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Short Review Paper

Vertical forests: real-time solution for the upcoming rise of air-pollution in India

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Abstract

Cutting of trees leads to the accumulation of greenhouse gases which poses an increasing threat that leads to an unfavorable climatic patterns. Due to smog and heat, metropolitan cities experiences bad weather condition leading to massive deaths which are more common in the past decade. Industries, vehicular emissions and other means poses a prominent cause that makes worse in the concentration of high toxic molecules in the air from multiple sources. Accumulation of Nitrous oxides, silicon gases increases the photochemical smog accumulating in the air which stimulates global warming by preventing the oxygen supply and fresh air. This inhibits the free flowing of oxygen supply which leads to various health issues and chronic infectory syndromes. To mitigate the rising effects of air pollution, a real-time solution called Vertical Forest has been proposed. The establishment of vertical forests produces its own local atmospheric zone by absorbing CO_2 and dust particles thus providing oxygen supply and humidity thereby facilitating the sustainable growth and development of the ecosystem. Vertical forest when integrated along with Internet of Things (IoT) favors efficient and a high synergy which contributes the sustainability in an effective way.

Keywords: Vertical Forest, IoT (Internet of Things), Heat Wave Deaths, Greenhouse gases.

Introduction

Global Warming became a major threat that poses a "Nightmare" to all the countries of the world. Though several reasons persist, it does not refer to the slow rise in the global mean temperature but a drastic change which cause a destructive impact on a mass scale. The emission of greenhouse gases are produced by the unanimous burning of wastes, metal, etc. which causes destruction to the Ozone layer in the atmosphere. The sudden rise in global temperature stimulates the occurrence of arrogant climatic factors in the form of famine, torrent and dearth, etc.[1,2,5] The average temperature in India rose from 1°c to 2°c from 2000 to 2005 which is expected to be doubled from the past decade. The emission of greenhouse gases retains the heat produced by the sun in the stratospheric layer. This leads to the accumulation of harmful gases which prevents heat radiated by the sun to be absorbed back into the space which is a natural phenomenon. Heat stress induces the normal body temperature to become stressed thereby provoking the infectious diseases such as cholera, dysentery, sweating, collapse and even heat-wave deaths[2]. Climatologists believe that the intensity of heat waves produced by the greenhouse gases has been in force which is expected to rise in the near future[3]. Within 21st century, it is estimated that the temperature would rise from 2.5°C to 5.5°C in India[3,4]. This has created a direct destructive impact in the climatic cycle which impacts the decrease in the air quality index, where the result leads to the lower yielding if crops, heavier consumption of energy, waterloss, and drought etc. The high temperature ambience has made an increase in the infectory disease which became more predominant than the past decade[6]. In 2017, both Andhra Pradesh and Telangana records the highest heat wave deaths of about 4200 to 4500 on an average which is expected to rise even more in the fourth coming years[7,8]. In order to prevent global warming of Indian cities, a real solution where both urban and rural areas can be orchestrated towards sustainable farming and afforestation practices, etc. Green Revolution has created a most promising methodology in revolutionizing the sustainable way of farming methods such as terrace farming, window farming, vermi-composting and so on. One such solution is the introduction of the vertical forest by the architect steffani Boeri[9,10]. He made a remarkable design in the construction of buildings which made a significant change in the art of reforestation where mankind has a feasible support to live with nature. With the help of vertical forest the smog, air pollution gets reduced to a considerable effect which also promotes the efficient supply of oxygen thereby providing humid air conducive to live.

Vertical Forest

Life styles in Indian metropolitan cities have migrated from separate homes into residential apartments in order to counter the dense population[2]. This result in cutting of trees (deforestation) thereby is making the ecosystem to become more unproductive to live. Government have made several initiatives

like Green India, Clean India and by allowing projects like eco-city, smart city huge investments have been made in order to make the sustainable living environment for the harmonious lifestyle of the people along with nature. Its been a day dream that the concept of eco-city came into the realistic existence. The ultimate goal of the eco-city is the elimination of carbon wastes (i.e. zero-carbon city) by the utilization of renewable resources and to make the world to be happy place to live for the mankind[10].

