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Utilization of mosses in metropolitan green spaces: A biological way to lessen temperature and contamination

The difficulties of air pollution, heat islands, and biodiversity impairment are worsening due to indiscrimenate growth and expansion of metropolises. Amongst the concrete jungles, one species of organism stands out as a potential confederate in dealing with these issues: Mosses, commonly known as bryophytes along with liverworts and hornworts, are typically ignored but provide incomparable aid to improve metropolitan environments. Comprising select moss species in metropolitan green zones may deliver a supportable, organic response to some of the most tenacious metropolitan complications.

Mosses have an exclusive capacity to engross and clean airborne pollutants. Mosses have perhaps the best air purifying and oxygenating abilities in comparison to other plants, thereby providing one of the best natural air filters, serving to clean the air. Mosses have natural capacity to engross and metabolize fine dirt, altering hazardous particles into natural and harmless biomass, besides conserving and dispersing large amount of moistness, which freshens the air. The species that have been evaluated for their air-purifying capabilities are *Grimmia pulvinata* (Hedw.) Sm., *Barbula unguiculata* Hedw. and *Homalothecium sericeum* (Hedw.) Schimp. Interestingly, all these species are almost cosmopolitan in distribution with a broad habitat range, including metropolitan areas (Katia *et al*., 2025).

Due to large surface area of thalli, the moss-derived filter is more efficient at filtering and cooling the ambient than larger trees and absence of a cuticle permit them to seize miniature particulate matter, heavy metals, and even nitrogen oxides (NOx) from the surroundings. In a recent attempt, moss species, viz., *Pleurozium schreberi* (Willd. ex Brid.) Mitt., *Sphagnum fallax* (H. Klinggräff) *H. Klinggräff*, and *Dicranum polysetum* Sw., have been evaluated for their heavy metal accumulation (Swisłowski *et al*., 2022). A study by Sharma *et al.* (2020) have demonstrated that mosses can effectively reduce PM 2.5 and PM 10 levels, making them appreciated tools for purifying air quality of metropolitan. Vehicular expulsions, industrial activities, and the erection of infrastructure all add up to the extraordinarily hazardous build-up of particulate matter and noxious gases in urban zones, making these areas hotspots for airborne effluence.

By creating natural cleaning through transpiration and evaporation, bryophytes can aid in reducing metropolitan heat islands, where temperatures are appreciable higher than nearby pastoral expanses due to anthropogenic activities and the prevalent heat-absorbing materials like asphalt and concrete (Glime, 2024). Additionally, mosses can aid in stabilizing local moisture content and high temperatures by integrating them into green rooftops and walls, reducing surface temperature and energy demand for cooling constructions (Francis and Lorimer, 2011).

Metropolitan green places are indispensable for upholding biodiversity, but old-style landscaping frequently highlights aesthetics over ecological significance. Common moss species, such as *Barbula constricta* Mitt. (*Didymodon constrictus* (Mitt.) K.Saito), with its capacity to flourish in varied climatic conditions, can construct microhabitats for small insects, certain fungi, and microorganisms (Wang *et al*., 2023). These microhabitats are pivotal to metropolitan biodiversity by attracting pollinators and other valuable species. By integrating common moss species into gardens, parks and green set-ups, metropolises can stand in wealthier and congenial ecosystems while preserving aesthetic charm. Notably, *Sphagnum* spp., are well known to improve the response of seedlings to climatic changes through other methods, for instance, transformed struggle for nutrient obtainability (Signe *et al*., 2020).

Common mosses such as species of *Sphagnum, Thuidium, Hypnum, Hyophila*, etc., are well recognized for their low maintenance; contrasting to old-fashioned turfs, which necessitates consistent composting, trimming and sprinkling. Most mosses, *viz., Hyophila involuta* (Hook.) A. Jaeger, *Rhodobryum roseum* (Hedw.) Limpr., *Hypnum cupressiforme* Hedw., *Pleurozium schreberi* (Willd. ex Brid.) Mitt., etc., require little care and they can grow in nutrient-deficient soils. Being drought-resistant, these mosses can grow well in predominant darkness where other plants fail to grow. Consequently, certain moss species are an excellent choice for ecologically friendly metropolitan landscaping, which not only lowers the upkeep costs and water

intake but also offer vital ecological balance. A recent study reflects the construction of a setup of moss-based biotechnological decontaminating filters under the Smart City awareness (Biloshchytskyi *et al*., 2023).

Biological monitoring has become an imperative apparatus for assessing the undesirable setback of human activities on the ambient environment. Owing to ever-increasing populace together with other environmental glitches, build-up of heavy metals in the environment is a massive disadvantage to the supportable surroundings. Heavy metal effluence, though being dumped regularly in tiny quantities, may accumulate in the environs over prolonged stages of time and will most likely produce possible environmental and human comfort threats in future. Thus, it seems very commanding to improve and pep up a persistent reflexive monitoring method to evaluate the nature and intensity of heavy metal and gaseous pollutions. In this context, the potential of bryophytes enormous and many species such *Hylocomium splendens* (Hedw.) Schimp., *Tillandsia usneoides* (L.) L., *Scleropodium purum* (Hedw.) Limpr., *Sphagnum cuspidatum* Ehrh. ex Hoffm., *Thuidium delicatulum* (Hedw.) Schimp., *Pleurozium schreberi* (Willd. ex Brid.) Mitt., *Hypnum cupressiforme* Hedw., *Rhodobryum giganteum* (Schwägr.) Paris, etc., have been used as a Bryomonitor worldwide (Alam, 2018).

Even with their potential in environmental cleansing, mosses face obstacles in metropolitan settings, such as struggle with intrusive species, habitat fragmentation and high pollution, which can limit their growth. Yet, these complications can be overwhelmed with the right preparation and supervision; for example, selecting moss species that can endure pollution and founding habitations that are encouraging to moss growth where they can increase their survival and effectiveness in somewhat harsh environments of the metropolitans.

Mosses are the major component of the second largest diversified group of plants. They are more than just ground cover and ornamental species; they are pioneers in succession along with lichens and are very sensitive to environmental happenings, hence can be used as a Bryomonitor. The biomonitoring role of these minute plants is well established; however, they are also powerful allies in the search for viable urban living. By integrating these peculiar plants into green spaces, metropolises can fight increasing air pollution, reduce heat islands, and expand biodiversity. As the expansion of metropolitans continues to change the existing world, implementing the potential of mosses could lead to healthier, greener, and more liveable cities.

However, one thing is clear: climate change has the potential to alter the distribution, survival, and ecological significance of mosses. While some species might adapt or shift their geographical ranges, many could experience increased stress due to changing moisture levels, extreme weather conditions, and alterations in their habitats. These changes could have significant consequences for ecosystems, particularly in peat-lands and other environments that depend on moisture. Therefore, to completely harness the natural aids of mosses, we should prioritize their fortification. Although they are small and easily unnoticed, their ecological roles in mitigating environmental hazards are massive. A careful, mutually beneficial approach is essential.

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