AEROMICROBIOLOGY
What is Aero microbiology?

Aero microbiology is the study of living microbes which are suspended in the air. These microbes are referred to as bio aerosols. There are significantly less atmospheric microorganisms than there are in oceans and in soil; there is still a large enough number that they can affect the atmosphere. These microbes have a chance to travel long distances with the help of wind and precipitate and increase the rate of infectious diseases caused by these microbes. These aerosols are ecologically significant because they can be associated with disease in humans, animals and plants. Microbes have the ability to suspend in the atmosphere where they can interact with the clouds and precipitate and make some changes in the clouds.

Physical/Microbial Habitats in air

There are two microbial habitats in air

1. Atmosphere
2. Clouds

Atmosphere:

The atmosphere as a habitat is characterized by high light intensities, extreme temperature variations, low amount of organic matter and a scarcity of available water making it a non-hospitable environment for microorganisms and generally unsuitable habitat for their growth. Nevertheless, substantial numbers of microbes are found in the lower regions of the atmosphere. There are five layers of atmosphere:

1) Troposphere -> 6-20 km
2) Stratospheres -> 50 km
3) Mesosphere -> 85 km
4) Thermosphere -> 690 km
5) Exosphere -> 10,000 km

Clouds: A visible mass of condensed watery vapor floating in the atmosphere, typically high above the general level of the ground. Clouds are also an acidic environment, with a pH ranging from 3 to 7.

Sources of micro-organisms in air:

Air is not a favorable environment for the microbial growth as it does not contain enough moisture and nutrients to support the growth and reproduction and there is no indigenous growth of flora in the air as well. Quite a number of sources have been found and studied that are responsible for the introduction of microbes in the air. The most common is soil. The soil microbes with the wind flow suspended in air and stay there and sometimes accumulate. Man
activities like digging, sloughing, and running also introduce microbes in the air. Air currents and splashing of water also introduces microbes in the air. Besides that air currents take away plant and animal pathogens from their surfaces and spread them in the atmosphere. Plant pathogens can spread more rapidly as compared to animal pathogens. For example: spores of Puccinia a gamines travel over a thousand kilometers. The main source of the introduction of microbes in the air is human beings. Human activity is the biggest source. The pathogenic microbes present in the respiratory tract of human being and the microbes present in the mouth are constantly released in the air but coughing, sneezing and laughing.

The microbes released in the air are in three forms depending upon on the size and moisture content. These three forms are:

1. Droplets
2. Droplets Nuclei
3. Infectious dust

Droplets:

Millions of Droplets are released when we sneeze, and mucus is expelled at about 200 miles away. These droplets are water droplets that carry micro-organisms if a diseased person released them. These droplets contain saliva and mucus. The microorganisms they carry are mostly of respiratory tract. The size of droplet determines for how long micro-organisms stay on the droplets. Droplets of large size settle in the air rapidly. These droplets carry microorganism are source might be a source of infectious disease.

Droplets Nuclei:

Particles of liquid, 1 -5 micrograms in diameter released during sneezing and coughing. Droplet nuclei are considered to be the raw material for the respiratory disorders. It contains saliva and mucus on its surface. Due to their small size they suspend in the air for a longer period of time. Droplet nuclei are considered to be the constant source of bacterial infections if the bacteria present on its surface remains viable. The viability of bacteria depends on the physical factored i.e. humidity, sunlight, moisture and the size of droplets as well.

Infected dust particles:

These dust particles introduced in the air by bed making, handling a handkerchief, dealing with a patient having dried secretion and digging and ploughing. Microorganisms stick to the surface of these droplets and get dried then they suspended by the methods given above. Dust particles laden with microbes are larger in size and they settle down in the air. Airborne diseases caused by two types of droplets.

1. Droplet infection caused by the droplets larger than 100micronmeter in diameter.
2. Airborne infections are caused by some dried residues of droplets. Droplet infection remains localized and concentrated whereas airborne infection may carry long distance. Microorganisms can grow for a longer period on dust particles. This is proved hazardous in hospitals and labs when closed dried specimens bottles are open and cotton plugs are removed from the bottles.