Evolution of Vertical Foresting: V**ertical Foresting** is a model fueled by Stefano Boeri in the city of Milan in 2014. The basic idea behind vertical foresting is giving back to nature which made the world wide architects to renovate the art of farming even too. With the thought of "Trees in the key", a sustainable method of vertical growth of trees in the residential buildings of metropolitan cities which contributes to biodiversity came into reality[6]. To support the concept of eco-city in the urban environment vertical foresting has been the most promising solution to mitigate the rising air pollution in India.

The First Vertical Forest in Italy: Bosco Verticale is the first vertical forest which was built in a pair of residential buildings where each tower houses has trees which absorbs smog and generates oxygen which limits the temperature in both seasons of the year[7]. The plants are suppresses the noise. The model has been tested such that the trees will not topped off due to the forces of wind. The trees include shrubs, perennials and facades where the vegetation accounts to one hectare of wood land. It is a green technology innovation abstract which encompasses leaves as a base in the geometry used instead of the raw materials in use. It is the sole responsibility of the designer to suit the environment in such a way the design has to accommodate sunlight by adjusting the physical, technical and the mechanical properties to adapt the environment thus facilitating the sustainability parameter[6]. Several biologists and horticulturists were concerned and engineered in order to evaluate the load imposed by the plants on the wall buildings. Keeping this in mind, podiums and balconies are built using reinforced steels.

Mitigation and its Effects: The vertical increases the biodiversity where the plants in the towers a virtual ecosystem thus providing habitats to the insects and birds for copulating the flora and fauna of the region. The new architectural design has wide opened the front doors for the smart cities which enables a nature based lifestyle, thus providing the space for the ballooning green harvesting and plant life. Vertical Foresting enables us to have a own climatic condition which absorbs the unwanted particulate matter present in the air. The model provides diversity and protects people and environment from sun radiations and from water contamination. Vertical Foresting aimed to have a control over its urban centers where each area of a urban sprawl. Small trees which are planted in the buildings have to be managed under the regulation supporting green foliage and vegetation. Drip Irrigation facilitates maintaining an ecosystem habitat across the floors by the sprinkling of water.

Second Vertical Forest in China: China as opened its doors for vertical foresting in order to reduce the nightmare about air pollution which became a major concern suited for countries with big populations. Nanjing twin towers encompass a large number of trees which covers a geographic area of about 65,000[10]. It is sensed that the emission of co2 has been absorbed to the order of 25 tons which produces 60kg of oxygen supply every day.

Vertical Forests in India: The Garden city of India, Bengaluru has got its first vertical garden which contains more than 10 species of plants planted already[12]. Automated Drip Irrigation facility has farms the garden of about 100 ml of water daily. The inculcation of these methods curbs air pollution and noise and provides a conducive environment for the adaptation of the ecosystem. It reduces the temperature and smog by purifying the air and supplying oxygen which absorbs the noise pollution too. It also engulfs a eco-friendly habitat for the flora and fauna. By making the walls full of green foliage, air pollution gets lowered which reduces the temperatures during summer by means of plant physiological cycle, thereby dropping the particulate matter and the absorption rate in the city. Buildings which are green foliated provide heat isolation which reduces power consumption, thereby decreasing the rate of pollution present in the environment[10].

Architectural Design

The architectural design of the vertical forests consists of towers which made of reinforced concrete along with the stair cases, elevators and mechanical, electrical and plumbing systems. The apartments have direct access to the terraces. The loads imposed by the plants can be calculated by the weight of the deepest container which has to ensure in terms of wind forces. After the plants are carefully selected, the main task is to find the center of gravity and air permeability. The trees are selected in such a way that they should be large or medium. The textile belts are used in order to root the balls of the tree. Figure-1 shows the architectural methodology of how to construct the vertical gardens in tall buildings[9].

