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Green Ways to Beat Air Pollution

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FOREWORD

Rapid, unplanned and unsustainable patterns of development make urban areas susceptible to environment and health hazards. One of the main reasons behind the deterioration of air quality is the rising concentrations of toxic gases in the atmosphere. Urban air pollution – of which a significant proportion is generated by vehicles, as well as industry and energy production – is estimated to kill around 800,000 people annually worldwide as reported in Health and Environment Linkages Initiative of World Health Organisation (WHO).

There is no such system developed at present that eliminates air pollutants but nature has created some systems to deal with the detrimental fallouts of different anthropogenic activities up to a certain limit. There are some plants that can survive well with higher pollutant concentration. They act as a pollution scavenger without sustaining serious decline in their growth. They improve air quality by providing oxygen to the atmosphere and can serve as tolerant species.

Sensitivity and response of species to air pollutants varies. The plant species which are more sensitive act as biological indicators of air pollution. In order to determine the tolerance or sensitivity of species, the Air Pollution Tolerance Index has been devised, using four biochemical parameters. The index and all biochemical factors of the species help in bio-monitoring and screening out of tolerant species from the sensitive ones. The selection of the species helps landscapers to design green belts around industries and National Highways. This is a reliable and cost-effective method to assess air quality.

According to WHO, around 3.8 million people die every year from the exposure to household air pollution. This household air pollution comes from a variety of sources and includes a wide range of gases, chemicals and other substances. These pollutants contribute to 'sick building syndrome', which causes symptoms ranging from allergies, headaches and fatigue through to nervous-system disorders, cancer and death. Plants are also a solution to enhance indoor air quality. They can effectively remove these pollutants. Through studies conducted by US based National Aeronautics and Space Administration (NASA), scientists have identified 50 houseplants that remove many of the pollutants and toxic gases. Generally indoor plants are selected on the basis of their aesthetic features rather than physiological requirements reflecting their capacity to remove air pollutants.

The slogan for the World Environment Day 2019 was “Beat Air Pollution”. To spread awareness on the theme, we are dedicating this issue on how to tackle air pollution indoors and outdoors. The present issue discusses the Air Pollution Tolerance Index, an important tool to screen out plants, based on their tolerance or sensitivity level to different air pollutants. Indoor pollution poses a serious threat to human health. The issue apprises the readers that in selecting the right plants which can reduce indoor pollution.

Air Pollution Tolerance Index: A Tool to Develop Green Space

Industrialization and Urbanization has a drastic impact on the environment. Air pollution is a key problem in degradation of environment by increasing the concentration of gases and introducing the suspended particulate matter to the atmosphere. It has an adverse impact on human health and environment. Rapid development of industrial science and technology has improved the life style but on the other hand gradually faces problem of pollution. It is very important to take the necessary steps to check air pollution. Research says that there is a link between air pollution and plant because plants can accumulate the air pollutant. Therefore, bio-monitoring is a reliable and cost-effective method to assess air quality. The tolerance of plant species can be assessed with the use of Air Pollution Tolerance Index (APTI), which is calculated from ascorbic acid content, relative water content, leaf extract pH, and total leaf chlorophyll content of tree leaves. The tolerance of plant species at different location decrease in the following order: industrial > roadside > urban areas. This suggests the best conditions for sensitive plants' development and growth in urban areas, while the presence of industrial activities in certain areas demands higher tolerance from plants. The APTI is an index that denotes capability of a plant to combat against air pollution.

Air Pollution Tolerance Index

Plants are organisms equipped with absorption and metabolic capabilities, as well as transport systems that can take up nutrients or pollutants selectively. Different variety of species has varied responses and reacting mechanisms to different types of pollutant depending on its concentrations, its combinations and its duration of exposure. The pollutants when come in contact with the plants are either being removed or are accumulated, chemically transformed or are assimilated into the metabolic system. During the interaction with the pollutants, some plants show minimal effects, while others show permanent damage. Thus, the response of plants to air pollution at physiological and biochemical levels can be understood by analyzing the factors that determine resistance and susceptibility. The use of a single parameter in eco-physiological study may not provide a clear picture of the pollution induced changes that may occur in plants.

