

THE INFLUENCE OF ENVIRONMENTAL FACTORS ON MICROBIAL GROWTH

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Introduction

- Microbial growth is greatly affected by chemical and physical nature of their surroundings instead of variations in nutrient levels and particularly the nutrient limitation.
- For successful cultivation of microorganisms it is not only essential to supply proper and balanced nutrients but also it is necessary to maintain proper environmental conditions.

- Thus, understanding of environmental influences on the growth of microorganisms becomes mandatory.
- Growth and death rates of microorganisms are greatly influenced by number of environmental factors such as solutes and water acidity, temperature, oxygen requirement, pH, pressure and radiation.

Solutes and Water Acidity

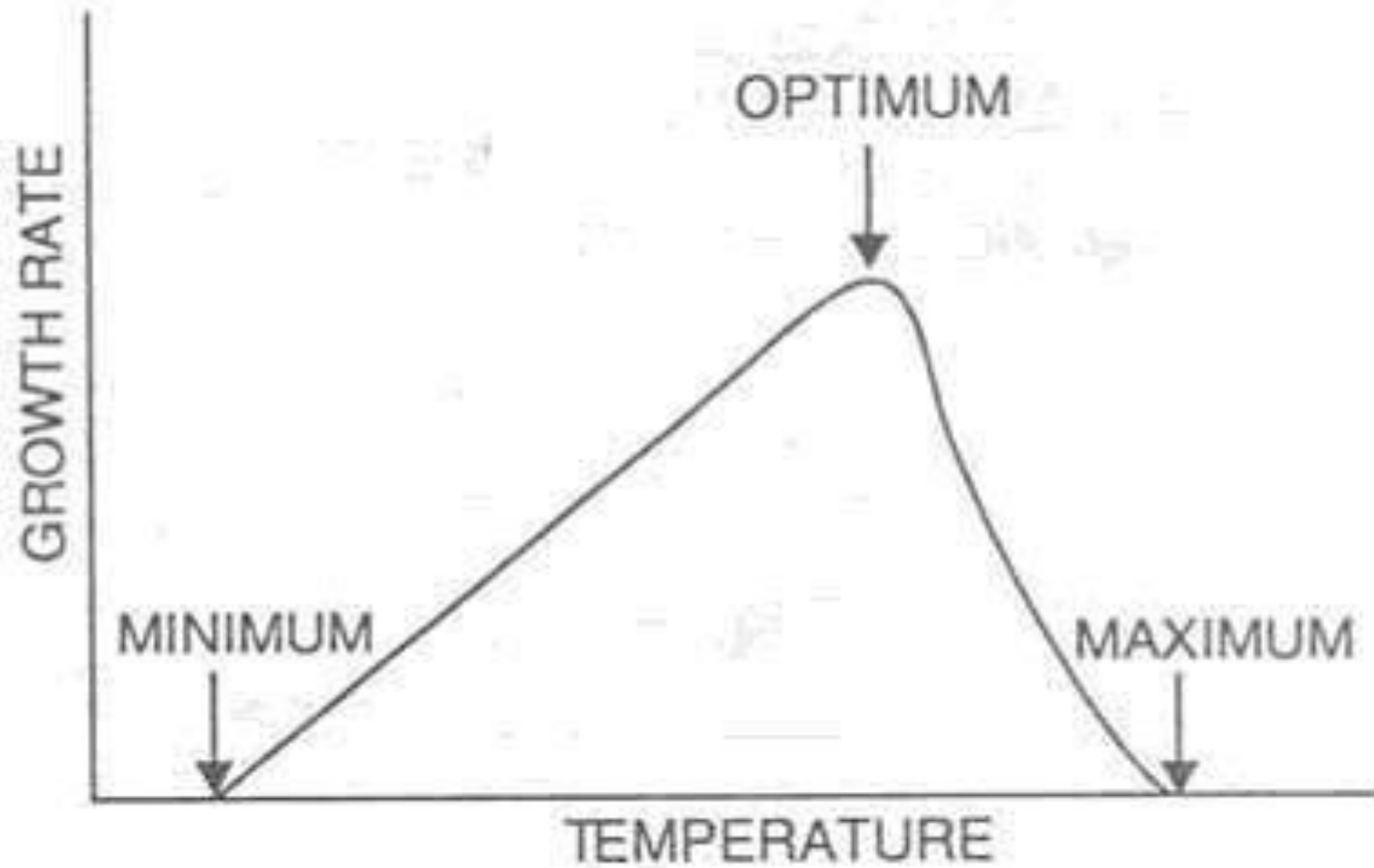
- Water is one of the most essential requirements for life. Thus, its availability becomes most important factor for the growth of microorganisms.
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- The availability of water depends on two factors - the water content of the surrounding environment and the concentration of solutes (salts, sugars etc.) dissolved in the water.

