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Assessment of Phytoremediating Potential of *Aglaonema commutatum* Schott for Indoor Pollutants

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Abstract

Indoor pollution is a major threat in today's world. Potential of *Aglaonema commutatum* Schott (Chinese evergreen) as a Phytoremediator, was tested against the gaseous pollutants released from household products like mosquito coil, joss (incense) sticks and naphthalene balls. The indoor pollutants released from these products are very dangerous to our health. These gases may affect our respiratory system, nervous system etc. Potted indoor plants were exposed to the pollutants. After exposing these plants to selected indoor pollutants, they were monitored with respect to visible symptoms, Pollution Indication Index (PII) and Gas Liquid Chromatography (GLC). The experiments were repeated thrice. Amongst all products tested, *Aglaonema* was found more tolerant to pollutants released from mosquito coil than other two products studied. It showed no visible injury after exposure, Pollution Indication Index was 0. After exposure, when plant extracts were analysed on Gas Liquid Chromatography (GLC) it showed many peaks of new compounds absorbed by the plant as compared to control. However, phytoremediation of Indoor pollutants using *Aglaonema commutatum* is still under research phase where understanding of which exact compounds are absorbed by the plant, how it translocates, and metabolizes is required.

1. Introduction

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in homes. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute the emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels can also increase concentrations of some pollutants. Long term exposure to these chemical vapours has brought dramatic increase in the number of cases of allergy, asthma, chemical hypersensitivity and cancer (The Inside Story: A Guide to Indoor Air Quality, a booklet). These Indoor pollutants, even at very low levels, can cause 'building-related illness' and symptoms of headache, sore eyes, nose and throat, or nausea (Carrer et al., 1999; WHO, 2000; Molhave and Krzyzanowski, 2003). Dust, moulds and fuel burning, gases through repellents, gases through joss sticks etc. also adds up to Indoor pollutants. Harmful indoor pollutants represent a serious health problem that is responsible for more than 1.6 million deaths each year, according to a 2002 World Health Organization report.

Lots of efforts have been made to reduce indoor air pollution. Inventing air purifier and reducing the use of potential source of air pollution has been done. The most surprising solution came from NASA, cooperating with ALCA (Associated Landscape Contractors of America) in a 2-year research. NASA announced some plants to be capable of absorbing the air pollutants, especially indoor air pollutants. Those air purifier indoor plants are not just ornamental plants, but are also excellent for purifying the air (Wolverton et al., 1989). The pioneering screening studies on indoor-air VOC (Volatile Organic Compounds) removal by plants (Wolverton et al., 1989; Wolverton Environmental Services Inc., 1991; Wolverton and Wolverton, 1993) showed reductions in VOC levels with over 50 species. Wolverton suggested that both plants and potting-mix microorganisms could be involved in the process.

In Pune region of Maharashtra state, India, people are very religious, so the use of strong smelling incense sticks is abundant. Due to outburst of severe diseases like dengue, Chikungunya, it has become mandatory for all households to use some type of mosquito repellent. Napthalene balls are also used in abundance in the household as room fresheners and insect repellents. It is established by research that the smoke released from these sources is very dangerous as we passively inhale it. These gases may affect our respiratory system, nervous system etc. The results of all these studies,

mentioned below, demonstrate the ability of indoor potted-plants to eliminate indoor pollutants released from household sources.

The aim of this paper is to present a review of research on known indoor absorbent plants to improve indoor air quality which is damaged due to household sources and to convey research findings of the project work in which several Indoor plants were tested against the pollutants released from household sources.

2. Material and Methods

Chinese evergreen (*Aglonema commutatum*) was selected as a test plant to be exposed to the Indoor pollutants released from household products (Plate 1). *Aglaonema commutatum* is the most commonly cultivated species, and commonly used as a houseplant. The monitor was chosen due to its easy growth in all types of mediums tested in the laboratory. This plant requires less maintenance, is fast growing and its lamina is broad enough to show injury symptoms.

One year old plants of *Aglaonema*, grown in 10 cm diameter pot with 3 kg of potting mixture in each pot were used. All horticultural practices were taken care of.

Plate 1: Monitor chosen *Aglaonema commutatum*

The factors such as local growing conditions, easily available and inexpensive nutrients, growth pattern, growing mixtures were considered. The plants used in these experiments were kept for several weeks in more or less the same environmental conditions of lighting and temperature to minimize any stress resulting from the closed environment.