The APTI plays a significant role to determine resistivity and susceptibility of plant species against

pollution level. The four biochemical parameters considered for APTI calculations are shown to be affected by air pollution by several researchers. Therefore, an air pollution tolerance index based on combined values of ascorbic acid, relative water content, total chlorophyll and pH of leaf extract has been used for plant tolerance evaluation.

$$\text{APTI}=\frac{[A(T+P)]+R]}{10}$$

Where: A=Ascorbic acid content (mg/gm), T=Total chlorophyll (mg/gm), P=pH of the leaf extract, R=Relative water content of leaf (%).

1. Ascorbic Acid:

Ascorbic acid is known to play an important role in cell wall synthesis, photosynthetic carbon fixation and cell division. It is also a natural antioxidant which plays an important role to prevent the damaging effect of air pollutant on plant tissue. The high amount of ascorbic acid therefore acts as a resisting factor of the plant to adverse environmental condition. It gives tolerance to plant by reacting rapidly with different pollutants. Therefore, the tolerance of plant depends on the amount of the ascorbic acid present in the plant cellular component which provides tolerance to plants from the negative effect of pollutants.

2. Total Chlorophyll Content:

Total chlorophyll content of the plant is a biochemical factor which influences photosynthetic activity as well as the growth and development of biomass. The chlorophyll content of plant varies from species to species; age of leaf as well as with other biotic and abiotic condition. It evaluates the impact of pollutants on plants. Several studies reported that there is a reduction in total chlorophyll content if plants are exposed to air pollutants. Therefore chlorophyll content is very essential for plants and a decline in it indicates air pollution.

3. pH of Leaf Extract Sample:

The leaf pH is biochemical parameter and pH is H+ ion concentration which specifies whether the substance is acidic (< 7), neutral (7) and base (>7). The photosynthesis is greatly affected with low pH value. So when the plant is exposed to air pollutant it alters the pH. An acidic pollutant due to the presence of SO_2 and NO_2 in the ambient air declines the leaf pH value and is the lowest in sensitive species. Higher pH values show resistance of species against environmental stresses. The pH is an indicator of pollution and the type of pollutant in the site.

4. Relative Water Content:

Water is basic need for the physiological activities in the plant. The total water content helps in maintaining its physiological balance under stressful conditions like exposure to air pollution. The relative water content (RWC) of a leaf is a measurement of its hydration status i.e., actual water content relative to its maximal water holding capacity at full turgidity. It indicates a degree of stress expressed under drought and heat stress. Therefore the plants keep high RWC to maintain physiological balance at polluted sites. The RWC is an appropriate measure of plants' water status and serves as an indicator of drought resistance in plants.

Anticipated Performance Index

In order to combat air pollution using green belt development, some socioeconomic and biological characteristics are considered. The Anticipated Performance Index (API) is a combination of parameters like the Air Pollution Tolerance Index (APTI) and several morphological characters of a plant to predict their tolerance to air pollution. The API value of plants species is useful in the selection of suitable plant species for urban green belt development, improving the air quality and providing aesthetic and recreational value. It is used as an

indicator to assess the capability of predominant species in the clean-up of atmospheric pollutants. The APTI and API helps to select the tolerant and indicator plant species to develop the green and eco-friendly environment.

Plants play a major role in maintaining the equilibrium of the biosphere, by cycling nutrients and gaseous elements like carbon dioxide and oxygen. Plants are also known to play a major role in removing pollutant from the environment as part of their normal functioning. Some plants can survive well with higher pollutant concentrations and act as air purifier. These plants can be used as an indicator, as they exhibit visible changes or some symptoms when exposed to certain concentrations of pollutants. Response and sensitivity to pollutants vary from plant to plant. Some are tolerant while some are sensitive. These plants are used as bio-indicators to assess the health of the environment and are also an important tool for detecting changes in the environment.

