process consists of a series of successive steps which are dependent on each other and also on outer environmental factors. These steps are source, release, dispersion, impaction and biological effect.

2.1 Sources and Release

The sources of airborne biological particles can be of many types. Large quantities of micro-organisms are found in most environment Humans and animals carry large quantities of microbes, for example on the skin and in the digestive systems. From these sources they can be released by passive release (external forces) or by active release.

Unicellular organisms like virus and bacteria have no possibilities to become airborne by their own force. On a small scale this can be a human sneezing, coughing or talking. For instance one single sneeze can produce millions of droplets with a speed of 40 rn/s to a distance of up to 100 cm from the mouth. Both humans and animals release small skin fragments from the body containing different bacterial species. Humans can release up to 5,000 bacteria per minute to the surrounding air.' This release can be a problem in operation rooms or industrial activities where a sterile environment is essential. Dental drilling, air humidifiers, and microbiological laboratory work are other examples of small scale local take-off processes. In these cases there is practically no outdoor aerosol dispersal of any significance although the initial concentration can be considerable. In somewhat larger scale active take-off can be found in connection with different industrial or agricultural activities like sewage treatment, waste water irrigation and animal rendering.

2.2 Dispersion

The airborne particles released from its substrate or environment in different ways are transported up in the atmosphere due to turbulance and air currents. The concentration of particles in a volume of air above the ground depends on the amount of particles released from the source per unit time, on the meteorological conditions in the air mass and also on the characteristics of the particles like mass and form.

Many of the biological particles that by different means are transported up in the air are large or attached to large particles or consist of aggregates. Particles over 10-20 pm will, due to their weight, soon be deposited again on the ground. The number of airborne particles will be high during a short time. Due to rapid evaporation (a 0.1 mm droplet will evaporate in only 1 second) they have a better chance to stay airborne especially if the relative humidity is low.

Table 1. Concentration of viable micro-organisms in the air of different occupational environments

Working place	Bacteria x $10^3/m^3$	Fungi x $10^3/m^3$	Ref
Sewage treatment	10 – 300		15
Do	100		16
Cotton mill	17	6	17
Do	10	–	18
Do	1200	200	19
Chicken rendering plant	23	2	20
Storage house	18	1	20
Poultry slaughter house	20		15
Swine house	170	–	21
Mushroom green-house	200	10	22
Saw mill	10	–	15
Garbage treatment	30	10	15
Compost	5	–	23
Bakery		6	24
Underground in London	4		25

The composition and concentration of the airborne flora shows great variations depending on geographical locality, meteorological situation, time of day and sampling techniques used.4 For example it can be mentioned that the concentration of airborne viable bacteria. over sea lies around 10 bacteria/m, somewhat higher over land around 10-100 bacteria/m, and in a city still highepw36 around 100-100000 bacteria/m. The same type of results were found as early as 1900 by miquel. The biological particles also show a seasonalz8 and diurnal variation in concentration. As one example the highest concentration for bacteria was found in the afternoon in a city, while for the fungi Cladosporium it was found before noon.

2.2.1 Vertical Transmksion

Miquel found that the levels of bacteria were less on the roof of pathenon in Paris than at the stree?' (5 per cent less on the roof). Using balloons Flemming in the beginning of 1900 found micro-organisms at a height56 of 4,000 meters. In USA using aircraft pollen and spores (Alternaria, Puccjnia and Cladosponrium) were found at 3,300 meters height.57 During 1950 micro-organisms were collected from 6,000 meters height over the North In Sweden studies have also been carried out of bacteria and fungi at different heights.6J9 Bacteria and spores of fungi have been isolated from material collected60 from 20 km. Using rockets,Russian scientists claim that they have collected micro-organisms like Mycobactenum, Micrococcus, Aspergillus and Pencillium from 48 to 77 km in the atmosphere.

2.2.2 Theoretical Models of Dispersal

In order to gain a better understanding of the aerobiological process and its different phases mathematical models have been constructed that simulate the natural conditions. The aim of these models is to forecast the spread of an aerosol or to trace the source of release. Most such models however, do not include biological important factors but a few that add deposition and viability has been described

2.2.3 Sampling Techniques in Aerobiolog

There are a great variety of airborne biological particles and various reasons for sampling them. Therefore a sampling device or method should be selected only after the purpose of sampling has been established.