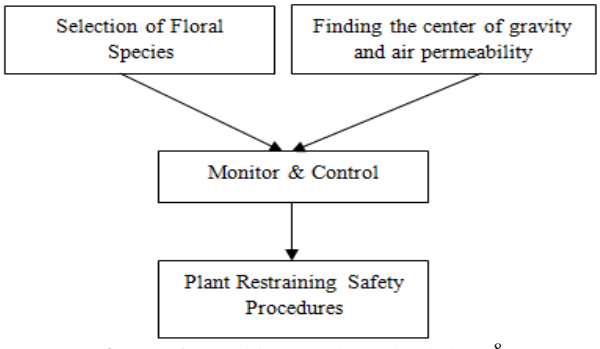

Figure-1: Architectural Methodology[8].

Selection of Floral Species: Specific criterias are necessary to be considered in order to accomplish the careful selection of floral species. The trees are chosen in such a way that they have tpo be grown according to the maximum height of the species in the nature. Careful attention has to be paid on the taller species which needs higher maintenance. Some of the specimens of the species are listed below as follows: Fagus Sylvatica-European beech, Parottia persica-Persian Ironwood, Quercus Ilex-Holly Oak, carylus Columa-TurkishHazel, Prunus Subhirtella-Higan Cherry, etc.[9]

Finding the center of gravity and air permeability: There are three different magnitudes to be considered while during the design of the vertical forests. The magnitude of the vertical depends on the size and thickness of the crop. It is because the vertical trees acts as sunscreen, windscreen and uses solar energy in order to perform transpiration and photosynthesis. Selection of trees based on these magnitude levels are divided into three types Q_1, Q_2 and Q_3. Selection of plants and shrubs are differentiated according to these magnitudes where Q_1 magnitude trees contributes high load which was countered by Q_2 magnitude which encompasses taller trees and Q_3 magnitude of shrubs and vegetative plants. The magnitude levels are summed up which should be related to find the center of gravity that does not restricts the possibility of air permeability[9].

Plant control system: The main concern is the management of the vertical forest ecosystem which are of three procedures as follows: shrinking, watering and dressing. Tree pruning is of much importance such that the growth should not restrict the load balance of the towers. Fertilizing is the main ingredient which facilitates the growth of the vertical trees with adequate watering capacity. Water consumption has to be reduced in such a way that drip irrigation has to be performed. Tree pruning maintains and manages the ecosystem by cutting the unwanted edges sproucing out from the tees during the summer time of the vegetation.

Shrinking: Shrinking of trees is an imporatnt factor since the flora installed has to be in a pre-determined shape such that the control has to be taken in a way that it should not impose much load in the building.

Watering: An IoT based automatic irrigation system that monitors the flora in order to undertake the maintenance and growth of the plants installed in the Verticale respectively.

Dressing: Dressing for plants has to be done very often in accordance with watering so that the nutrients required for the flora shows a beautiful impact on the growth and favors energy surge that takes care of the whole building.

Monitor and Control: All the discussed details are to be carefully monitored such that a report has to be made in a due course of monthly basis for the effective maintenance of the ecosystem.

Effects of Vertical Foresting in the Ecosystem

Pros: Vertical Forest Ecosystem suppresses the global mean temperatures of both urban and rural cities which absorbs CO_2 and the photochemical smog as well. It also cleans the air pollutants and mitigates fuel vehicular emissions which also act as a sound proof barrier. It creates habitats for birds and beneficial insects, thus increasing biodiversity. It also has several advantages which includes the speeding up of recovery time for patients through biophilia. Green construction lowers the extreme temperatures, by absorbing dust, and emissions. Green walls acts as a heat isolator which reduces the demand for power consumption too[10].

Cons: The adoption of vertical forests in cities requires huge construction and Maintenance costs. Pollination has become a major factor which sustains the ecosystem. The labour cost soars high too.

Conclusion

Smart city projects in India have gained a massive attention where if vertical foresting gets included then a vertical forest can be brought into existence. Further research and inclusions along with IoT(Internet of Things) enables even more smarter projects where human race will rage into the ancient times being a part of nature.

Future Scope: Incorporation of tree sensors along with the IoT kit(Raspberry Pi 2 kit) enables a new area whereby provides a most significant and a promising real-time solution in order to compensate the rise in air pollution and the heat wave deaths as well too.

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