Several researchers had carried out APTI assessments of different plant and found that plants with a high index value were tolerant to air pollutants and vice-versa.

Air pollution Tolerance Index Range for Plants:

APTI Value	**Response**
<1	Very Sensitive
1 to 16	Sensitive
17 to 29	Intermediate
30 to 100	Tolerant

On the basis of their indices, different plant groups were categorized into very sensitive, sensitive, intermediate, moderately tolerant and tolerant plant groups.

The tolerant plants can be used in plantation on road sides and in industrial areas. Sensitive plants can be grown in public green spaces of urban areas. So plants for their sensitivity/ tolerance levels to air pollution is important because the sensitive plants can serve as bio-indicators and tolerant plants as a sink for controlling air pollution in urban and industrial areas.

Several Researches in the field of APTI reveals that species like *Ficus benghalensis*, *Ficus religiosia, Samanea saman, Bougainvillea glabra, Peltophrum pterocarpum, Azadiracta indica, Polyalthia longifolia* etc. were tolerant to air pollutants and can be used as effective indicators and pollution scavengers.

Air pollution is one of the major environmental problems receiving global attention because of its adverse impacts on both plants and animals. Hence, there is a need of integral efforts toward remediation and monitoring of air pollution. Monitoring air pollutants through plants is not only an economic, convenient and credible method but it is also eco-friendly. Plants show different damage symptoms to different air pollutants. The plants sensitive to a particular pollutant or mixture of pollutants can also be used as veritable tools towards mitigating environmental and health problems associated with air pollution. Screening of plants as a bio monitor is very important. It requires proper selection and screening of sensitive and tolerant plant species which are bio indicator and sink for air pollution. The Air Pollution Tolerance Index and Anticipated Performance Index of the common species are a vital index and play an important role in selection of plants.