In general it can be stated that present air sampling apparatus can be divided according to sampling principle into impaction, filtration and deposition samplers. For impaction an air current is blown or sucked by a pump through a slit or a hole towards a surface where particles are impacted. The surface can be a solid, or consist of a liquid. Impaction on solid surfaces gives a measure of the number of micro-organisms particles present. It can, though, be difficult to estimate if a particle consists of one or many small particles. If the impaction occurs on a liquid surface, particle aggregates will be broken up and an estimate can be obtained of the total number of organisms in the sample.

Filtration is the most common method for removing particles from air drawn into an entrance by suction. The air passes through a fibrous or porous medium that impacts or sieves the particles.

Table 2. Sampling principles for airborne particles and micro-organisms

Sampling principle	Type of apparatus	Equipment
Impaction		
– Solid surface	Slit samplers Cascade impactors Centrifuges	BIAP, Bourdillon, Casella Andersen, May impactor Wells aircentrifuge, Reutercentrifugal sampler
	Spore traps	Hirst spore trap, Burkard spore trap
	Precipitation	Thermal, Lovelace, Electrostatic TSI 3200
– Liquid	Cyclones Impingers	Porton, FOA-cyclone Allglass, Midget, GreenBurg Smith, Marx, Multistage, Bublers
Filtration	Fiberfilters Membranefilters	Glassfiber Millipore, Sartorius

3. BIOLOGICAL EFFECTS

Micro-organisms can after dispersion be deposited in different living organisms where they in some cases can cause harmful effects on humans, animals or plants. On humans these effects can be divided into the well-known infectious diseases and the less studied effects whereby micro-organisms and biological matter can cause occupational hazards. The classical effects of allergenic biological particles, like pollen or fungi etc, on humans are beyond the scope of this paper.

3.1 Human Diseases

Historically airborne contagion have been regarded as ';he predominant route of infection concerning most infectious diseases. With increasing awareness of transmission by water and food as well as by insects and direct contacts many cases of disease were removed from the airborne category.* From the beginning of the

20th century there have been a pendulum - like change in opinion of the importance of the airborne route of infection. During the 10s or 20s an almost total denial of airborne transmission was predominant.~' In a series of papers Wells brought new insights on the transmission of contagious diseases through the air.n-74 During the 30s and 40s many studies were performed with the aim to prove the importance of the airborne route. The results of these studies were not conclusive75 and the belief in airborne contagion, thus, became less in the early 50s.

Direct evidences, for airborne transmission instead of indirect, started to appear in the 50s much due to the expanded controlled experimental research in airborne infection that developed e.g. military medicine.

3.1. 1 Legionnaires' Disease

Legionnaires' disease was first described as the cause of an outbreak of severe pneumonia in ~hiladelphia" in 1976. The pattern of illness suggested airborne spread in a hotel but the source of spread was not identified. Since then, Legionella pneumophila has been identified as the cause of the disease.84 Airborne transmission is likely to be the most common way of human infection. Several investigators have shown that L. pneumophila can be found in numerou's environmental niches, including natural fresh-water, potable water, and cooling-tower water.s89 Although the members of genus Legionella are essentially intracellular organisms during their growth in humans they are also capable of growth in vitro provided very special conditions exist. To explain the high quantities of Legionella necessary to cause the numerous airborne outbreaks, some sort of multiplication in nature seems probable. In the laboratory it has now been shown that the viable bacterial count can be increased inside the amaeba A. castellani. Whether interactions of this type actually occur in L. pneumophila containing environments is still unknown.

Outbreaks are generally associated with some human activities allowing the production of an infectious aerosol. Experimental studies have confirmed the airborne transmission.Belowa number of cases where airborne spread has been shown will be presented in more detail.

