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**ROLE OF BRYOPHYTES IN POLLUTION MONITORING**

Bryophytes, both the **liverworts** and **mosses** (like the **lichens**) can **indicate** the presence of **pollutants** in the environment and can also be used to **monitor** the levels of environmental pollution. These tiny plants effectively function as **bioindicators**<sup>a</sup> and **biomonitors**<sup>b</sup> of both **air** and **water pollution**. This is possible because of their **habitat diversity**, **small size** and **simple structure**, which results in the greater **absorption** and **accumulation** of **pollutants** from the **environment**. These plants are also ideal for **pollution studies** both in the **laboratory** and in the **field**. Bryophytes are either **sensitive** or **tolerant** to **pollutants**. **Pollution-sensitive bryophytes**, unlike most plants, exhibit **toxicity symptoms**, **arrested growth** and even **mortality** when exposed to **pollutants** even in minute quantities. **Population study** of these **bioindicators** can reveal the **nature** of the pollution. In contrast, **pollution-tolerant bryophytes** can **trap** and **sequester** pollutants from the environment in their bodies without affecting **growth** and they can **accumulate** these **pollutants** at a **higher rate** compared to other plants. **Chemical analysis** of these plants can be used to **biomonitor** the **degree** of pollution. Thus, bryophytes are like living instruments or **bryometers** that can be used for **pollution monitoring** of the **atmosphere** and **water bodies**.

**Air Pollution Monitoring**

**Bryophyte populations** in **urban** and **industrial areas** can decline due to their **sensitivity** to **gaseous** and **particulate pollutants** present in the **air**. **Urban areas** have **diverse habitats** for bryophytes and some of these are more **sensitive** to **air pollution**. Bryophytes growing on **tree trunks** are more **sensitive** than those on **stone walls**. For **epiphytes**, those on **branches** are similarly more **sensitive** than those near the **base**. **Pollution-sensitive** bryophytes **die** quickly when **transferred** (along with their substratum) from unpolluted to **polluted areas** in **cities** and **factories**. These pollutants can affect **individuals** or the entire **population**. Air pollutants inhibit **sexual reproduction** by reducing **sex organ** formation. These also reduce **photosynthesis** by degrading **chlorophyll**, which affects **plant growth** and can eventually cause **death**. **SO<sub>2</sub>** exposed plants show brownish spots on chloroplasts and plasmolysis of leaf cells. **NH<sub>3</sub>** causes leaf tip chlorosis, followed by necrosis. **O<sub>3</sub>** uptake results in acute injury, premature ageing and senescence. The **moss** *Atrichum undulatum* which is highly **sensitive** to **air pollution**, is one of the best known **bioindicators**. Several species of *Sphagnum* are sensitive to **O<sub>3</sub>** in the air. The **liverwort** *Marchantia polymorpha* and the **moss** *Funaria hygrometrica* show morphological changes when exposed to air-borne **heavy metals**. **Pollution-tolerant** bryophytes can **endure** high levels of **pollutants** present in the **air** and can behave as **sinks** for these **pollutants**. **Transplanting** these bryophytes to **air pollution** affected areas and their **chemical analysis** can be used to **biomonitor** the **levels** of **air pollutants**. **Mosses** such as *Glyphomitrium humillimum* can **tolerate** high concentrations of atmospheric **SO<sub>2</sub>**. **Mosses** such as *Polytrichum commune* can accumulate **heavy metals** from the air. With or without **lichens**, by simply counting the **abundance** and **frequency** of bryophytes, the IAP (**Index of Atmospheric Purity**) can also be calculated.

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<sup>a</sup> Organisms that are used to indicate qualitative changes in the environment.

<sup>b</sup> Organisms that are used to monitor quantitative changes in the environment.

**Water Pollution Monitoring**

**Aquatic bryophytes** can be used to study water pollution as **indicators** and **monitors** of pollutants in **freshwater ecosystems**. It is known that when the **water pollution** level goes up, the **frequency** of **pollution-sensitive** bryophytes decreases. **Polluted sites** of rivers have reduced incidence of **bryophyte populations** that are **pollution-sensitive**. The **aquatic moss** *Sphagnum* is an useful **bioindicator** for water quality, especially **acidified waters**. Other **aquatic bryophytes** are **indicators** of **heavy metals**. When **heavy metals** enter the cell, it inhibits **photosynthesis** and damages **enzymes** and **membranes**. **Mercury** is particularly toxic at low concentration. In the **moss** *Rhytidiadelphus squarrosus* this **heavy metal** inhibits photosynthesis, increases respiration, reduces chlorophyll and caused loss of intracellular ions. In India, thriving populations of the **liverwort** *Riccia frostii*, a **pollution-sensitive** species, are the **bioindicators** of less polluted **river sites**. **Pollution-tolerant** aquatic bryophytes can also accumulate **heavy metals** and **metalloid** from the polluted water in their bodies that can be **chemically analyzed** for **biomonitoring** their **levels** in **water bodies**. Some **aquatic bryophytes** can accumulate **heavy metals** from polluted water to a much greater extent than most vascular plants because they can **absorb** water over their **entire surface** through the **thin-walled** parenchymatous cells. The **older tissues** of the plant have higher concentrations of these **heavy metals** as compared to the **younger parts**. **Mercury**, a common **heavy metal** pollutant, is accumulated as **crystals** of **HgS** in the cell wall. The ability of **foliose liverwort** and **mosses** to accumulate **heavy metals** depends upon their **total leaf area**. The **foliose liverwort** *Jungermannia vulcanicola* and the **mosses** *Fontinalis antipyretica* and *Platyhypnidium riparioides* are commonly used for **biomonitoring** the levels of **heavy metal** pollutants in **rivers**. In India, the **liverwort** *Riccia gangetica*, a **pollution-tolerant** species that thrives in **polluted sites** near **cities** and **factories**, has been used to **biomonitor** the **levels** of **pollutants** in the **Ganges**. Thus, **bryophytes** are invaluable as **bioindicators** and **biomonitors** of **heavy metals** and other pollutants in **inland water bodies**.

**Further Reading**

Hait, G, K Bhattacharya & AK Ghosh (2007) *A Text Book of Botany* (Vol. 1). New Central Book Agency, Kolkata.

Shukla, RS & PS Chandel (1996) *Plant Ecology*. S Chand & Co, Jalandhar.

Govindaparyari, H, M Leleeka, M Nivedita & PL Uniyal (2010) Bryophytes: indicators and monitoring agents of pollution. *NeBIO* 1: 35-41.