A vacuum dessicator (300 mm, plastic) (Plate 2) where air temperature and relative humidity were 25±2°C and 40–60%, respectively, was used for the exposure experiments. It had an outlet to the lid. The outlet had a V1valve. An air tight test tube was attached to the V1 with silicon tubing for excess gas release (Plate 3). The top of the dessicator was removable and fitted with a rubber gasket to provide an airtight seal. The artificial growth lights remained on continuously. A battery-operated fan was placed in the chamber for continuous air circulation. Control experiments were

Plate 2: Exposure chamber, vacuum desiccators

Plate 3: Exposure of *Aglaonema commutatum* in the exposure chamber

conducted prior to placing plants in the system. These control experiments were conducted with all the equipment in place except plants.

The system proved to be airtight with no loss of gases in the plant-free and pot-free control experiments. The air filled with gaseous pollutants was monitored initially and after four hours. Experiments were then conducted with *Aglaonema commutatum*. In each experiment, 1 plant of the same species was enclosed in the chamber. The plant was placed such that fumes of products tested came in contact with the plant. Indoor pollutants released from commonly used household products like mosquito coil, joss sticks and naphthalene balls were chosen for the exposure. Three sets of plants were exposed for each product.

The leaves of plant were counted before insertion. The plant was removed from the chamber after exposure and the leaves were studied for any visible injury symptom. For each exposed plant the following parameters were considered: 1) Visible injury, 2) PII, 3) GLC analysis. A Pollution Indication Index (PII) was then calculated by the formula: Pollution Indication Index (PII) = Number of leaves exposed (E)/ Number of leaves affected (A) X 100. After each treatment leaves of treated plants were soaked in n-Hexane. All samples were analysed by GLC (Fig. 1) by Electron-capture Detectors (ECD).

Gas chromatography is a very sensitive method for the separation and quantification of chemicals, and it is perfect for the analysis of fatty acid components. Like in any other chromatographic technique, separation of compounds depends on their partition between a stationery and mobile phase. In Gas chromatography the mobile phase is a gas that is moved through a column, while stationery phase is a liquid film that coats the column fillings in packed columns) or the column wall (in capillary columns). Hence, the correct name for gas chromatography is "Gas Liquid Chromatography", abbreviated GLC. Compounds are injected onto the column and carried through it by the mobile phase; depending on their partition into the stationary phase, they move slower or faster. A sensitive detector is required at the end of the column to detect and quantify the compounds as they leave the column (www.sfu.ca/bisc/bisc-429/GLC.html).

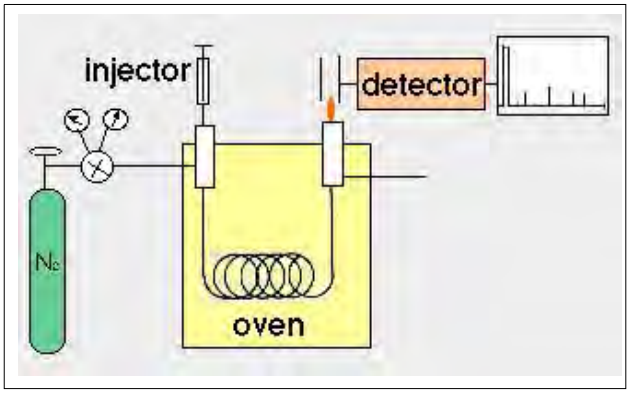

Fig. 1: A schematic diagram of GLC technique

3. Results

At the end of the treatment, when the plants were monitored for visible injury it was observed that there was no visible injury in all three sets of the plant as compared to control. It was observed for all the household sources studied. No change in leaf colour was observed in all treatments. PII calculated after the treatment for all exposures was 0 for all treatments.

3.1. Results for treatment of Aglaonema (GLC analysis)

Results of GLC analysis showed significant findings to consider *Aglaonema* as a potential phytoremediator for the Indoor pollutants studied. It was observed that as compared to control, new compounds were absorbed by the plant as established by new peaks in Gas Liquid Chromatography (GLC) graphs (Fig. 2, Table 1). Plants of *Aglaonema*, showed peaks at the retention time (RT) 1.447, 1.879, 4.318 after GLC analysis in control experiments.

