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DEVELOPMENT OF STEP-WISE RANKING FOR INDOOR PLANTS AS INDOOR AIR POLLUTANT PURIFIERS

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Abstract: When compared to the outdoor air environment, it is indoors which is more polluted owing to various influences. This anthropogenic forced situation hence warrants inception of natural purifiers/filters such as the indoor plants. However literatures available are ambiguous on the ability of all indoor plants and focuses only on a few, and even those are restricted to random pollutants. Since indoor plants do not remove all pollutants, and also all are not known to perform the natural purification act; it can be quite cumbersome to decide which plant is best suited for any generic toxic indoor air environment. While the ranking of indoor plants is very much needed to strategize the indoor air environment pollution abatement measures; unfortunately at present there is no system available to-date to rank the indoor plants or even a methodology to develop it. The present research focuses on developing a mechanism of ranking in terms of maximum pollutant(s) removal efficiency. To achieve this, initially all indoor plants from the existing literatures were identified, and eventually the weighted 'ranking' was arrived at by studying several parameters such as 'number of indoor air pollutants removed' and 'removal efficiency in terms of their frequency & magnitude'; based on their relative 'severity' ranking. The research arrived at the conclusion that indoor flora namely Spider Plant, Peace Lily, English Ivy and Golden Pothos ranked as 1st, 2nd, 3rd and 4th respectively are relatively the best in terms of indoor air purification.
Keywords: Indoor Air Quality, Pollutants, Ranking, Indoor Plants

1. INTRODUCTION

Most individuals spend more than 90% of their time indoors. Compared to outdoor environment, it is indoors which is more polluted on account of various reasons ranging from bad ventilation & housekeeping practices to modern & tight constructions [1]. Hence this warrants ergonomic corrective measures such as inception of indoor plants, however all indoor plants do not remove any or all pollutants. Environmental Protection Agency (US-EPA) has listed about 50 indoor plants that reduce upto 90-95% of toxic chemical present in indoor environment, with NASA supporting this claim [2,3]. These include Aloe Vera (Figure 1), Areca Palm, Arrowhead Vine (Figure 2), Australian Sword Fern, Bamboo Palm (Figure 3), Begonia, Boston Fern, Ceriman, Chinese Evergreen, Corn Plant, Dumb Cane, Elephant-Ear Philodendron, English Ivy, Golden Pothos, Heart-Leaf Philodendron, Lucid Asparagus, Peace Lily, Reed Palm, Spider Plant etc. [4].

Figure 1: Aloe Vera

Figure 2: Arrowhead Vine

Figure 3: Bamboo Palm

Their efficiency was confirmed by carrying out studies in controlled conditions simulating the natural environment, over a 24-hour period. The process mechanism involves toxic chemicals being absorbed by the plant through stomata and then transferred to the roots where the microbes break down the wide varieties of unhealthy compounds into simpler molecules which could be reabsorbed by plants [5]

2. SCOPE OF STUDY

Currently there are no ranking system or ranks available w.r.t indoor plants due to various reasons such as lack of awareness, dearth of research on indoor air pollution owing to high cost etc. To overcome the resultant gap in literature, the present study advents a new technique with sequential weightage analysis to rank the indoor plants.

3. METHODOLOGY

An ideal ranking approach for indoor plants was developed in this study by a sequence of simple steps. Firstly, all the major indoor plants (available in the literature till date) which purify the polluted indoor environment were compiled, and then screened for obtaining clarity on which all pollutant or pollutants they were able to remove as cited in available literatures. Further weightage analysis was carried out in two stages. Firstly, 30% weightage was decided based on the number of indoor air pollutants. Secondly 70% weightage was affirmed based on the frequency & magnitude of the pollutants removed i.e., removal efficiency based on the removal rate & initial concentration. This part of the computation was majorly based on severity of the indoor air pollutant removed; hence it was ascertained according to the ranking of indoor air pollutants. Presumably, an ideal ranking technique would rank highest those pollutants whose abatement would produce the greatest benefit. For this five sequential criterions focusing on priority wise classification to develop the final ranking. Primarily, from an exhaustive literature survey, all the potential sources contributing to indoor air pollution were identified. Secondly, all the toxic indoor air pollutants were extracted from databases of E.P.A. and W.H.O. In the next step, frequency assessment was carried out for sources and pollutants based on emission and occurrence. The list was then prepared for subsequent stages of assessment. The database was then subjected to analysis, in terms of severity and frequency of health impacts. The previous two rankings were individually subjected to weightages (30% and 70% for rankings of 1st and 2nd assessment respectively) and reassessed for New Ranking. This was further compared with Carcinogenicity Index and Indoor Air Quality Standards. Finally the ranking was arrived at with the top spot grabbed by a chemical that posed the greatest threat to human health, in the least concentration and least frequency [6]. The Subsequent resultant highlighted the Ranking for Indoor Plants as best Indoor Air Pollution Purifiers The results was then compared with the US-EPA list of 'Best Indoor Plants' [3] and NASA's purifying score [2] to validate the efficiency of the evolved methodology.