**Factors affecting Microbial Survival in air**

Factors affecting on the microbial survival in air are

1. Temperature
2. Humidity
3. Nutrient content
4. Acidity and PH

Temperature is the major factor in controlling the growth of microbes in the air. High temperature inhibits the growth of microbes and sometimes denatures the structural conformation of microbes. Very few microbes i.e. extremophiles can bear high temperature and survive. Similarly very low temperature is also not suitable for the growth of microbes as the ice crystal formation occurs.

Humidity has its own role in maintaining the growth of microbes in air. Gram – bacteria associated with the aerosols are tending to survive for a longer period in low humidity. Nutrient availability is less in the atmosphere so it does not support the microbial growth.

**Bio aerosols:**

Bio aerosols are the airborne particles that are formed by the process involves biological materials and generates much energy to separate the small particles from the larger one. Bio aerosols are classified on the bases of their sizes and they mostly range in 0.02-100um in diameter. These bio aerosols are given the name of microorganisms that dispersed in the environment by the process of transport and deposition followed by launching.

Now we’ll be discussing these three pathways briefly that how these pathways are taking place.

**Launching:**

Launching is the process in which the microbes loaded particle are suspended to the earth atmosphere. This is mainly done by the aquatic and terrestrial sources. For instance, the sneeze is introducing the bio aerosols to the atmosphere. This process includes three factors to be enlightened:

(a) Air turbulence created by the movement of humans, animals and machines;
(b) The generation, storage, treatment and disposal of waste material;

(c) Natural mechanical processes such as the action of water and wind on contaminated solid or liquid surfaces; and

(d) The release of fungal spores as a result of natural fungal life cycles.

Some other examples could be an instantaneous linear source might be a passing aircraft releasing a biological warfare agent or a passenger jet releasing the unburnt carbon particles source. (Pradipta K. and Mohapatra, 2008)

**Bio aerosol transport:**

Transport or dispersion is the process by which a viable particle moves from one point to another with the speed of wind or when it is launched in to air with a force. The force of airborne particle is dependent on the kinetic energy gained by it from the force at which it is launches to the atmosphere and the wind speed. Transport of bio aerosols can be defined in terms of time and distance. This type of transport is common within buildings or other confined spaces.

**Bio aerosols deposition:**

The last pathway that involves the spread of bio aerosols in the atmosphere is deposition.

This is the process in which the microbe loaded particles adhere to the surface. This can be further divided to the three more types.

1. Gravity settling
2. Surface impaction
3. Rain deposition

**Gravity settling:**

The main mechanism associated with deposition is the action of gravity on particles. Force acts on the particles heavier then air, pulling them down. Larger particles will have higher velocities and will settle down of the aero microbiology pathway faster. It should be however noted that for particles of microbiological relevance that are exposed to winds above $8 \times 10^3$ m/hr, gravitational deposition may be negligible.

**Surface impaction:**

It is the process in which the bio aerosols particles are having the contact with the surfaces such as leaves, trees, wall etc. with the impaction there is a loss in kinetic energy. The impaction potential causes the collision of a particle to the surface and facilitates its attachment to the same. However, depending on the nature of the surface of a particle can bounce after collision.
Bouncing off a surface causes the particle to reenter the air current at a lower rate, which can have one of the two effects: (Sharma, 2005)

1. It can allow subsequent downward molecular diffusion and gravitational settling to occur, resulting in deposition on another nearby surface, or
2. It can allow the particle to escape the surface and once again reenter the air current.

**Rain deposition:**

Rain fall and electrostatic charges also effects the deposition. It occurs as a condensation reaction between two particles, which combine and create a bio aerosol with a larger mass, making it to settle faster. The overall efficiency of rain deposition also depends upon the spread area of the particle plume. Larger, more diffuse plumes undergo stronger impaction than smaller, more concentrated plumes. Rain deposition is also affected by the intensity of rain fall. However on the other hand Electrostatic deposition also working as the same, it condenses bio aerosols, but it is based on electrovalent particle attraction. All particles tend to have some type of associated charge. Microorganisms typically have an overall negative charge associated with their surfaces at neutrals ph. These negatively charged particles can associate with other positively charged airborne particles, resulting in electrostatic condensation.

