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RESEARCH ARTICLE

Screening House Plants for Indoor Pollution Removal Capacity, Specifically Allethrins, A Poisonous Pesticide Released from Smoke of Mosquito Coil

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ABSTRACT

Four house plants were screened for Indoor pollution removal capacity. Pollutant removal capacity was tested for allethrin, an organic pollutant released from smoke of mosquito coil. Exposure was done in a static glass chamber with dimensions 3 X 3 X 4 where individual plants as well as group of plants were placed. Individual absorption capacity as well as capacity of tested plants in synergism was studied. Samples were analyzed by gas chromatography–mass spectrometry (GC MS) to quantify pollutants to determine removal capacity. The removal capacity is also expressed on a leaf area basis which varied with plant species. Of the 4 species tested, Aglaonema commutatum had the highest removal efficiencies for allethrin when placed in group. But same plant showed less capacity individually. Chlorophytum commutatum showed high capacity individually but showed less capacity in group. The four species ranged in their removal efficiency individually and in groups. Multiple species are needed for maximum improvement of indoor air quality, In future, many more species of low light requiring house plants need to be screened individually and in synergy. Specific species combination need to be given for specific VOCs as leaf structures influence transpiration rate and this affects rate of absorption.

Keywords- : House plants, Indoor pollution, allethrin, quantification, GC MS.

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INTRODUCTION

Many people spend up to 90 % of their time indoors so they face long term exposure to Volatile Organic Pollutants (VOCs) present in the indoor environment. There is increase in health problems like allergies, headache, fatigue, asthma, neuro related problems due to indoor air pollution and sometimes it may lead to cancer.

Indoor pollution is now one of the major threats to public health. The major reason for increase in problem of indoor problem is today's lifestyle. We spend almost 90 % time indoors. Our houses are with less ventilation facility. So the air inside is trapped in the close spaces. There is no air circulation. It is called as Sick Building Syndrome. Indoor air pollutants primarily originate from building product emissions, human activities inside the building, and infiltration of outdoor air (Wolkoff and Nielsen, 2001).

Phytoremediation is an emerging technology that uses plants to degrade, extract, contain, or

immobilize contaminants such as metals, pesticides, explosives, oil, excess nutrients, and
pathogens from soil and water (EPA 2000). Phytoremediation has been identified as a more cost
effective, noninvasive, natural, and publicly acceptable method of removing environmental
contaminants than most chemical and physical methods (Arthur et al. 2005).

The environment has many man made organic pollutants which are harmful to the living organisms. Many of them are toxic while some are carcinogenic. Organic pollutants are released to the environment via spills (fuel, solvents), military activity (explosives, chemical weapons), agriculture (pesticides, herbicides), industrial (chemical, petrochemical), wood treatment, etc. Depending on their properties, organic pollutants can be degraded in the root zone of plants or up-take, followed by degradation, sequestration or volatilization. The goal of phytoremediation is to completely mineralize organic pollutants into relatively non-toxic constituent, such as CO_2, nitrate, chlorine and ammonia (Cunningham et al.,1996).

Dr B. C. Wolverton (1996) in his book Eco-friendly Houseplants stresses on how house plants can indeed become an integral component of healthy buildings, whether homes or offices. He has provided the information on how different houseplants can improve the air in ones " personal breathing zone". Fifty houseplants are described based on its ability to remove VOCs**.**

Moghadam et al (2017) designed a hydroponic system for indoor air remediation by bacteria and mondo grass (*Ophiopogon japonicus*). Results showed that enriched consortium had high degradation ability. Among the isolated strains, Staphylococcus epidermis and Pseudomonas sp. were found to be more efficient. Biodegradation rate was higher in 35°C and in all selected phenol concentrations (500 to 1500 mg/L) bio filtration system was able to degrade phenol. Results revealed significant ability of hydroponic system for remediation of air by bacteria and plant. Obviously, the system may be seen as an important tool in air bioremediation.

Several indoor species have been screened for their ability to remove benzene (Liu et al., 2007). Plants remove VOCs from indoor air through stomatal uptake, absorption, and adsorption to plant surfaces (Beattie and Seibel, 2007; Korte et al., 2000; Sandhu et al., 2007).
Many researchers have studied absorption capacity of different house plants but their

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ability to absorb VOCs released through household sources is not studied as yet. In present study, four house plants were screened for their ability to remove allethrin, a poisonous pesticide released through mosquito coil. Along with the individual absorption capacity of four house plants, ability to absorb in synergy is also tested in this research.