- In most cases, the cell cytoplasm possesses higher solute concentration in comparison to its environment.
- Thus, water always diffuses from a region of its higher concentration to a region of the lower concentration. This process is called **osmosis** which keeps the microbial cytoplasm in positive water balance.
- When a microbial cell is placed in hypertonic solution (or, solution of low water activity), it loses water and shrinkage of membrane takes place.

- This phenomenon is called **plasmolysis**. Microorganisms show variability in their ability to adapt the habitats of low water activity. Microorganisms like *S. aureus* can survive over a wide range of water activity and are called as **osmotolerant**.
- Sea water, microorganisms are called as **halophiles** since they require high concentration of salts (between 2.5 to 6.2 M) to grow. Halobacterium, a halophilic archaeobacterium, inhabits Dead Sea (a salt lake situated between Israel and Jordan and the lowest lake in the world), the Great Salt Lake in Utah.

Temperature

- All forms of life are greatly influenced by temperature. In fact, the microorganisms are very sensitive to the temperature since their temperature varies with that of environment.
- On the basis of susceptibility to the thermal conditions, microorganisms are classified into three categories: thermophiles. Mesophiles and psychrophiles.



Thermophiles

- **Thermophiles** are microorganisms that show growth optima at 55°C. They often have growth maxima of 65°C, while few can grow even at 100°C and higher temperatures.
- The vast majority of thermophiles belongs to prokaryotes although a few microalgae (e.g., *Cyanidium caldarium*) and microfungi (e.g. *Mucor pusillus*) are also thermophiles.
- A few microorganisms are hyperthermophiles as they possess growth optima
- between 80°C and about 113°C. Hyper thermophiles usually do not grow well below 55°C (e.g.. *Pyrococcus abyssi*, *Pyrodictium occultum*).

Mesophiles

- Mesophiles are microorganisms that have growth minima between 15°C-20° C; optima between 20-45°C and maxima at 45°C.
- Most microorganisms fall within this category. Almost all human pathogens are mesophiles as they grow at a fairly constant temp. of 37°C.

