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The Botanical Tower An Engineering Solution

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Abstract: Air pollution has wide-ranging and deleterious effects on human health. The Global Burden of Disease study has described the worldwide impact of air pollution with as many as 5.5 million deaths [1] in the year 2016. The main air pollutants are in gases forms, particles in suspension, different ionizing radiation forms. The gases forms are oxidized and reduced forms of carbon (CO2, CO, CH4), of nitrogen (NO2, NO, N2O4, NH3, $NH4^+$), SO2, O3, C6H 6 vapors, Hg, volatile phenols, Cl2, etc. The particulate forms are PM10 and PM2.5 particulate matter, heavy metals with toxic effect (Pb, Ni, Cd, As), polycyclic aromatic hydrocarbons PAHs, etc. A study across the Chicago region determined that trees and plants removed approximately 17 tons of carbon monoxide (CO), 93 tons of sulfur dioxide (SO2), 98 tons of nitrogen dioxide (NO2), and 210 tons of ozone layer[2]. With more than 12 thousand people residing per square kilometer indicates the limited availability of usable land area and forest cover being less than 23.68% [3] forced us to think on the principle of maximum vegetation in minimum land area. Based on this principle Botanical Tower is the solution which is expected to increase the Green cover up to 11 times of the original area.

KeywordsAir Quality Index, Wind Rose Diagram, pollution level study of ghaziabad

I. INTRODUCTION

While the world is struggling with climatic terror and it has proved difficult to cope with the nature's wrath. Air pollution has started swallowing the lives of millions (approx. 7 millions in 2014) [4]. The emission of pollutants in the atmosphere is an inherent byproduct of combustion process. Recent research have found that ambient concentration of fine particulates matter including pollutants like benzene, formaldehyde, carbon monoxide, carbon dioxide etc. are responsible for the ozone layer depletion and also damaging the earth's environment[5]. These factors are associated with incidence of premature mortality and morbidity outcomes. Also resulting in premature death related to poor outdoor air quality.Solution to every environmental problem is to bring the environment to its natural stage. Today we are dealing with the problem of maintaining the balance between the pollutants and oxygen level concentration in the atmosphere. Last few decades have witnessed an exponential growth in the concentration of these pollutants. Countering the imbalance in the atmosphere involves the need to increase the vegetation in the surrounding. Based on the current scenario the requirement of the vegetation has increased proportionally with the increase in the amount of pollutants. But the problem currently has elevated to such an extent that even the previous state of nature won't help us. With carbon emission crossing more than 40Gtc (40 billion tonnes of carbon) per year [6] and release of toxic chemical being more than 310kg per second [7] in our environment. It was the need of the hour for us to research for effective solution.Engineering solution to this problem is the construction of Botanical Tower. Botanical Tower is a structural building which provides maximum space area for the vegetation in minimum land area which will responsibly remove the harmful pollutants from the atmosphere.The project is the result of an inspiration from small scale terrace gardening to Chinese ambition of Forest city. Careful selection of the particular species and the allotted land area to each one of them will eliminate the proportional pollutants in air. The construction of this Botanical Tower will help us to reach the contented amount of oxygen level in the atmosphere and also reduce the concentration of carcinogenic pollutants and increase outdoor air quality.Notable points in the construction of Botanical Tower is the selection of species, allocation of land area, building of such an huge structure which can sustain heavy dead load, earthquake load, wind load, etc. Selection of materials and resources of energy to construct eco-friendly and economical structure with be the major challenge. Also to ensure the growth of species in restricted constraint is the major blockage.

II. PROBLEM DEFINITION

Facts about Air pollution [8]

- More than nine out of 10 of the world's population – 92% – lives in places where air pollution exceeds safe limits, according to research from the World Health Organization (WHO).
- Air pollution is the fourth-largest threat to human health, behind high blood pressure, dietary risks and smoking.
- There were an estimated 6.5 million deaths worldwide from air pollution-related diseases in

2012, WHO (World Health Organization) data shows. That's 11.6% of all global deaths – more than the number of people killed by HIV/AIDS, tuberculosis and road injuries combined.

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- More than 1 million air pollution-related deaths occurred in China and over 600,000 in India in 2012, according to the WHO.
- The study by the World Bank and the Institute for Health Metrics and Evaluation (IHME) calculated the economic cost of air pollution. It found that air pollution led to one in 10 deaths in 2013, which cost the global economy about $225 billion in lost labor income.
- WHO guidelines state annual average concentrations of PM2.5 should be below 10 micrograms (mcg) per cubic meter, but the vast majority of the world's population is living in areas exceeding this limit.

Facts about pollutants of Air pollution

- Emission of Carbon dioxide has crossed the 40 GTC (40 billion tonnes) per year which is exorbitantly high than the specified standards [9].
- Emission of Greenhouse gases has crossed 46GTC per year and has led to the ozone layer depletion, global warming, etc[10].
- Emissions of SOx, NOx and the VOC (Volatile organic compounds) have increased by many folds.

