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PHYTOREMEDIATION OF INDOOR POLLUTION-A MINI REVIEW

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ABSTRACT

Recently, several reports of poor indoor air quality at home and work places with serious side effects on human health have hit the headlines. Though we spend 90% of our time indoor, the monitoring and control of indoor air quality has been neglected. Sources of indoor air pollution consist of combustion products from oil, gas, kerosene, coal, wood, tobacco products, building material, asbestos, carpet fibres, pesticides used in home, biological pollutants like mites and molds and aerosols from personal care products. Outdoor air pollution also enters the indoor area by ventilation and infiltration. However, the pollutants persist in the indoor air for long time duration exerting detrimental effects on the occupants. The commonly observed harmful effects are irritation of eyes, nose and throat. Also cough, wheeze, chest tightness and increased airway responsiveness to allergens. Many indoor ornamental plants such as spider plant, snake plant, golden pothos and Gerber daisy *etc*. have been seen to mitigate the indoor pollution. In fact, the nursery business is blooming due to increase in demand of these plants. Plants remove pollutants such as carbon dioxide through photosynthesis, degrade volatile organic compounds (VOC) through rhizosperic microbes and have the capacity to sequester particulate matter. An interesting concept of green walls or botanical biofilters is causing waves in phytoremediation. The early results of such systems are encouraging. The present paper reviews the plants and mechanism of pollution mitigation through indoor plants.

KEYWORDS: Indoor Air Pollution (IAP), Volatile Organic Compound (VOC), Indoor Air Quality (IAQ), Phytoremediation.

INTRODUCTION

India is one of the most populated countries in the world. Dense population has resulted in high indoor pollution (IAP) due to human activities such as cooking, fuel used for heating, tobacco, developing industrialization, chemical cleaner, from chemicals and infiltration from ventilation. Indoor air has been reported to be more polluted than that of outdoor.[1,2] Indoor pollutant consists of several toxic gases such as volatile organic compounds (VOC), Trichloroethylene (TCE), xylene, toluene and formaldehyde, octane, α-pinene, benzene, Carbon monoxide (CO), Nitrogen dioxide (NO_2), pesticides *etc*. Outdoor pollutants which involve Industrial or agricultural activities and traffic conditions also infiltrate into indoor air.[3] lHarmful effects of IAP are manifested as Asthma, cancer, cardiovascular diseases, Sudden infant death syndrome (SIDS). Some of the common indoor pollutants and their harmful effects have been summarized below:

- **Volatile Organic Compounds**: (VOC) - Cause respiratory tract diseases, nerve diseases, irritation of eyes, and loss of coordination, visual disorders, nausea, allergic reactions, and asthma.
- **Formaldehyde** - Causes breathing difficulties, Skin rash, other allergic reaction.
- **Moulds** - Conjunctive irritation, nerve diseases, Hypersensitivity reactions, asthma, Systemic infections, asthma.[4]
- **Carbon Monoxide**: Causes fatigue, vomiting, irritability, sleepiness, confusion, Unconsciousness, coma and Death.

Indoor air quality (IAQ) has thus become a concern of grave public concern. Phytoremediation is emerging as an important way for the mitigation of IAP. Plant mitigates indoor pollution through different processes which involve phytoremediation, adsorption, and absorption and stomata uptake. These activities depend upon the surface area of plant leaf and also the plant variability, temperature, humidity, water available, light source etc. Therefore it would be of great scientific as well as public value to know about the plant species that can be used to treat IAP.

General Benefit of Indoor Plants

1. Enhancement in IAQ (Indoor Air Quality): By the help of indoor plants (IPs), CO2 (carbon dioxide), NO2, Volatile Organic Compounds (VOCs) and other harmful indoor pollution are absorbed by plants their medium. Indoor air mitigate by the IPs.

2. Reduction in energy depletion or greenhouse gas emanations: Canada display that the shading by the use of living walls reduce indoor heats significantly in summer and resultant in lowering of energy budgets around 23%.[5]

3. Reduction in heat: Because of evapotranspiration green wall reduce temperature nearby the planting area. Alexandri's study determines that green walls beneficial in reduce temperature down to more 'eco-friendly' levels or energy saving for cooling buildings near by 32% to 100%.[6]

4. Hydrology: Indoor plants effective on hydrology because they can successfully control quick release of stormwater to the drains.