4. RESULTS AND DISCUSSION

As can be observed from Chart 1, the screening of indoor plants essentially engaged the most dangerous indoor pollutants. These included Benzene, Acetone, Formaldehyde, Toluene, Carbon Monoxide), Nitrogen di-oxide, Trichloroethylene and Xylene; ranked as 1, 2, 3, 5, 7, 9, 10 and 19 respectively. The ranking mechanism and ranking of Indoor Air Pollutants was also developed by the present authors [6]. The outcome of the checklist confirms that the number of plants removing Acetone, Benzene, Carbon Monoxide, Formaldehyde, Trichloro Ethylene, Toulene, NO_2 and Xylene are 1, 25, 7, 34, 19, 18, 1 and 5 respectively.

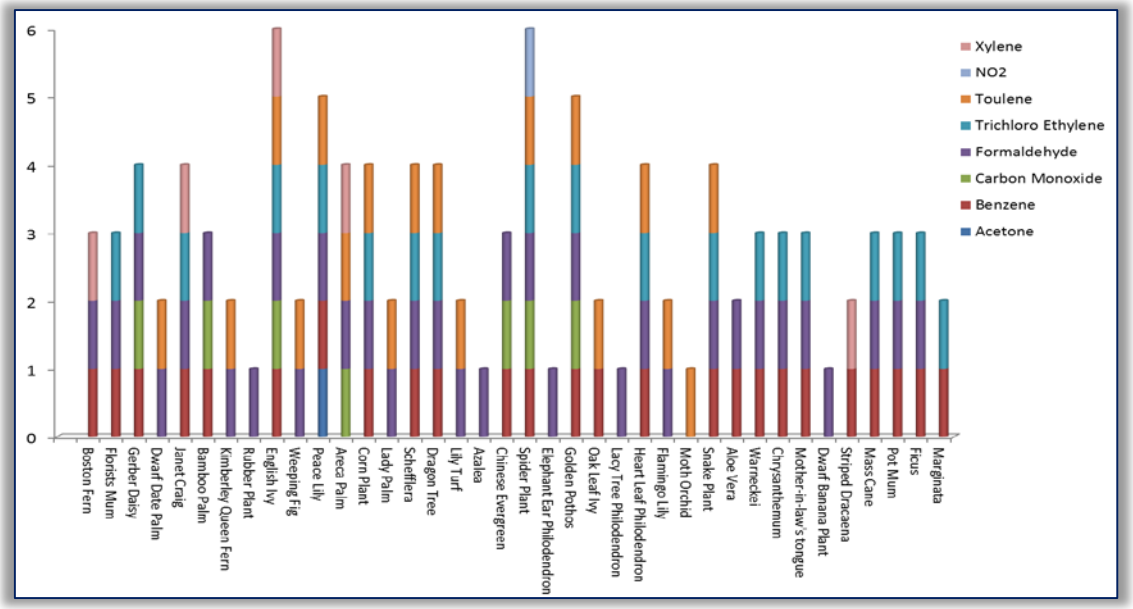

Chart 1: Removal Checklist of Indoor Air Pollutants by Plants compiled from Literature

Noteworthy mention in this Checklist analysis is that to-date no literatures have reported the removal of PVC, Cadmium and Poly-chlorinated Biphenyls which are ranked 4, 6 and 8 respectively. This study has also excluded the other ranked indoor air pollutants (11 onwards upto 18), and also those chemicals (such as chlorine, fluoride and chromium) that finds a mention in literature for removal by plants but isn't included in severity ranking of indoor air pollutants. The exclusion is probably due to their ignorable impact on human-health due to lower generation rates, or fewer indoor & fugitive sources and/or negligible frequency/ magnitude. Hence, any plant such as Wistaria, which is known to remove only these afore-mentioned excluded pollutants, is also omitted from the weightage analysis.

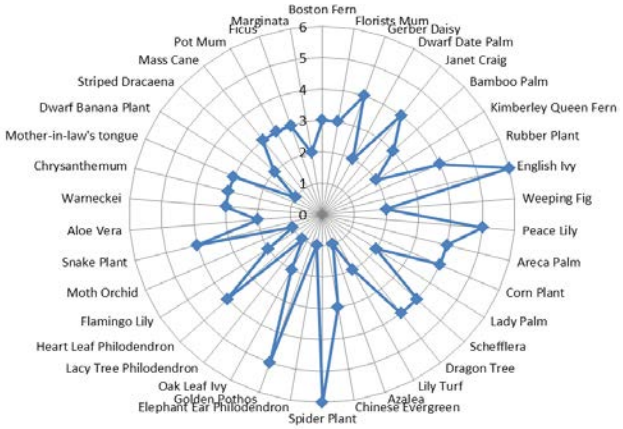

Chart 2: Count of Indoor Air Pollutants Pollutant removal by Indoor Plants

As can be observed from Chart 2, the maximum number of indoor air pollutants was removed by English Ivy and Spider Plant. The initial ranking was derived from subjecting count accomplished by each plant for 30% weightage analysis. Herein it may be observed that English Ivy (ranking-1), Spider Plant (ranking-1), Peace Lily (ranking-2) and Golden Pothos (ranking-2) are the top 4 plants in naturally purifying the indoor air. Nevertheless it is not merely the number of pollutants removed that matter, but the severity of each of these pollutants which can reveal the true potential of each plant species in purification of indoor air.