Psychrophiles

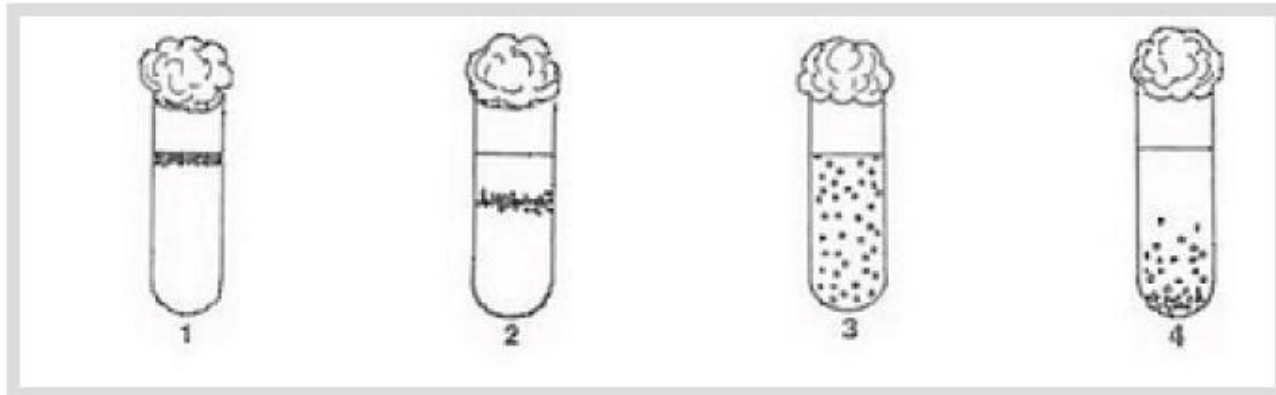
- Psychrophiles have optimum temperature for growth at 15°C , however, few can grow even below 0°C .
- The maximum growth temperature of psychrophiles is around 20°C .
- The spoilage of refrigerated food takes place because of facultative psychrophiles.

Oxygen Requirements

- The atmosphere of earth contains about 20% (v/v) of oxygen. Microorganisms capable of growing in the presence of atmospheric oxygen are called aerobes whereas those that grow in the absence of atmospheric oxygen are called as anaerobes.
- The microorganisms that are completely dependent on atmospheric oxygen for growth are called obligate aerobes whereas those that do not require oxygen for growth but grow well in its presence are called as facultative anaerobes.

- Aerotolerants (e.g. *Enterococcus faecalis*) ignore O₂ and can grow in its presence or absence. In contrast, obligate anaerobes (e.g., *Bacteroids*, *Clostridium pastewianum*, *Furobacterium*) do not tolerate the presence of oxygen at all and ultimately die.
- Few microorganisms (e.g., *Campylobacter*) require oxygen at very low level (2-10%) of concentration and are called as microaerophiles.

Relationship of Oxygen and growth (Shake tubes method)



1. Aerobic

2. Microaerophilic

3. Facultative

4. Anaerobic

Pressure

- Normal life of microorganisms on land or on the water surface is always subjected to a pressure of 1 atmosphere. But, there are many microbes that survive in extremes of hydrostatic pressure in deep sea.
- Others are there that not only survive rather grow more rapidly at high pressures (e.g., *Photobacterium*, *Colwellia*, *Shewanella*) and are called barophilic. Some archaeobacteria are thermobarophiles (e.g., *Pyrococcus* spp., *Methanococcus jannaschii*).

- However, A barophile has been recovered from the depth about 10,500 m in sea near Philippines and has been found able to grow at 2°C temperature and below about 400-500 atmospheric pressure.

Radiation

- Some electromagnetic radiations, particularly the ionizing radiation (e.g., Xrays, gamma rays) are very harmful to microbial growth.
- Low levels of these radiations may cause mutations and may indirectly result in death whereas high levels may directly cause death of the microbes.
- Ionizing radiation, however, destroys ringstructures, breaks hydrogen bonds, oxidizes double bonds and polymerizes certain molecules.

- Ultraviolet (UV) radiation is lethal to all categories of microbial life due to its short wavelength and highenergy; the most lethal UV radiation has a wavelength of 260 nm.
- Ultraviolet radiation primarily forms thymine dimers in DNA to cause damage. Two adjacent thymines in a DNA strand join each other covalently and inhibit DNA replication and function.

- Microbial photosynthetic pigments (chlorophyll, bacteriochlorophyll, cytochromes and flavins), sometimes, absorb light energy, become excited or activated, and act as photosensitizers.
- The excited photosensitizer (P) transfers its energy to oxygen which then results in singlet oxygen (1O_2). The latter is very reactive and powerful oxidizing agent and quickly destroys a cell.
- The singlet oxygen is probably the main weapon employed by phagocytes to destroy engulfed bacteria.



Thankyou