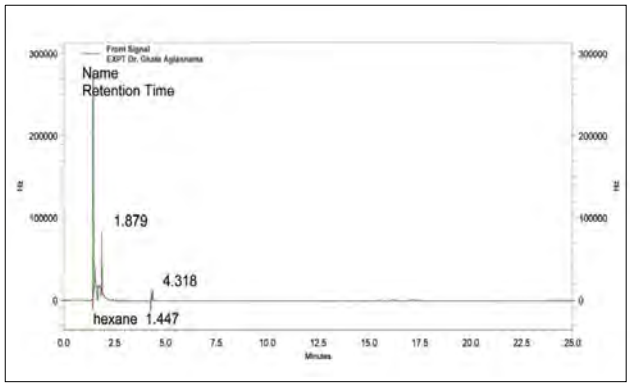

Fig. 2: Control of *Aglaonema* after GLC analysis; X axis 1 unit=5,000 HZ, Y axis 1 unit=1 min

Table 1: Retention time of chemicals in *Aglaonema* leaf for control after GLC analysis

Pk #	Name	RT	Area	Con. mg/L
1	hexane	1.447	3479757858	0.000
2		1.879	492551839	0.000
3		4.318	132609078	0.000
Total			**4104918775**	**0.000**

When plants were exposed to pollutants released from mosquito coil, new peaks of compounds were seen at RT 1.369, 1.433, 1.446, 1.481, 1.869, 2.072 as compared to control (Figs. 3-4, Table 2).

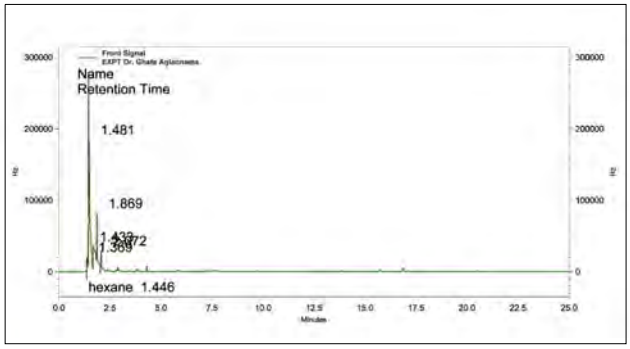

Fig. 3: Treatment of *Aglaonema* with gases released from Mosquito coil; X axis 1 unit=5,000 HZ, Y axis 1 unit=1 min

Table 2: Retention time of chemicals in *Aglaonema* leaf for specified area of peak when treated with gases released from Mosquito coil

Pk #	Name	RT	Area	Con. mg/L
1		1.369	98697237	0.000
2		1.433	27379563	0.000
3	hexane	1.446	848026563	0.000
4		1.481	1061597428	0.000
5		1.869	436748909	0.000
6		2.072	218978059	0.000
Total			**2691427759**	**0.000**

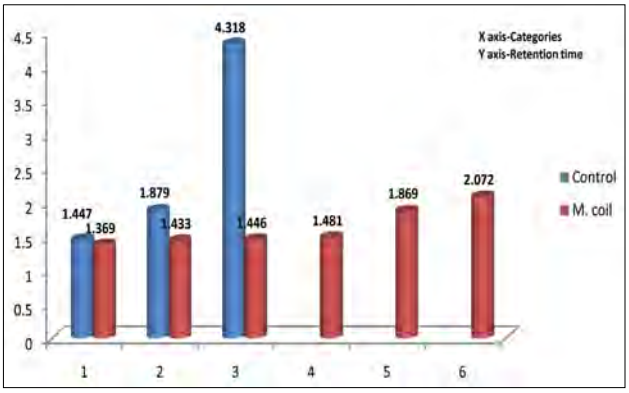

Fig. 4: Comparison of peaks for control and mosquito coil after GLC analysis

When plants were exposed to pollutants released from joss sticks, new peaks of compounds were seen at RT 2.026, 4.386, 13.305 and 13.844 as compared to control (Figs. 5-6, Table 3).

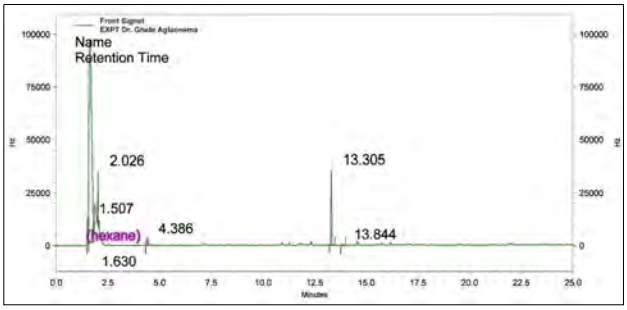

Fig. 5: Treatment of *Aglaonema* with gases released from Joss Stick; X axis 1 unit=5,000 HZ, Y axis 1 unit=1 min