MATERIAL AND METHOD

Aglaonema commutatum (Chinese evergreen), *Syngonium podophyllum* (Arrow head vine), *Chlorophytum comosum* and *Polyscias fructicosa* (Ming aralia) are commonly cultivated species as house plants are chosen for experiments. Plants are native to humid, shady tropical habitat. Plants were chosen due to their easy growth in all types of mediums tested in the laboratory. Plants require less maintenance, are fast growing. Plants were tested for their ability to absorb indoor pollutants.

House plants were purchased from local vendors. They were repotted in 10 cm diameter pot with 2 kg of potting mixture. Composition of the potting mixture was kept standard for growing all test plants. The standard composition used was vermicompost (1.5 kg) + enricher (1/2 kg) + 1 gm Activated charcoal + 2 ml Sphingomonas consortium. Activated charcoal is added for large absorption surface and consortium of Sphingomonas is added for fast activity to absorb and break poisonous pollutants. All horticultural practices were taken care of. The factors such as local growing conditions, growth pattern were studied. 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 change in environment.

All research experiments were carried out at the Research Lab, Know How Foundation, Pune, MS, India. A glass chamber, of 3 x 4 x 4 feet is used for the exposure experiments. Dimensions of glass chamber for control were 3 x 3 x 4 feet. This mini chamber simulated a small room. A battery-operated fan was placed in the chamber for continuous air circulation. Thermo-hygrometer was kept in the chamber for monitoring temperature and humidity. Reading for light intensity was taken on photometer. Test plants with all standards were kept in the treatment chamber (Photo 1 & 2).

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Photo 1 : Glass chamber for treatment having two compartments, Treatment and control

Photo 2 : Treatment chamber

Mosquito coil was weighed before placing it in the chamber. Mosquito Coil was lit and placed in front of the fan and chamber door was kept closed. It was arranged so that smoke of the coil will be passed through test plants with the help of fan. Control plants were placed in the control chamber without burning any coil.

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The air filled with gaseous pollutants was monitored before and after the whole coil was burnt up. Three sets of plants were exposed for testing. The leaves of plant were counted before the experiment. 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) GCMS 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 collected for analysis. All samples were analysed on a triple quadrupole GC/MS/MS (Aglilent 7000C) with Electrospray Ionisation (ESI) at MAARC Labs Pvt. Ltd., Nanded Phata, Sinhagad Road, Pune 411041.

RESULT AND DISCUSSIONS

After exposure, all plants were monitored for visible injury. No visible injury was observed in all three sets of plants as compared to control. Leaf color did not change after treatment. PII calculated after the treatment was 0.

Result of GCMS analysis

Results of GCMS analysis showed significant findings, when they were tested individually, but when they were tested in groups for their synergic activity all species showed enhanced activity. *Aglaonema* showed highest absorption in synergism i.e. 2458 ppb. Control set did not show any absorption as established in the chromatogram. (Fig 1-16 & Table 1-16). Out of four species of house plants, individual species showed significant absorption of allethrins. *Polyscias* showed highest absorption of allethrins ie 1357 ppb, when tested individually among all four house plants (Fig 17).In similar experiments Yang et al, 2009 screened twenty-eight commonly used ornamental species for their ability to remove five volatile indoor pollutants: aromatic hydrocarbons (benzene and toluene), aliphatic hydrocarbon (octane), halogenated hydrocarbon [trichloroethylene (TCE)], and terpene (a-pinene). Of the 28 species tested, *Hemigraphis alternata*, *Hedera helix*, *Hoya carnosa*, and *Asparagus densiflorus* had the highest removal efficiencies for all pollutants; *Tradescantia pallida* displayed superior removal efficiency for four of the five VOCs (i.e., benzene, toluene, TCE, and a-pinene).The five species ranged in their removal efficiency from 26.08 to 44.04 mg_m–3_m–2_h–1 of the total VOCs. *Fittonia argyroneura* effectively removed benzene, toluene, and TCE. *Ficus benjamina* effectively removed octane and a-pinene, whereas *Polyscias fruticose* effectively removed octane. The removal efficiency of volatile organic compound (VOC), expressed on a leaf area basis varied with plant species. In this research leaf area wise absorption is also calculated. *Chlorophytum* showed highest absorption per square cm. of leaf area. Lowest absorption was seen in *Aglaonema* as per square cm of leaf area. (Fig 18-21).

In another study, Darlington et al examined incorporation of amount of biomass into the indoor space can have an (negative) impact on indoor air quality. A relatively large ecologically complex were established in a 'airtight' room in a recently constructed office building in downtown Toronto. Air quality parameters of concern were total VOCs (TVOCs), formaldehyde. The results showed that the incorporation of a large amount of biomass associated with indoor bio filters has good impact on indoor air quality.