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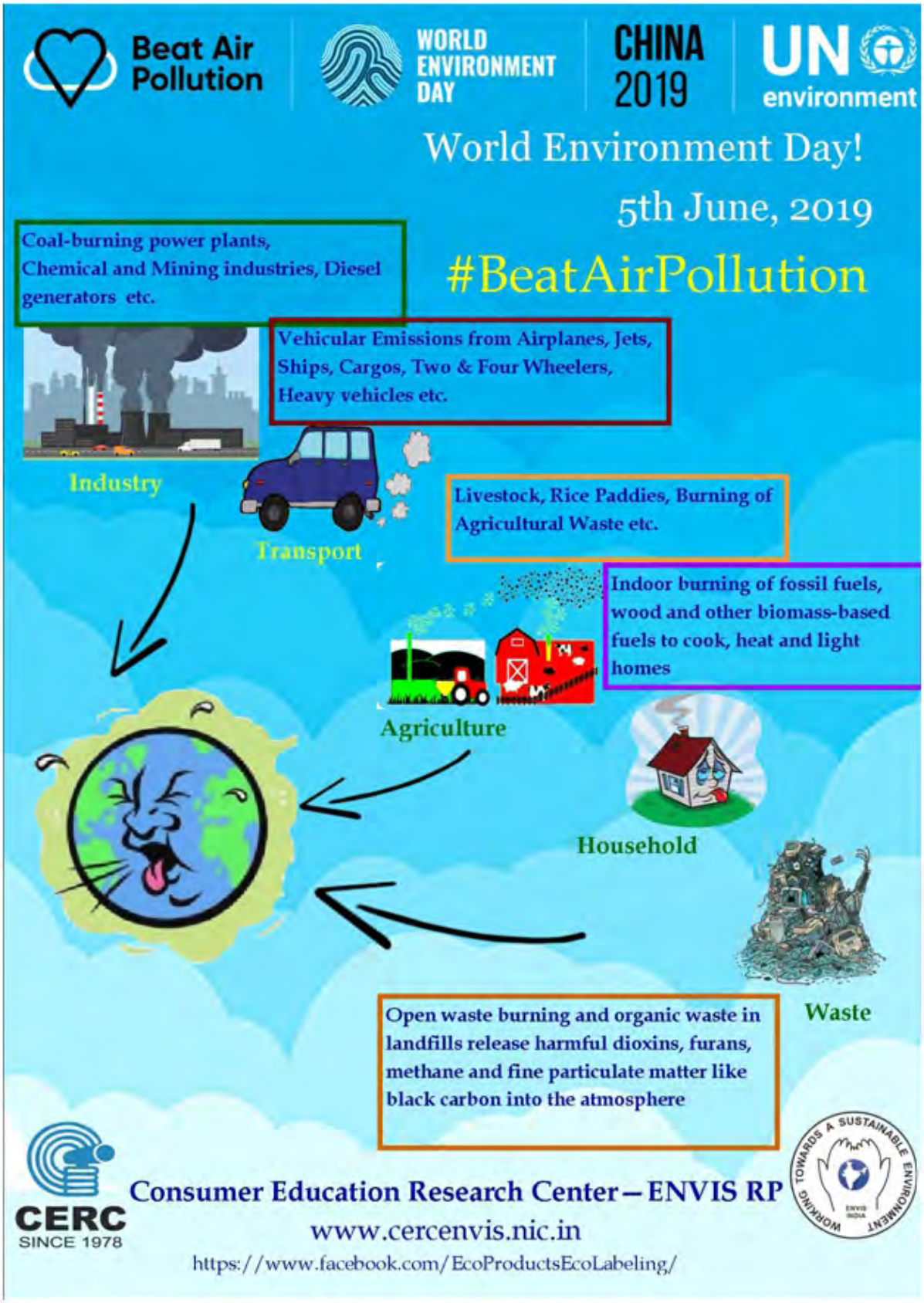
Beat Air Pollution
WORLD ENVIRONMENT DAY
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UN environment
World Environment Day!
5th June, 2019
#BeatAirPollution
Coal-burning power plants, Chemical and Mining industries, Diesel generators etc.
Vehicular Emissions from Airplanes, Jets, Ships, Cargos, Two & Four Wheelers, Heavy vehicles etc.
Industry
Transport
Livestock, Rice Paddies, Burning of Agricultural Waste etc.
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Household
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WORKING TOWARDS A SUSTAINABLE ENVIRONMENT

Natural, Eco-Friendly and Anti-Pollutant Houseplants

Indoor air pollution is fast becoming a grave environmental risk to public health. The term "building related illness" has been coined to describe afflictions such as bronchitis, asthma, etc. that can be traced to specific airborne contaminants in buildings. Two major problems with indoor air pollution are the identification of the trace chemicals and their correlation with disease like symptoms.

Modern homes and office buildings commonly trap pollutants like benzene, formaldehyde, a ubiquitous chemical found virtually all indoor environments, trichloroethylene (TCE), etc. A 2-year study conducted by the US based the National Aeronautics and Space Administration (NASA) and the Associated Landscape Contractors of America (ALCA) shows that some common plants help reduce the rising levels of indoor air pollution and combat the "sick building syndrome". According to the US EPA (Environmental Protection Agency), indoor levels of pollutants may be up to 100 times higher than outdoor pollutant levels and have been ranked among the top five environmental risks to the public. The study of NASA found that there were specific plants that were most effective at removing benzene, formaldehyde, trichloroethylene, xylene, and ammonia from the air – harmful chemicals that have been linked to health effects like headaches, eye irritation, dizziness and nausea. A study by scientists of University of Technology, Sydney, Australia also found that the main agents of the benzene removal were the micro-organisms of the potting mix rhizosphere, but with some species, the plant also made a measurable contribution to removal rates by absorption. Potting mix samples from all plant species remove approximately 97% of the benzene in 24 hours, while the micro-organism cultures remove approximately 95%. Potted plant microcosm has a capacity to contribute greatly to healthier indoor air and lay the foundation for the development of the plant/substrate system as a complementary bio-filtration system.

