

Impact of Vertical Gardening on Air Quality in Urban Areas

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<https://doie.org/10.10346/AE.2025566192>



ABSTRACT

Vertical gardening extends beyond a mere horticultural trend; it serves as a sustainable and innovative response to the challenges posed by urbanization and environmental degradation. Through the adoption of vertical gardening practices, individuals can convert limited or underutilized spaces into verdant, productive environments, thereby enhancing ecological sustainability and fostering a renewed connection with nature. This article examines the historical development of vertical gardening, outlines its ecological and practical benefits, evaluates plant suitability, and provides a structured, step-by-step framework for establishing vertical garden systems. The World Health Organization (WHO) recognizes the importance of air quality for health. The WHO has determined that over 90% of the global population resides in urban areas where pollutant levels exceed established limits. Additionally, the WHO has identified that 4.2 million fatalities annually are caused by exposure to outdoor air. Improving air quality is a critical issue in today's rapidly urbanizing globe. One such solution that has gained significant attention is vertical gardens. Vertical gardens offer an innovative and effective solution for improving air quality in urban areas. Vertical gardens are structures in which plants are grown vertically, either hydroponically or in soil. They can be freestanding or attached to buildings, and they bring colorful vegetation to metropolitan environments. Vertical gardens minimize pollutants including carbon dioxide, nitrogen oxides, and particulate matter. Spider plants, peace lilies, and Boston ferns are common plants used in vertical gardens to purify the air. Toxins in the air can cause cardiovascular disorders, respiratory disorders and other major health concerns. With the potential to create healthier and more sustainable urban environments, vertical gardens are poised to play a significant role in improving air quality in the future. Vertical gardening is a practice of growing plants in vertically stacked layers or on upright structures. Unlike traditional gardening (which requires horizontal land space), vertical gardening allows plants to grow upwards using supports like walls, frames, trellises, or specially designed vertical systems. It is ideal for small urban spaces (balconies, rooftops, walls) indoor gardening, Urban beautification, Commercial and institutional green infrastructure.

Keywords: Vertical Gardening, Air Quality, Urban Areas and Pollutant.

INTRODUCTION

Vertical gardening is an innovative and space-efficient method of growing plants by utilizing vertical surfaces such as walls, poles, trellises, or specially designed

structures instead of traditional horizontal garden beds. It is particularly useful in urban areas where ground space is limited. By growing plants upward rather than outward, vertical gardening allows

individuals to cultivate a wide variety of ornamental, edible, and medicinal plants in small spaces such as balconies, rooftops, terraces, or even indoor walls. Vertical gardening—commonly referred to as living walls, green walls, or vertical farms—has emerged as an increasingly viable and environmentally conscious response to the challenges associated with rapid urbanization and environmental degradation (Ibrahim Momtaz, 2018). As urban areas expand and impervious surfaces proliferate, urban heat island effects intensify, leading to elevated ambient temperatures. Vertical gardens have gained recognition for their potential to mitigate these effects by enhancing energy efficiency, improving air quality, and contributing to ecological resilience (Patel et al., 2018). Vertical gardening is particularly suited to dense urban landscapes and arid regions where horizontal gardening space is limited. However, modern vertical gardening has undergone substantial advancements, driven by innovations in technology, materials, and a more nuanced understanding of plant biology and environmental interactions.

Classification of Vertical Gardening

a) Green Walls / Living Walls

- These are engineered vertical systems where plants grow on panels that are fixed to walls. The plants may grow in soil, cocopeat, or hydroponic media. Includes built-in irrigation and drainage systems. Used for aesthetics, air purification, and insulation in buildings. Example: Indoor plant walls in offices or malls.

b) Green Facades

- Plants climb or trail along vertical supports like **mesh, netting, or**

trellises attached to walls. Unlike green walls, plants are rooted in the ground or containers at the base. Common plants: *Ivy*, *Bougainvillea*, *Passiflora*. It is a natural and less technical structure.

Benefits of Vertical Gardening

1. Space Efficiency
2. Environmental Benefits
3. Efficient Water Use
4. Higher Crop Yield per Area
5. Aesthetic and Architectural Value
6. Improved Thermal Insulation
7. Psychological and Health Benefits
8. Biodiversity Support
9. Easy Maintenance and Harvesting
10. Economic Benefits
11. Sustainability and Waste Recycling
12. Fresh Produce
13. Low Maintenance

Plants Suitable for Vertical Gardening

A diverse range of plant species can be effectively cultivated in vertical garden systems. However, the selection of appropriate plants should be informed by site-specific environmental conditions, including sunlight exposure, temperature, humidity, and overall climate (Morrison & Sweet, 2011). Successful vertical gardening depends on choosing species that are well-adapted to the vertical orientation and maintenance requirements of the system. The following categories highlight plant types commonly utilized in vertical gardens due to their adaptability, growth habit, and functional benefits:

1. Culinary Herbs

Species such as *Ocimum basilicum* (basil), *Rosmarinus officinalis* (rosemary), *Thymus vulgaris* (thyme), *Mentha spp.* (mint), and *Petroselinum crispum* (parsley) are well-suited for vertical gardens due to their compact

growth and high utility in home kitchens.