Wood et al reports the results of a field-study on the effects of potted-plant presence on total VOC (TVOC) levels, measured in 60 offices (12 per treatment), over two 5–9 week periods, using three planting regimes, with two ‘international indoor-plant’ species. Fourteen VOCs

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were identified in the office air. The findings demonstrate that potted-plants can provide an efficient, self-regulating, low-cost, sustainable, bioremediation system for indoor air pollution, which can effectively complement engineering measures to reduce indoor air pollution, and hence improve human wellbeing and productivity.

A diverse cross-section of plants was capable of removing the VOCs tested. The removal efficiency varied within a single species as a result of differences in the chemical properties of the individual compounds Yoo et al. (2006). Results in this research also showed diverse absorption potential of different species studied individually and in synergy.
Indoor plants are also known for their significant psychological and physical benefits to individuals living/working in environments where they are present. They reduced stress, increased task performance, and decreased symptoms of ill health (Bringslimark et al., 2007; Son, 2004)].

CONCLUSIONS

House plants have the potential to significantly improve the quality of indoor air. Their increased use in indoor spaces has a tremendous positive impact on the quality of indoor air as well as health of people in the indoor environments. In our research it is proved that four house plants have tremendous capacity to absorb allethrin, a poisonous pesticide released through smoke of mosquito coil. When their absorption capacity was examined individually and in group, species showed variation. It indicates that for maximum improvement of indoor air quality multiple species are needed as they work in synergy. In future, many more species of low light requiring house plants need to be screened individually and in synergy. Specific species combination needs to be given for specific VOCs as leaf structures influence transpiration rate

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TABLES AND FIGURES:

TABLES AND FIGURES FOR EXPOSURE OF PLANT FOR ALLETHRIN ABSORPTION IN SYNERGY

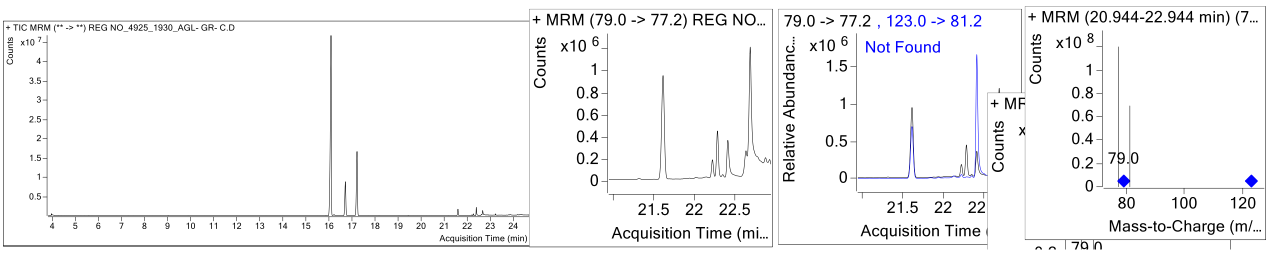

Fig 1 : Control of Aglaonema commutatum. No absorption

Table 1 : Quantitation Results for Aglaonema control

Compound	RT	Response	Conc	
Allethrin	21.549	0	0.0000	µg/L

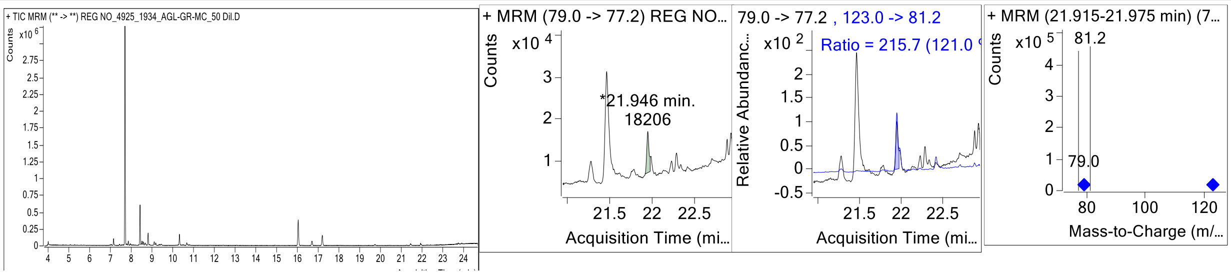

Fig 2 : Absorption of Allethrins by Aglaonema commutatum- Set 1

Table 2 : Quantitation Results for Aglaonema Set 1

Compound	RT		Response	Conc	
Allethrin	21.946	18206	2458.1067	2458.1067	µg/L

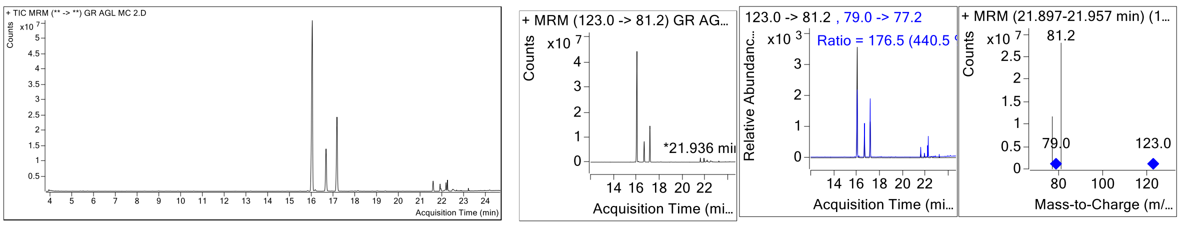

Fig 3 : Absorption of Allethrins by Aglaonema commutatum- Set 2.

Table 3: :Quantitation Results for Aglaonema Set 2

Compound	RT	Response	Final Conc	
Allethrin	21.936	1800696	1307.5817	µg/L

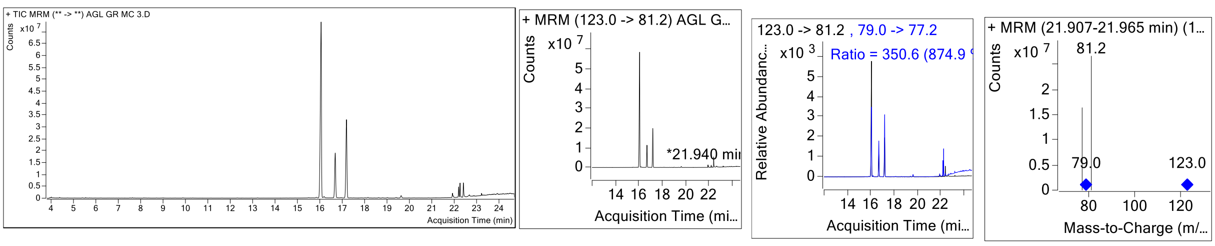

Fig 4 :Absorption of Allethrins by Aglaonema commutatum- Set 3.

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Table 4 : Quantitation Results for Aglaonema Set 3