How indoor plants clean the Air

Most indoor plants have very high rates of photo-synthesis which allow them to grow in very diffuse light, because generally they grow under the shade of the canopy of forests. This feature also allows them to grow indoors. The leaves, roots, soil and micro-organisms work together in a symbiotic relationship to remove pollutants. Air pollutants are removed from the air by being absorbed through tiny pores in their leaves. They are moved through the plant, to the root zone, where they are broken down by soil microbes. Some chemicals are broken down by the plant's own biological processes. They purify and renew stale indoor air by filtering out toxins, pollutants and the carbon-di-oxide we exhale -- replacing them with oxygen. So, with the right selection of indoor plants, we can continuously purify the air, day and night!

Which plants work best

The following plants are out of 50 such houseplants identified by NASA. These are easily available and easy to grow. Here are some, simple and effective ways to detox the inside air.

Aloe vera

Commonly known as Aloe, GhiKanvar or Ghikumari in Hindi.

Aloe vera is a succulent plant species. It cleans the air perfectly. A single *Aloe vera* plant can refresh any small apartment. It removes formaldehyde effectively from indoor air. It is also known for

its medicinal properties. It is commonly used plants in herbal cosmetics and medicines. The gel inside the leaves is excellent for helping to heal burns and cuts. It has beneficial effects on human health and it is easy to grow.

Keep it on the kitchen window sill as it has the quality of absorbing formaldehyde produces from natural gas from gas stove and kerosene. The plant continuously releases oxygen through the night so it's a good one to keep in bedroom as it keeps air very clean.

Alert: Aloe gel is generally safe and can be effective in treating skin conditions such as burns and psoriasis. However, avoid using aloe latex orally. It is toxic to cats and dogs.

Rubber Plant

These houseplants clean the air by emitting high oxygen content, and purify indoor air by removing chemicals, such as formaldehyde or other toxins like benzene and trichlorethylene from the air. It also eliminates bacteria and mold spores from the air. It needs low maintenance.

Keep it in a large open space, preferably with bright indirect light or full sunlight. It can grow outside on porch or terrace in the summer. Varieties with plain green leaves are more tolerant of low light conditions than those with variegated foliage which need several hours of direct sunlight everyday to maintain good colour contrast. It is 'bonsai-able'also.

Alert: The Rubber Plant emits a white sap when pruned or broken. It's irritating to their innards and skin so keep pets away from this.

Peace Lily

Commonly known as Spath.

It is a beautiful plant with gentle white flowers. Pollutants like benzene, toluene, xylene, ammonia, formaldehyde and trichloroethylene are successfully filtered out by the beautiful Peace lily house plant. It also soaks up mold spores. It also effectively removes all common indoor pollutants generated by furniture, electronics and cleaning products. With enough light, peace lilies may produce white to off-white flowers in the early summer and continue to bloom throughout the year. It is a very adaptable and a low-maintenance house-plant.

Keep it near carpeting, rubber, dry-cleaned items, tobacco smoke, gasoline, synthetic fibres, plastics, ink paints, varnishes, lacquers, oils and detergents. Keep these plants out of direct afternoon sunlight, but in a well-lit area.

Alert: All parts of the peace lily plant contain calcium oxalate—a substance that may cause stomach and respiratory irritation if ingested in large amounts. Keep peace lilies out of reach of small children and pets.

Spider Plant

Common names for spider plant include Airplane plant, Spider ivy, Ribbon plant and St. Bernard's lily.

The spider plant absorbs all the chemicals spray while cleaning the apartment. This plant is very simple and undemanding. It is a very popular garden plant and it does not require much watering. It is very adaptable for hanging basket.

Keep it near carpeting, bathroom or window facing traffic/road. They can grow in almost any lighting conditions except for bright, direct sunlight.

Alert: Spider plants are a non-toxic houseplant and safe for children and all pets.