Table 3: Retention time of chemicals in *Aglaonema* leaf for specified area of peak when treated with gases released from Joss stick

Pk #	Name	RT	Area	Con. mg/L
	hexane			0.000 BDL
1		1.507	140212835	0.000
2		1.630	6647929044	0.000
3		2.026	193288774	0.000
4		4.386	72128980	0.000
5		13.305	583480538	0.000
6		13.844	14566545	0.000
Total			**7651606716**	**0.000**

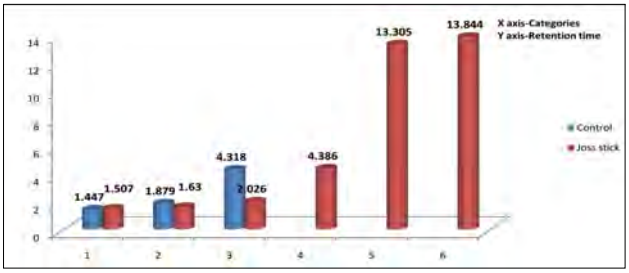

Fig. 6: Comparison of peaks for control and Joss sticks after GLC analysis

When plants were exposed to pollutants released from Napthalene balls, new peaks of compounds were seen at RT 1.525, 1.577, 1.928, 4.366 as compared to control (Figs. 7-8, Table 4).

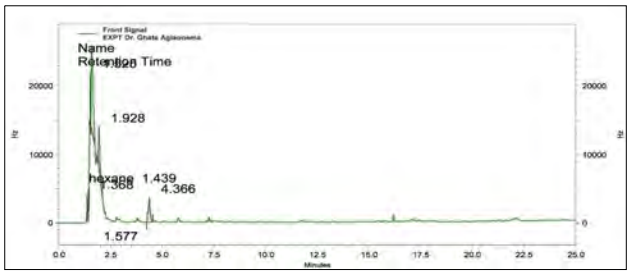

Fig. 7: Treatment of *Aglaonema* with gases released from Napthalene balls; X axis 1 unit=5,000 HZ, Y axis 1 unit=1 min

Table 4: Retention time of chemicals in *Aglaonema* leaf for specified area of peak when treated with gases released from Napthalene balls

Pk #	Name	RT	Area	Con. mg/L
1		1.368	29401007	0.000
2	hexane	1.439	28367710	0.000
3		1.525	50242049	0.000
4		1.577	615327209	0.000
5		1.928	215707878	0.000
6		4.366	167175382	0.000
Total			**1106221235**	**0.000**

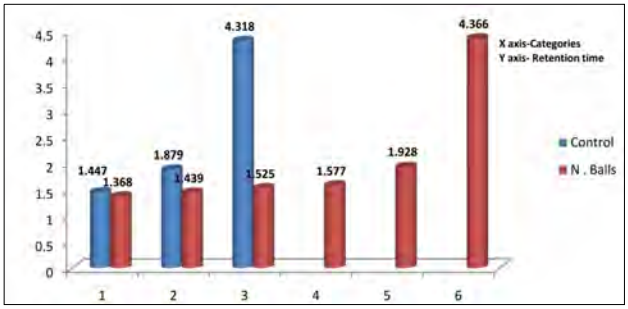

Fig. 8: Comparison of peaks for control and naphthalene balls after GLC analysis

4. Discussion

Phytoremediation of Indoor pollutants through the use of indoor plants is now popular. Studies conducted over the past five years by the University of Technology, Sydney found that small groups of the Janet Craig and Sweet Chico plants placed in offices with high airborne concentrations of volatile organic compounds consistently reduced total VOC levels by up to 75%. Reductions to negligible levels were maintained over the course of 5- 12 week period studied. "Potted plants can provide an efficient, self-regulating, low-cost, sustainable bioremediation system for indoor air pollution," researchers concluded.

Aglaonema commutatum when exposed to different pollutants released from household products revealed that it possesses the potential to tolerate the poisonous pollutants. However, the tolerance varied in terms of the products tested. The tolerance was also reflected in the GLC analysis. When all household products tested were compared it was observed that all of them showed new peaks as compared to control (Fig. 9). The numbers of new peaks seen in the treatment of mosquito coil were more as compared to the other two products. In the treatment of the joss sticks the plant extract showed new peaks which were not observed in the other two products tested. These peaks are indicative of new compounds absorbed by the plant. Plant extract after treatment with naphthalene balls also showed new peaks but less in number and level as compared to other two products studied. The new peaks after GLC analysis, may be the indicative of the poisonous gases absorbed by the plant. But further confirmation on Gas Chromatography Mass Spectrometry (GCMS) is required.