5. Depletion in sound pollution: Plants and their medium effective by way of sound barriers which can be seen on several roadside.

6. **Food production:** By the use of vertical green wall people also can grow food on their wall.

7. Enhancement of healthiness or comfort: Because of green wall people have supplementary vegetation inside our livable atmospheres which raise working situation. In a survey in the USA will show that employees are more satisfy with greenery atmosphere.[7,8]

Some of the plants which have been reported to reduce indoor pollutants have been tabulated below:

Table 1: Plants that remove indoor pollution.

PLANT NAME	SCIENTIFIC NAME	KNOWN POLLUTANT REMOVED	HABITAT
Spider Plant	*Chlorophytum Comosum*	Benzene, Formaldehyde CO Xylene	Tropical and Southern Africa, Western Australia
ZZ Plant	Zamioculcas zamiifolia	Benzene, toluene, ethylbenzene, and xylene (BTEX)	Tropical Africa, Kenya
Snake Plant	*Sansevieria trifasciata*	Ethylbenzene toluene VOC	Tropical West Africa from Nigeria east to the Congo
Golden Pothos	*Scindapsus Aures*	Toluene Benzene CO NO_2	Native to the understory forest in the Solomon Islands
Aloe	*Aloe*	Benzene Formaldehyde.	Tropical and subtropical territories
Chrysanthemum	*Chrysanthemum indicum*	Formaldehyde	Mountain slopes, Grassland area, groves, wet places and roadsides, rivers fields, saline area by coastlines

Gerber Daisy	*Gerber Daisy*	Trichloroethylene Benzene	Native to South Africa.
Areca Palm	*Chrysalidocarpus lutescens*	Toluene Xylene Formaldehyde Dibutyl phthalate	Tropical to many temperate climate zones

REMOVAL MECHANISM

Different mechanisms by which plants remove indoor pollution include 1) microbial degradation (rhizospheric microorganisms) 2) plant-liquid extraction (phytoexteraction), 3) plant-gas extraction (stomatal uptake), 4) enzymatic catalysis inside tissues, 5) directly by evaporation from leaves or indirectly by plant transpiration (Figure 1).[1,9,10,11,12] A few authors suggest that impurities are removed by shrubs through root system, by soil, or through stomata in case root.[13,14] Rhizosphere microbial flora is also responsible for pollutant removal.[10,1,2,15] Gases which are absorbed by plant diffuse into intercellular space which react with inner surface of leaves or absorbed water to form acid. Suspended air particle are diverted along with the leaf surface and fall to the ground rain fall. It is testified that a large tree with > 77cm diameter deplete almost 70 times more air pollution per annum than small trees which having diameter less than 8 cm.[16]