Money Plant

It is also called devil's vine or devil's ivy, Golden Pothos.

This plant acts as an excellent natural anti-pollutant against

common pollutants like benzene, formaldehyde and carbon monoxide. It is a powerful air purifying plant that clean the air in house very effectively, due to its particular affinity for volatile organic compounds (VOCs) most commonly in the form of off-gassing from synthetic paint or carpets.

Keep it in a bedroom, where it is best suited and which is usually closed for long duration during the day time when we are away. We may also place it near the furniture.

Alert: The plant is listed as toxic to cats and dogs because of the presence of insoluble raphides. Due to the calcium oxalate within the plant, it can be mildly toxic to humans as well.

Bamboo Palm

Also known as the Butterfly Palm and the Areca Palm.

It does an excellent job as an indoor, air purifying plant, with a particular penchant for formal dehydes, benzene, trichloroethylene and carbon monoxide. It is also a natural humidifier and making it a well suited plant for dry climates or those with breathing troubles.

Keep the palm in a sunny location or a place that receives bright indirect light. Do not place the palm in direct sunlight or near an air vent.

Alert: It is a non-toxic to pets and humans even if eaten.

Snake Plant

Also known as Mother in Law's Tongue, Golden Bird's Nest, Good Luck Plant.

They help remove benzene, formaldehyde, trichloroethylene and xylene from indoor air. This plant can be seen everywhere, mostly in offices and restaurants. It requires almost no care. It only needs to be watered about once a month. It likes dry air and little sunlight.

Keep it near carpeting and rubber based or dry cleaned items.This plant is great for bedrooms because it converts CO_2 to oxygen only at night so it literally cleans the air as you sleep.

Alert: Mildly toxic if eaten. Toxic to pets.

Chrysanthemum

Also popular as Garden Mum or Mums, Guldoudi in Hindi.

This plant was found by NASA to be a real air-purifying plant. It removes ammonia, benzene, formaldehyde and xylene from home's air. It is popular and inexpensive, plus they can be planted outside too.

Keep it near tobacco smoke, gasoline, synthetic fibres, plastics, ink, paints, varnishes, lacquers, oils and detergents.

Alert: Toxic to both cats and dogs.

Chinese Evergreen

Emits high oxygen content, and purifies indoor air by removing chemicals, such as formaldehyde, benzene or other toxins like carbon monoxide, trichloroethylene and more. They are thought to bring good luck and were used as decoration in Asian countries long before they made it west.

Keep it near gasoline sources and carpeting and away from any cold drafts as well as air conditioning or heating vents.

Alert: Poisonous for pets.

Gerbera Daisy

Commonly known as Transvaal daisy, Daisy.
NASA says this plant is fantastic at removing benzene, a known cancer-causing chemical. They are great at producing oxygen and cleaning the air. It also absorbs carbon dioxide and gives off oxygen overnight, which

is said to improve our sleep! It can remove formaldehyde and trichloroethylene from your house.

Keep them in a sunny spot when they are indoors or in the porch. This is an indoor/outdoor plant. Place outdoors during the summer so that it can get the most sunshine or near sunny, south facing window it will thrive.

Alert: It is not toxic to pets.

Dieffenbachia

Commonly known as Dumb cane, Leopard Lily.

Its large leaf surface area helps it to quickly remove air contaminants from indoor spaces. It cleans formaldehyde and other toxins from the air. It also removes xylene and toluene - two other pollutants.

Keep it near the furniture. It likes moderate sunlight and watering.

Alert: Poisonous to pets. These are poisonous and avoid coming into contact with the sap and if so, wash it off before accidentally rub eye or somewhere equally unfortunate.

Dracaena

Commonly known as Warneckii, the Song of India, Madagascar Dragon Tree and Pleomele.

It is known for removing trichloroethylene, a chemical found in many solvents, dry cleaning solutions and refrigerants. Also said to remove benzene, a carcinogen. It is the most efficient plants at removing formaldehyde from the air in home, as well as other VOCs like benzene and xylene.