Thereby applying 70% weightage analysis, the Revised-Final ranking was arrived at wherein it may be inferred that Spider Plant (ranking-1), Peace Lily (ranking-2), English Ivy (ranking-3) and Golden Pothos (ranking-4) are the top 4 natural purifiers of indoor air. The deviation from initial to and revised final ranking for all indoor plants is presented under Table 1. As a credibility check; the plants securing final top rankings were also found to be mentioned in EPA's list of best Indoor Plants [2] and in NASA's list of best Indoor Plants [3]. While EPA list was generic, NASA listed the indoor plants on their merit basis in terms of their Purifying Score for by studying only limited Pollutants. As the studies by EPA and NASA were inadequate in terms of the range of indoor plants and indoor air pollutants addressed; the present result need not necessarily satisfy the hierarchy developed by them. As can be observed from Final Rankings (Table 1); plants ranked within top ten as per present research (such as Corn Plant, Schefflera, Dragon Tree, Spider Plant, Golden Pothos, Heart Leaf Philodendron and Snake Plant ranked 7, 6, 9, 1, 4, 9 and 5 respectively) was not even rated by NASA. Also Peace Lily which was ranked 2nd in present study was rated only 7.5 by NASA, much below to other lower ranked plants such as Areca Palm (NASA rating 8.5 & ranked 16 by present study), Lady Palm

Table 1: Step-wise Development of Final Ranking of Indoor Plants

Name of the Plant/ Ranking	Initial Ranking	Final Ranking	NASA Score
Boston Fern	04	21	7.5
Florists Mum	04	20	--
Gerber Daisy	03	10	--
Dwarf Date Palm	05	25	7.8
Janet Craig	03	12	7.8
Bamboo Palm	04	11	8.4
Kimberley Queen Fern	05	25	--
Rubber Plant	03	08	8.0
English Ivy	01	03	7.8
Weeping Fig	05	24	--
Peace Lily	02	02	7.5
Areca Palm	03	16	8.5
Corn Plant	03	07	--
Lady Palm	05	25	8.5
Schefflera	03	06	--
Dragon Tree	03	09	--
Lily Turf	05	24	--
Azalea	06	27	--
Chinese Evergreen	04	12	--
Spider Plant	01	01	--
Elephant Ear Philodendron	06	27	--
Golden Pothos	02	04	--
Oak Leaf Ivy	05	23	--
Lacy Tree Philodendron	06	27	--
Heart Leaf Philodendron	03	09	--
Flamingo Lily	05	25	--
Moth Orchid	06	28	--
Snake Plant	03	05	--
Aloe Vera	05	22	--
Warneckei	04	14	--
Chrysanthemum	04	13	--
Mother-in-law's tongue	04	15	--
Dwarf Banana Plant	06	27	--
Dracaena "Janet Craig"	05	28	7.8
Mass Cane	04	18	--
Pot Mum	04	17	--
Ficus Alii	04	19	7.7
Marginata	05	26	--

(NASA rating 8.5 & ranked 25 by present study), Bamboo Palm (NASA rating 8.4 & ranked 11 by present study), Rubber Plant (NASA rating 8.0 & ranked 08 by present study), Dwarf Date Palm (NASA rating 7.8 & ranked No. 25 by present study), Ficus Alii (NASA rating 7.7 & ranked No. 19 by present study) and Dracaena Janet Craig (NASA rating 7.8 & ranked No. 12 by present study). Ironically, Bostern Fern which shares same rating by NASA of 7.5 is ranked a far low at 21 by present study). However, English Ivy with a NASA rating of 7.8 has been ranked 3rd. These discrepancies are due to the fact that the NASA studies did not consider the severity of each indoor air pollutant or encompass the entire range of indoor plants as undertaken in present study. The present study was entirely dependent on secondary data, which also was sparse owing to factors such as limited research and cost of pollution analysis.

5. CONCLUSIONS

It is highly recommended to have indoor plants that perform natural detoxification of indoor air environment. However not all the indoor plants available have this ability and those having present varied capacity, and neither does the literatures confirm specifically which indoor plants are better than the rest. To overcome this lacuna, the present study advents a new technique with sequential weightage analysis to rank the indoor plants. The study arrived at the conclusion that Spider Plant, Peace Lily, English Ivy and Golden Pothos are relatively the best in terms of pollutants removal efficiency. Ranking of the indoor plants thus also gives an economic edge in the selection of the finest plants for variable toxic indoor environment. The present research shall facilitate assistance to indoor environments requiring attention, and therewith also assists in the formulation and prioritization of indoor air pollution control strategies.

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