3.1.2 Tuberculosis

Pulmonary tuberculosis is perhaps the most well-known example of an airborne infection, and several studies have shown that small sized aerosol particles can result in infection. The pathogenesis of the infection was studied in rabbits exposed to a cloud of Mywbacterium tuberculosis. The primary sites of deposition were the peripheral alveoli of the lungs. This work was confirmed by Nyka who exposed mice to a cloud of M. tuberculosis and found single bacilli in their lungs by microscopic studies.

3.1.3 Q-fever

Coxiella burnetti has since long been known to cause laboratory infections. This and experimental aerosol work with laboratory animals have clearly shown the potential airborne route of this Organism. The recently recognized sporeform gave further support to the possibility for natural airborne outbreaks.

3.1.4 Brucellosis

Laboratory experiments clearly show that different Brucella spp can be transmitted by aerosols.104 It has also been widely recognized that Brucella spp is a potential hazard in laboratories. The natural route of infection has however traditionally been considered to be by consumption of pasteurized milk products or by direct contact.

3.1.5 Anthrax

The pulmonary form of anthrax-infection has been excessively rare in modern times.s0 Extensive laboratory studies have been performed and also in a field study monkeys were exposed to a naturally occuring aerosol of the bacterial spores.

An outbreak of five cases of inhalation anthrax, four of them fatal, occurred among workers in a goat-hair processing mill. The contamination of anthrax spores in the air, measured with an Andersen sampler some months after the epidemic, clearly indicated the airborne nature of the infection. 25-30 per cent of spores were found to be less than 5 microns in diameter. 18 cases of inhalation anthrax by industrial contacts in USA since 1900 have been reviewed by Brachman.

3.1.6 Pest

The epidemiology of the pulmonary form in nature is not fully understood. Pulmonary infections with Yersinia pestis have been studied in the laboratory and it has been shown that 1 micron particles initiate pneumonia in guineapigs, while inhalation of larger particles leads to septicaemia, presumably from invasion through the upper respiratory tract.

3.1.7 Psittacosis

Small outbreaks of psittacosis often follows the same route, suggesting an airborne infection. Birds in cages have been shown to cause spread of infectious aerosols giving rise to infections in humans. More extensive evidence of airborne psittacosis is found in the repeated outbreaks among employees of turkey and chicken processing plant^."^ The airborne character of these outbreaks seems clear.

3.1.8 Tularemia

Francicella tularensis was frequently studied as a possible biological warfare agents in the post-war period, and also laboratory accidents have been reported.11G118 However, in nature, few evidences of airborne infection have clearly been shown. One example may be a tularemia epidemic in northern Finland where respiratory symptoms were observed in 72 per cent of the 50 patients. They acquired the infection during common farming activities.

3.1.9 Measles

Many investigations have shown that measles often can be airborne, but it is far from clear whether measles is solely an airborne infection, or whether contact and airborne routes both play roles under different circumstances. It is clear however that airborne infection is sufficiently common and important to be a determining factor in the continuance of measles at the present time.

3.1.10 Smallpox

The main route of the now eradicated since a decade variola infection was by direct contact.'" A few cases of proven airborne transmission have however been described. In an outbreak in Germany 17 cases with three deaths, occurred in an hospital with one infected patient. This was said to be the first demonstration that smallpox could be transmitted by air currents.

3.3 Animal and Plant Diseases

There is a vast literature that covers the spread of plant and animal diseases. In many cases it can be questioned if these really have been transmitted by air. In the following a number of examples of possible airborne transmissions will be given but it does not aim at covering the whole of this area of aerobiology.

Airborne transmission of some viral animal diseases are well-known. Newcastle disease of poultry and foot and mouth disease of cattle. can cause severe economic losses for the food producing industry.

As one example of an airborne transmitted animal disease a major outbreak of FMD occurred in England in 1967-68 which became the subject of several extensive investigation. Meteorological records were examined covering periods of previous FMD outbreaks in England and the data suggested that some of these outbreaks occurred during a period which would favour a windborne transport of infection from the continent. Snow and rain. were also factors contributing to the spread of FMD.

Of the plant diseases which are caused by micro-organisms, a large majority are caused by fungi. These can form spores which are resistant to drying and can be easily spread by wind.

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