**Diseases caused by Bioaerosols**

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**Important Airborne pathogens**

- Up to 70% of plant pathogens are airborne
  - Rusts (caused by fungi)
  - Some citrus bacterial diseases
- **Diseases of livestock**
  - Tuberculosis (bacterial diseases)
  - Aspergillus (fungi)
  - Viral diseases
- **Diseases of humans**
  - Anthrax, tuberculosis, diphtheria, typhoid fever (bacteria)
  - Fungal diseases
  - Viruses (common colds, flu, chicken pox)
Mechanisms to control Bioaerosols in the Laboratory

Hospitals and Microbiology laboratories are two such indoor environments that come under the category of Intramural Aeromicrobiology with possibly the highest potential for the aerosolization of pathogenic microbes. Hospitals are the centers for the treatment of immense number of patients with a variety of diseases. This accounts for a high percentage of individuals including the staff and patient visitors to become the active carriers of many infectious airborne pathogens or microorganisms. The microbiological laboratories are equally important in this regard as they too serve as a breeding ground for pathogenic organisms. Staszkiewicz et al (1991) reported that eight employees in the clinical microbiology laboratory developed acute brucellosis which implies that even under strict hygienic and controlled conditions aerosolization events may take place.

The control of bioaerosols can be managed in a variety of ways and at each point of their spread whether it be launching, transport or deposition. The mechanisms used to control bioaerosols include ventilation, filtration, UV treatment, electrostatic precipitation, impaction, thermal treatment, biocidal agents and physical isolation. (Hinds, 1999) Some of the control methods are described below.

Filtration

Airborne contaminants can be filtered through a unidirectional airflow filtration method which is a simple yet an effective method for microbial control. HEPA filters or High-efficiency particulate air filters are reported to remove virtually all infectious particles from the air. These are particularly used in the biosafety hoods but because of their high cost they are not often used in constructing filtration systems. The most commonly used filtration system is the air filtration system that rely mainly on the principles of baghouse filtration that works exactly the same as the vacuum cleaner bag.

Ventilation

Ventilation is the most commonly used method to prevent the accumulation of airborne pathogens or microorganisms. In this type, a flow of air is created through areas where airborne contamination takes place. This can be achieved by simply opening the window and allowing outside air to enter inward and circulate. Moreover, air-conditioning and heating units can also be employed that pump outside air inside. This method however is the least preferred or effective method for the control of airborne pathogens. The reason why is ventilation depends upon mixing of extramural air with intramural air to decrease the concentration of airborne particles but this target is not achieved in some cases and the mixing of extramural air with that of intramural can actually increase the airborne particles concentration.
Biocidal Control

This type of control represents an added treatment that can be employed to eliminate all airborne microbes with an affirmation of their non-viability and non-infectiousness. Various biocidal control methods are available for that matter which include super heating, super dehydration, ozonation and UV irradiation. The most commonly employed, however, is the Ultraviolet Germicidal Irradiation or UVGI. UVGI has been reported to be able to control variegated airborne pathogens but some microbes have also shown various levels of resistance against it.

Physical Isolation

Isolation is defined as the enclosure of an environment through the use of positive or negative pressurized air gradients and air tight seals. Negative pressure exists when mounting airflow travels into the isolated region. For instance, the chambers or wards in the hospitals for TB patients are created to protect others outside the wards from the infectious agent, *Mycobacterium tuberculosis* generated within the patient wards. Air from such wards is exhausted into the atmosphere after passing through the HEPA filters and biocidal control chamber. Positive pressure isolation chambers function on a principle exactly opposite to the negative pressure isolation. Positive pressure exists when air is forced out of the room or any chamber thereby protecting the occupants of the chamber from outside contamination. For instance, the critical care wards in the hospitals for immunosuppressed patients which includes those of organ transplant, HIV infected and chemotherapy are under this sort of pressure and are protected from exposure to infectious pathogens of any sort.