Keep under filtered indoor light or a semi-shade spot is an ideal location. This low-maintenance plant is extremely popular and takes little work to keep it alive. It is the perfect bed-room plant.

Alert: Keep pets away from this plant, as it can be toxic to animals when ingested.

Every single one of the houseplants listed above is a great tool in improving indoor air quality. The best method to improve indoor air quality is to have some of these houseplants around.

Apart from these plants, all species of Bamboo palm are very easy to grow and they help in removing volatile airborne pollutants and a wide range of chemical vapours.

How to Position Them

As a rule of thumb, in an 8-foot ceiling house, 2-3 plants in 6x8-inch pots will clean 100 square feet of space. The more vigorous the plant, the more air it can filter.

When positioning the plants, try to strike a balance between light and ventilation because the effect of plants on indoor air pollution appears to be reduced if they are set in a draft. House plants are very sensitive to drafts and also keep away from any heat sources in the house. Place a plant within "personal breathing zone", a space 6x8 cubic feet around where we can work at our computer, watch TV, or sleep. Plants placed within this zone can add humidity, remove bio-effluents and chemical toxins and suppress airborne microbes. Placing several inches of aquarium gravel over the soil in the plant container will help prevent the formation of molds, a common allergen.

Note: Flowering plants need sun to bloom and grow in a sunny spot either near open window indoors or out in the porch (other outdoor plants like this also clean the air when brought inside for a short time)

Source: Insight: The Consumer Magazine, March-April 2005, How to grow fresh air: fifty Houseplantsthat purify your home or offices by Dr. Bill Wolvert on www.wolvertonenvironmental.com
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Celebration of World Environment Day at CERC Campus



On 5th June2019, CERC - ENVIS team conducted an in-house celebration of world environment day with CERC staff, interns and visitors. This year's theme was 'Air Pollution' with the slogan #BeatAirPollution. China was the host country to organize the main event. The programme began with a brief introduction on the objective behind the celebration of world environment day and its theme by Dr. Ashoka Ghosh (ENVIS). Further a brief presentation was made by Ms. Divya Namboothiri (ENVIS) on Air Pollution and its causes, types and its effects on Health and Environment. The programme continued with the participants attending a questionnaire of 10 questions related to Air Pollution by the UN. The participants were showed two videos by the United Nations and one video by the Ministry of Forests & Climate Change. Followed by a pledge to plant more trees. The participants were also requested to donate raincoats and umbrellas for the underprivileged through "Aap le no otlo" – A sharing Platform. The programme concluded by a recital of a Guajarati poem on environment by a CERC Staff Ms. Minal Shukla . The ENVIS team distributed a spider plant to all the CERC Staff members which is known to absorb indoor air pollution.

Extending the festivity of World Environment Day, Van Mahotsava which is an annual tree planting festival was celebrated in the first week of July. During this festival thousand of trees are planted all over India. As a part of this festival, 150 trees were donated by Waterman Industries Pvt. Ltd. Mr Bharat Patel, Managing Director, Waterman Industries Pvt. Ltd, Mr Utkarsh Chhaya, Technical Advisor, Waterman Industries Pvt. Ltd and Mr Uday Mawani, CEO - CERC inaugurated the event by planting trees in CERC campus premises followed by the entire CERC employees.

The Environmental Information System acronymed as ENVIS was implemented by the Ministry of Environment & Forests by end of 6th Five Year Plan as a Plan Scheme for environmental information collection, collation, storage, retrieval and dissemination to policy planners, decision makers, scientists and environmentalists, researchers, academicians and other stakeholders.

The Ministry of Environment and Forests has identified Consumer Education and Research Centre (CERC), Ahmedabad, as one of the Resource Partners to collect and disseminate information on "Environment Literacy - Eco-labelling and Eco-friendly Products". The main objective of this ENVIS Resource Partner is to disseminate information on Eco products, International, and National Eco labeling programmes.

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