2. Succulents

Low-maintenance and drought-tolerant succulents such as *Sedum spp.*, *Echeveria spp.*, *Sempervivum tectorum* (hens and chicks), and *Crassula ovata* (jade plant) are ideal for vertical systems, especially in regions with limited rainfall.

3. Ferns

Shade-tolerant ferns like *Nephrolepis exaltata* (Boston fern), *Platycerium bifurcatum* (staghorn fern), *Adiantum spp.* (maidenhair fern), and *Asplenium nidus* (bird's nest fern) are commonly used for their lush foliage and adaptability to humid environments.

4. Climbing and Trailing Plants

Species such as *Hedera helix* (English ivy), *Epipremnum aureum* (pothos), *Rosa spp.* (climbing roses), and *Clematis spp.* offer aesthetic vertical coverage and are suitable for trellised or modular systems.

5. Ornamental Grasses

Textural and visually dynamic options like *Pennisetum setaceum* (fountain grass), *Festuca glauca* (blue fescue), and *Hakonechloa macra* (Japanese forest grass) provide architectural interest in vertical planting schemes.

6. Annual Flowering Plants

Fast-growing and colorful species such as *Petunia spp.*, *Impatiens walleriana*, *Pelargonium spp.* (geraniums), and *Verbena spp.* are popular for seasonal vertical displays.

7. Perennials

Hardy and long-lived species such as *Hosta spp.*, *Heuchera spp.* (coral bells), *Tiarella cordifolia* (foamflower), and *Ajuga reptans*

(bugleweed) offer consistent ground cover and foliage interest over multiple growing seasons.

8. Edible Vegetables and Fruits

Space-efficient edible plants like *Lactuca sativa* (lettuce), *Fragaria × ananassa* (strawberries), *Solanum lycopersicum* (dwarf tomato varieties), and *Beta vulgaris* (Swiss chard) are increasingly integrated into urban vertical farming systems.

9. Native Plant Species

The inclusion of regionally adapted native species enhances biodiversity, improves plant resilience, and typically reduces maintenance inputs. Selection should be guided by local ecological conditions and conservation goals.

Step-by-Step Guide for the Preparation of a Vertical Garden (Ivanova et al., 2020)

The construction of a vertical garden involves a systematic approach to ensure structural stability, effective irrigation, and optimal plant growth. The following procedural steps outline the standard method for establishing a vertical garden:

Step 1: Site Preparation

Select an appropriate location, either indoors or outdoors, with adequate sunlight (depending on plant requirements) and convenient access to a water source for irrigation. The surface should be structurally capable of supporting the garden system.

Step 2: Frame Installation

Securely install a vertical frame made of durable materials such as galvanized metal or treated wood. The frame can be wall-mounted or constructed as a freestanding structure, depending on spatial and structural considerations.





Step 3: PVC Sheeting Attachment

Affix a 1.00 cm thick polyvinyl chloride (PVC) sheet to the frame using rivets. This layer provides waterproofing and mechanical support, protecting the wall from moisture damage and maintaining overall system integrity.

Step 4: Felt Layer Installation

Staple a sheet of polyamide felt or horticultural-grade geotextile fabric onto the PVC surface. This material serves as the growing medium and root support system. It should be breathable, rot-resistant, and capable of retaining moisture.

Step 5: Formation of Plant Pockets

Create planting pockets by making horizontal slits in the felt layer. These openings will hold soil or planting plugs and provide space for root development.

Step 6: Plant Integration

Introduce selected plant materials—either seeds, cuttings, or established plants—into the prepared pockets. Selection should be based on light, moisture, and spatial requirements.

Step 7: Irrigation System Installation

Implement a drip irrigation system to ensure uniform and efficient water distribution across all layers. An automated timer-controlled system is recommended for consistency and reduced labour.

Step 8: Water Collection and Recirculation

Install a water collection trough or container at the base of the structure to capture excess runoff. This water can be filtered and recirculated to promote water efficiency.

Step 9: Ongoing Maintenance

Conduct regular inspections to monitor plant health, detect and control pests or diseases, and ensure proper irrigation.

Periodic pruning and nutrient supplementation may also be necessary to maintain optimal performance.

CONCLUSION

Vertical gardening transcends its characterization as a mere horticultural trend, functioning instead as an innovative and sustainable response to the pressing challenges of urbanization and environmental degradation. By integrating vegetation into vertical surfaces, individuals and communities can transform otherwise underutilized spaces into productive green environments. This practice not only enhances urban aesthetics but also contributes to ecological sustainability and fosters a renewed human connection with nature—achieved incrementally, one wall at a time.

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