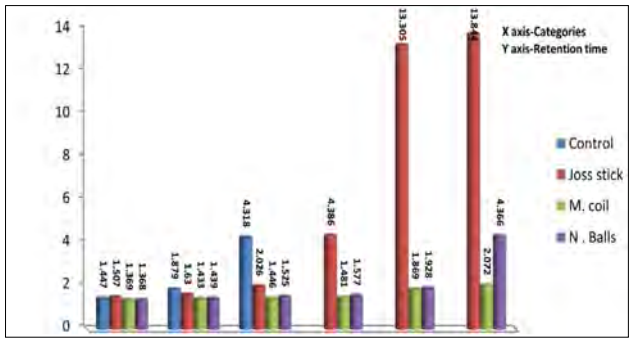

Fig. 9: Comparison of peaks for all categories after GLC analysis

A research conducted by Zhou *et al.* (2011) in China, thirty plant species from Araceae, Agavaceae and Liliaceae families were tested for their abilities of removing formaldehyde in the air. Species such as *Aglaonema commutatum, Spathiphyllum floribundum, Agave potatorum, Dracaena fragrans, D. reflexa, Cordyline fruticosa* showed the most resistance to formaldehyde pollution damage. These plants have high absorption ability to formaldehyde and receive less damage.

The ability of plants to remove VOCs is called "phytoremediation." To better understand the phytoremediation capacity of ornamental plants, the research team tested 28 common indoor ornamentals for their ability to remove five volatile indoor pollutants. "The VOCs tested in this study can adversely affect indoor air quality and have a potential to seriously compromise the health of exposed individuals, Kays explained (ASHS, 2009).

In another study, Margaret Burchett, a professor who led the Sydney studies, estimates that six or more plants in a 1,200- to 1,500-square-foot house could achieve noteworthy contaminant reductions (Tarran, 2007). At work, "if you have a couple of nice plants sitting on your desk, it will help purify the air you breathe," says Bill Wolverton, author of the new book "Plants: Why You Can't Live Without Them," and one of the NASA scientists who studied plants.

Scientists believe plants can begin removing

pollution the moment they're placed in a room and can be particularly useful in spaces where there's little outside ventilation. As for remedies, ventilation often works best, but not every climate is suitable for open windows and doors.

A personal breathing zone is an area of 0.17 to 0.23 cubic metres (6-8 cubic feet) surrounding a person. These are usually areas where an individual remains for several hours working, watching TV or asleep. Plants placed within this zone can add humidity, remove bio-effluents and chemical toxins and suppress airborne microbes. Plant-filled rooms contained 50 to 60% fewer airborne moulds and bacteria than plant-less rooms. Dr Wolverton also places *Aglaonema commutatum* in the top 50 Indoor pollution absorbent plants.

Aglaonema plant did not show any visible injury though the plant was in contact with the poisonous fumes. This shows tolerance of *Aglaonema* towards all household products tested. Once the identification of the compounds absorbed by the plant is established by Gas Chromatography Mass Spectrometry (GCMS) technique, *Aglaonema* may be considered as the potential phytoremediator for the household products studied.

5. Conclusions

The results obtained in this study highlight the tolerance of *Aglaonema commutatum* Schott for gases released from mosquito coil, joss sticks and naphthalene balls so can act as a potential phytoremediator. This conclusion is based on its growth, suitability to grow in easily available nutrient medium, visible injury, PII and Gas Liquid Chromatography (GLC) analysis. In this research identification of specific plants for Visual Injury Symptoms of pollutants is made possible. GLC analysis of treated plants further confirmed the research findings. Future research on how to screen and harvest plants, choosing an assortment of plants for particular pollutants of concern, understanding mechanisms for nutrient and heavy metal removal, and ideal environments for maximum plant uptake etc. needs to be done.

Aglaonema commutatum Schott can be proposed as a potential phytoremediator for Indoor pollutants. Small size of the plant is of great advantage in transportation and exposure in affected areas and can be analysed periodically. However, understanding of exact compounds absorbed by the plant, its translocation, and metabolism is to be studied in the further research.

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