Going through all the perspective mentioned it has been observed that the growing air pollution is not only tarnishing this modern world but also affecting our sustainability. The problems in bringing our Earth to natural state is classified into three simple categories are as follows:

1) Enormous population growth.
2) Growing pollutants.
3) Depleted vegetation.

Enormous population

For the last 50 years, world population multiplied more rapidly than ever before, and more rapidly than it is projected to grow in the future. In 1950, the world had 2.5 billion people; and in 2005, the world had 6.5 billion people. By 2050, this number could rise to more than 9 billion (see chart "World Population Growth, 1950-2050"). If we are intending to increase the vegetation cover, then where we would allocate this huge population of 7 billion as land area is confined?

Growing pollutants

Concentrations of carbon dioxide, the major cause of global warming, increased at their fastest rate for 30 years in 2013,despite warnings from the world's scientists of the need to cut emissions to halt temperature. The annual greenhouse gas bulletin from the WMO showed that in 2013 concentrations of CO_2 in the atmosphere were 142% of what they were before the Industrial Revolution. Other potent greenhouse gases have also risen significantly, with concentrations of methane now 253% and nitrous oxide 121% of pre-industrial levels. If we avoid the population issue and yet pour the efforts to bring back the nature to its original state, then the vegetation area would be too less to handle such huge pollutants which is already present and increasing exponentially.

Depleted vegetation

India has lost 367 square kilometers of forest cover in the past two years. According to the India State of Forest Report, 2011, released by the Forest Survey of India (FSI) on February 7, the total forest cover in the country is now at 6,92,027 sq. km. This accounts for 21.05 per cent of the total geographical area of India. The already depleted vegetation area would have been occupied for residential, industrial, commercial, etc. purpose, thus it's not feasible to remove the setup at once. Who will then feed such huge population, What about the production, shelter, clothing, etc.? So, we as being Civil Engineering, we are designing an ambitious solutions to all the problem described above – THE BOTANICAL TOWER

III.REVIEW OF LITERATURE

NASA conducted its CLEAN AIR STUDY [11] programme in 1989 to clean the air in the space station for the scientists. Its results suggested that certain common indoor plants may provide a natural way of removing toxic agents such as benzene, formaldehyde and trichloroethylene from the air. Industrial areas in India like Vapi, Ankleshwar, Ghaziabad, and Singrauli have also led us to face the same problem due to the heavy concentration of pollutants in the atmosphere.NASA researchers suggest efficient air cleaning is accomplished with at least one plant per 100 square feet of home or office space. Since it was not feasible to grow one plant per 100 square feet hence botanical tower is the solution. This study estimates the total damage costs of air pollution to be US$ 3.0 trillion in 2010, or 5.6% of Gross World Product (GWP) . These losses are equivalent to US$ 430 for every person on the planet. Damage costs are divided almost equally between indoor and outdoor air pollution at the global level; while around two-thirds of the damages are to the populations of developing countries. Health related damages account for 85% of total damages.

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Global damage costs are on a downward trend: starting from around 23% of GWP in the year 1900, the damage costs are predicted to fall to below 3% of GWP by 2050.
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IV.METHODOLOGY

Pollution, population and Land area are the major blockage in the path of restoring the nature to its natural state. Scientists have been trying to invent the machinery which can replace the huge area of natural vegetation to a compact solution of oxygen production and air purifier. But it has only yielded the realization of the importance of THE GREEN patch on Earth.The solution to the mentioned problem of maximum vegetation in minimum area can be resolved by building the storied house for plants in industrial vicinity. There are over 1 million species of plants on Earth [12] and we are gifted with variety of useful species which can remove almost all of the pollutants from our environment.

No.	Pollutants	Species for encountering the specified pollutants
1	Benzene (Particulate)	Chinese evergreen, Peace lilies, Snake plant, etc.
2	CO_2	Cilivia, Monstera, Pachira, etc.
3	Formaldehyde	Rubber Plant, Chlorophytum, Broadleaf Lady Palm, etc.
4	Toluene	Dracaenas, Moth Orchids, etc.
5	Trichloroethylene	Dracaenas, Areca palms, English ivy, etc.
6	CO	Golden pothos, Bamboo palms, Rubber Plant, etc.
7	Ammonia	Chrysanthemums, Peace lilies, Creeping Lily turf, etc.
8	Chloroform	Bamboo palms, etc.
9	Xylene	Spider plant, Areca palms, Chrysanthemums, etc.

