**CHAPTER 2: ABIOTIC FACTORS**

**A. Climatic Factors**

**1. Definition of Climate**

Climate refers to the set of atmospheric and meteorological conditions characteristic of a specific region of the globe. A region's climate is determined by studying meteorological parameters (temperature, humidity, precipitation, wind strength and direction, sunlight duration, etc.) over several decades.

**2. Main Climatic Factors**

The climatic elements that play an ecological role are numerous. The most important are temperature, humidity and rainfall, light, and photoperiod (the distribution of daylight and darkness in a day). Others, such as wind and snow, are less significant but can sometimes have a notable impact.

**2.1 Temperature**

Temperature is the most critical climatic factor, as all metabolic processes depend on it. Phenomena like photosynthesis, respiration, and digestion follow van't Hoff's law, which states that the rate of a reaction is a function of temperature.

Most living organisms can only survive within an average temperature range of 0 to 50°C. Extremely low or high temperatures trigger a dormant state (quiescence) in some animals, known as estivation or hibernation, during which development is nearly halted.

The limits of a species' geographic distribution are often determined by temperature, which acts as a limiting factor. Extreme temperatures, rather than averages, frequently restrict a species' ability to thrive in a given environment.

**2.2 Humidity and Rainfall**

Water constitutes 70–90% of the tissues of many actively living species. Access to water and minimizing water loss are fundamental ecological and physiological challenges. Based on their water needs and habitat distribution, species are classified as:

* **Aquatic species**: Permanently live in water (e.g., fish).
* **Hygrophilous species**: Thrive in humid environments (e.g., amphibians).
* **Mesophilous species**: Require moderate water and tolerate alternating dry and wet seasons.
* **Xerophilous species**: Inhabit dry environments with significant water deficits (e.g., desert species).

**Adaptations to Drought:**

**In Plants:**

* Reduced transpiration through impermeable cuticular structures.
* Fewer stomata.
* Smaller or modified leaves (e.g., scales or spines).
* Seasonal leaf shedding and regrowth after rain.
* Deep root systems for water uptake.
* Water storage in specialized tissues with protective epidermis.

**In Animals:**

* Extracting water from food.
* Reducing water excretion via concentrated urine.
* Metabolic water production from fat oxidation (e.g., camels).

**2.3 Light and Sunlight**

Sunlight refers to the duration of direct sunlight exposure. Solar radiation consists of visible light, infrared, and ultraviolet rays. Light influences organisms through its intensity, wavelength, and duration (photoperiod). Photoperiod increases from the equator toward the poles:

* **Equator**: Equal day and night year-round.
* **Tropics**: Minor variations with little impact.
* **High latitudes**: Days and nights exceed 24 hours, reaching 6 months of daylight or darkness at the poles.

**Effects on Plants:**
Plants adapt to light intensity and duration, especially during the transition from vegetative growth to reproduction (flowering). They are categorized as:

* **Short-day plants**: Flower only with ≤12 hours of daylight.
* **Long-day plants**: Require ≥12 hours of daylight to flower.
* **Day-neutral plants**: Flowering unaffected by day length.

**Effects on Animals:**
Photoperiod regulates biological rhythms:

* **Seasonal rhythms**: Synchronize reproduction with favorable conditions or trigger diapause before harsh seasons.
* **Circadian rhythms**: 24-hour cycles governed by an internal "biological clock" influenced by light and temperature.
* **Lunar rhythms**: Activity cycles triggered by moonlight, common in marine animals.

**2.4 Wind**

Wind results from atmospheric movement between high- and low-pressure systems. Its ecological impacts include:

* Drying effect (increased evaporation).
* Cooling effect.
* Dispersal of seeds and organisms.
* Reduced insect activity.
* Forest clearings from fallen trees, enabling new growth.
* Mechanical shaping of plants (anemomorphosis).

**2.5 Snow**

Snow is a key ecological factor in mountainous regions. Snow cover insulates the ground: at 1-meter depth, soil temperature is -0.6°C vs. -33.7°C at the surface.

**B. Edaphic Factors (Soil-Related)**

**1. Definition of Soil**

Soil is a dynamic, living medium composed of mineral and organic matter. It forms from the weathering of parent rock under physical, chemical, and biological processes, influenced by the atmosphere and organisms. Plants and animals rely on soil for water, minerals, and habitat.

**2. Key Edaphic Factors**

**2.1 Soil Texture**

Texture is determined by particle size:

| **Particle** | **Diameter** |
| --- | --- |
| Gravel | >2 mm |
| Coarse sand | 2 mm – 0.2 mm |
| Fine sand | 0.2 mm – 20 µm |
| Silt | 20 µm – 2 µm |
| Clay | <2 µm |

**Soil Types:**

* **Fine textures**: High clay content (>20%), retaining water but hard to cultivate.
* **Sandy/coarse textures**: Loose, prone to seasonal drying.
* **Loamy textures**: Balanced silt-clay-sand mixtures (optimal for agriculture).

**Biological Impact:**
Organisms like earthworms prefer loamy or clayey soils, which retain moisture better than coarse soils.

**2.2 Soil Structure**

Refers to particle arrangement:

* **Particulate**: Loose, sandy soils.
* **Massive**: Compact, cemented soils (e.g., clay), limiting organism movement.
* **Aggregate**: Ideal for life, with pores allowing air/water circulation.

**2.3 Soil Water**

Exists in four states:

* **Hygroscopic**: Bound to particles, unusable by organisms.
* **Non-absorbable capillary**: Trapped in tiny pores, accessible only to specialized organisms.
* **Absorbable capillary**: Available to plants and microbes (pores: 0.2–0.8 mm).
* **Gravitational water**: Drains through large pores.

**2.4 Soil pH**

Determined by parent rock, organic matter, and climate:

* **Basic pH (>7.5)**: Limestone-derived soils in dry climates.
* **Acidic pH (4–6.5)**: Humid/cold climates, coniferous forests, siliceous/granitic rocks.

Organisms vary in pH tolerance: **acidophiles**, **basophiles**, or **neutrophiles**.

**2.5 Chemical Composition**

Key elements like chlorides and calcium influence flora and fauna:

* **Halophytes**: Thrive in saline soils.
* **Calcicoles**: Tolerate high calcium; **calcifuges** avoid it.
* **Toxico-resistant species**: Survive in soils with heavy metals (e.g., metallophytes).