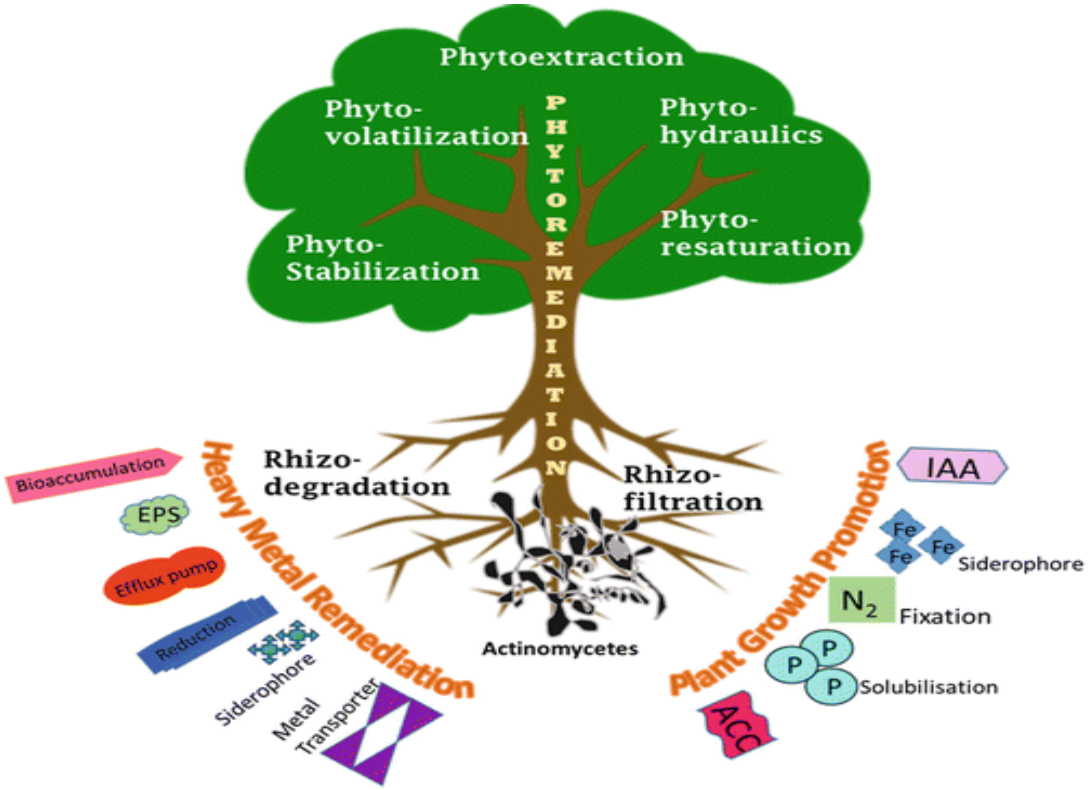

Figure 1: Mechanisms involved in phytoremediation.

Table 2: Plants with VOC and other chemical removal potential.

PLANT	VOC REDUCTION %	REMOVAL OF OTHER POLLUTANTS
Hemigraphis Alternata	44%	Formaldehyde, CO_2
Hedera Helix	38%	Methanol, NO and NO_2
Tradescantia pallida	34%	Particulate matter (PM), black carbon (BC)
Asparagus Densiflorus	31%	NO_x, TVOC
Hoya Carnosa	26%	SO_2 and N_2O

Scientific studies on phytoremediation of indoor pollution

Gawrońska and Bakera in 2014 studied the removal of particulate matter from indoor air from home, apartment, and perfume bottling room using spider plant.[17] Their study revealed that spider plants accumulate significant amount of particulate matter and the accumulation depends on the type of activities happening in the indoor area. Abbass *et al.* 2017 reported the mitigation of ozone from indoor area by five common indoor plants Peace Lily, Ficus, Calathia, Dieffenbachia, Golden Pothos and reported moderate ozone removal from indoor environment.[18] The leaf surface area was the important factor for ozone removal. Kim *et al.* 2008 studied the removal of volatile formaldehyde by aerial and root parts of two common indoor plants *Ficus japonica* and *Ficus benjamina*.[19] They reported that the amount of formaldehyde removed by the aerial plant parts during the day was substantially greater than in the night when the stomata were closed. Orwell *et al.* 2004 studied the removal of benzene by potted plants and the rhizospheric microorganisms and they concluded that rhizospheric micro-organisms were to be the main agents of removal.[20] Strong evidence of plants and rhizospheric and endophytic microorganisms for removal of pollutants has emerged. In a study removal of formaldehyde by *Euphorbia milii* and corresponding levels of IAA were determined. It was observed that has IAA levels and airborne formaldehyde removal by *Euphorbia milii* enhanced when inoculated with endophytic isolates.[21] *Zamioculcas zamiifolia* plants have been shown to detoxify ozone (O_3) on adding of Bacillus cereus ERBP[22] Promising results of toluene removal was demonstrated by bioaugmentation of phyllosphere of *Azalea indica* with a toluene-degrading enrichment culture of *Pseudomonas putida* TVA8 was studied by Kempeener *et al.* 2003.[23]

DISCUSSION

As discussed above these studies are strong advocates for use of potted plants in the indoor environments for mitigation of effect of indoor air pollutants. Studies have indicated the use of native ornamental plants for the IAP removal which can be adopted by individual

households for their benefits. In case of big enclosures, like offices and factory sites, indoor plants should be kept and maintained for reduction in pollutant levels. Design and installation of '*Green walls'* is an interesting concept. Green wall also known as living wall, bio walls or vertical vegetation and it is grown-up on a distinct structural system that can be committed to the wall with automatic watering facility. Green wall reduce heat and air pollutant inside the building and outside also report in climate changes. They contain growing medium, soil, automatic water system and climbing plants or shrubs attach to the wall which creates façade.[5] So, we can get pleiotropic benefit from indoor plants.

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