Table: 4.1

Agenda of the construction are as follows:

- Deciding the appropriate location for the Botanical tower considering the wind data, type of industrial belt and geographical map.
- Selection of the effective species so as to remove all of the pollutant around surrounding.
- Will appropriately allocate the carpet area to each species according to their benefits and corresponding proportion of the pollutants in the air.
- Deciding floor to floor height to occupy all the species and also to provide required ventilation.
- Construction of a storied apartment to sustain extreme dead load, wind load and earthquake load of about 20-25KN/m^2 [13].
- We will use minimum soil thickness for the growth of the species as even a 0.1metres of thickness soil will increase the dead load of about 2KN/m^2.
- We will be required to provide extremely impermeable waterproof layer using combination of Geomembrane, Geo filters and Geo textiles as provided in liner in the waste dump.
- Planning and provision of the drainage layer, insulation layer and supply channel for the water.
- Using natural sources of energy and making it economical in construction and a complete GREEN and ECO-FRIENDLY structure.

We are required to design a suitable steel or concrete structure to meet such an exorbitant loading conditions. Our structure must be able to resist all the natural calamities as the investment for this ambitious project will be huge. The

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project must not only effectively eliminate the Air pollutants at its sources but also ensure the recovery of lost natural fauna.

Location of the Botanical Tower will be decided by considering the various factors such as Wind direction data of the specified industrial location, type of industrial belt, pollutants released by the industries, distribution of the industries in the given area and most importantly is the availability of land and funds.

Major Area of our research are as follows:

1. Selection of industrial area where project would be prove highly efficient and fruitful
2. Study of the Air Quality Index and Pollutants level in the selected environment
3. Selection of Construction Site for the proposed Industrial area and the planning aspects
4. Selection of species depending upon their air filtering capacity and their growth parameters

V. DATA ANALYSIS

Three major industrial areas were brought under the comparative study i.e. Vapi GIDC, Ankleshwar GIDC and Ghaziabad Industrial Area. They were extensively compared for their Geographical area, Area of Impact, Extent of Impact, Impact severity, currently deployed purifying tools, Vegetation area surrounding the industry, etc.

As Ghaziabad comprises of about 1500 small, medium and high scale industries [14]. It emits tremendous Air pollutants as can be observed in data from CPCB. Data collection of Air quality Index of Ghaziabad observed for more than 3 months urged the necessity of an innovative solution. Study revealed that the PM10, SO_2, NO_2, PM2.5, O_3 and CO always lies under Moderate to Severe category. Air quality of Ghaziabad continues to be severe every day during our observation. [15]

Selection of Species

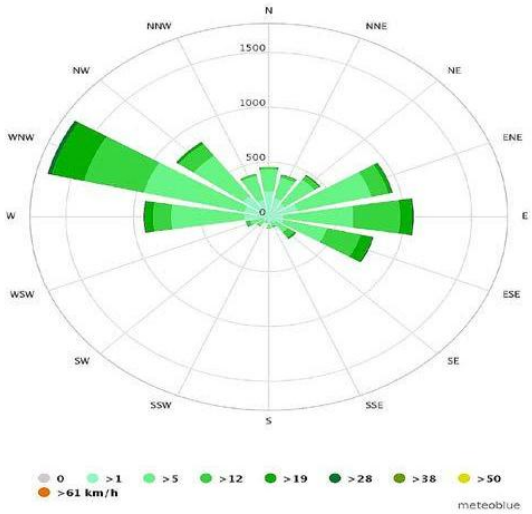
After studying the Air Quality Index and the relative proportion of pollutants in the air of Ghaziabad, the main objective was to find species of plants which can counter and thus purify the air.

Various species was scrutinized and were selected on the basis of the following criteria:

1. Ability to remove harmful pollutants such as benzene, formaldehyde, carbon dioxide,etc
2. Oxygen producing capability up to greater extent
3. Ability to carry out photosynthesis at ranging temperature
4. Based on their dimensions, weight, and their natural habitat

Selection of the site of construction should be such that maximum amount of the air in the atmosphere should come in contact with the botanical tower for its purification. Thus Wind Rose Diagram is important in appropriately deciding the location and dimension of the building.

Wind Rose Diagram was superimposed on the Geographical Map so to identify the area of maximum impact and thus suitably locate our tower.



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VI.CONCLUSION

Thus after conducting a successful research over the project for its feasibility and outcomes. We would be able to achieve the following benchmarks.

1. Depolluting approx. 60-70% (estimated, based on the wind data study) of the pollutants at its source and thus achieving the most efficient air filter machinery at such a huge scale and extreme low cost.
2. Oxygen (O_2) concentration will be elevated soothingly and thus lowering the proportion of CO_2 in the environment proportionally.
3. Green cover of up to 11 times of the original area will be achieved and thus tackling our major concern of Maximum vegetation in Minimum land area.
4. A center of Research Study for Medicines will be established and simultaneously boosting the development of Ayurveda as well.
5. Protection of useful endangered species.
6. A Location of Tourist Attraction which will eventually attract great revenue and subsequently decreasing the maintenance expense and proving the structure financially profitable.
7. Dangers of Acidic Rain and Pulmonary, Respiratory, Nephrological, etc. disorders will be eliminated to near zero level.Ultimately, it will be a Locality to be loved for living as well as industrializing and eventually a Role Model for entire Globe Selection of Site for Construction

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