Compound	RT	Response	Final Conc	
Allethrin	21.940	1612346	1170.9039	µg/L

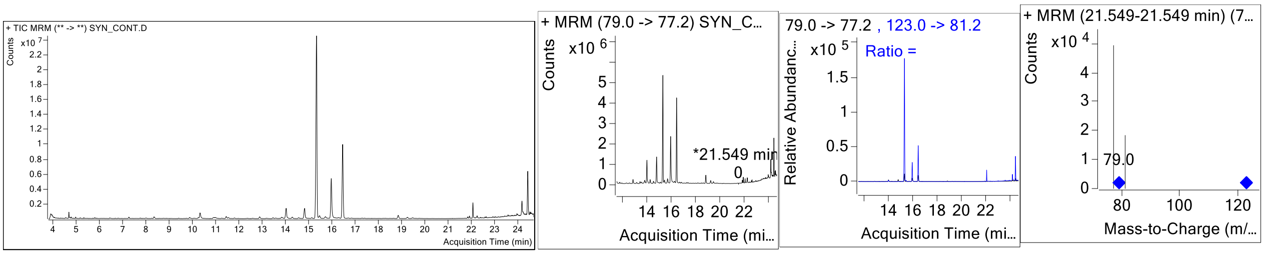

Fig 5 : Control of Syngonium podophyllum. No absorption

Table 5 : Quantitation Results for Syngonium

Compound	RT	Response	Conc	
Allethrin	21.549	0	0.0000	µg/L

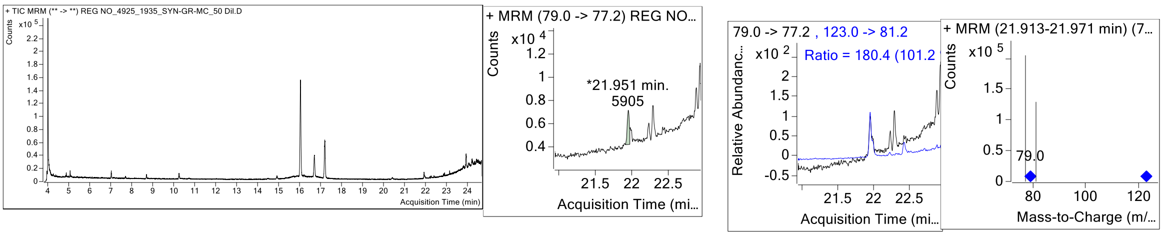

Fig 6 : Absorption of Allethrins by Syngonium podophyllum- Set 1

Table 6 : Quantitation Results for Syngonium

Compound	RT	Response	Conc	
Allethrin	21.951	5905	1038.8492	µg/L

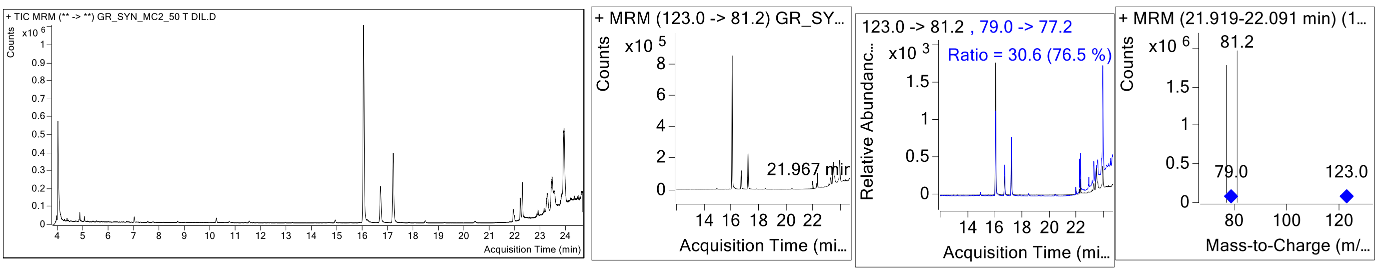

Fig 7 : Absorption of Allethrins by Syngonium podophyllum- Set 2

Table 7 : Quantitation Results for Syngonium

Compound	RT	Response	Final Conc	
Allethrin	21.967	147982	108.2805	µg/L

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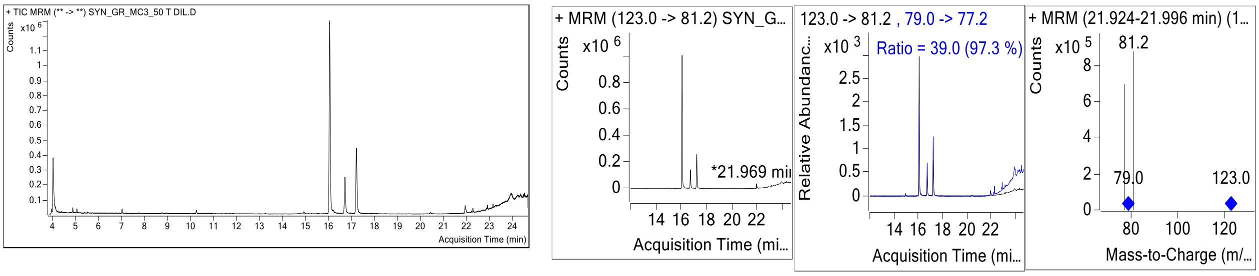

Fig 8 : Absorption of Allethrins by Syngonium podophyllum- Set 3

Table 8 : Quantitation Results for Syngonium				
Compound	**RT**	**Response**	**Final Conc**	
Allethrin	21.969	72682	53.6383	µg/L

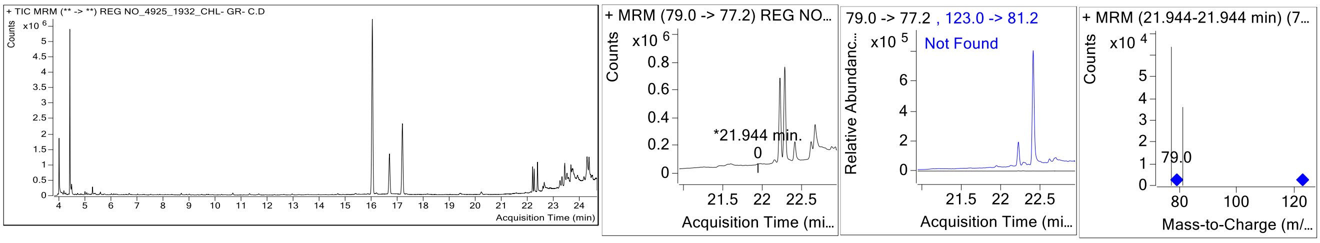

Fig 9 : Control of Chlorophytum comosum. No absorption

Table 9 : Quantitation Results for Chlorophytum				
Compound	**RT**	**Response**	**Conc**	
Allethrin	21.944	0	0.0000	µg/L

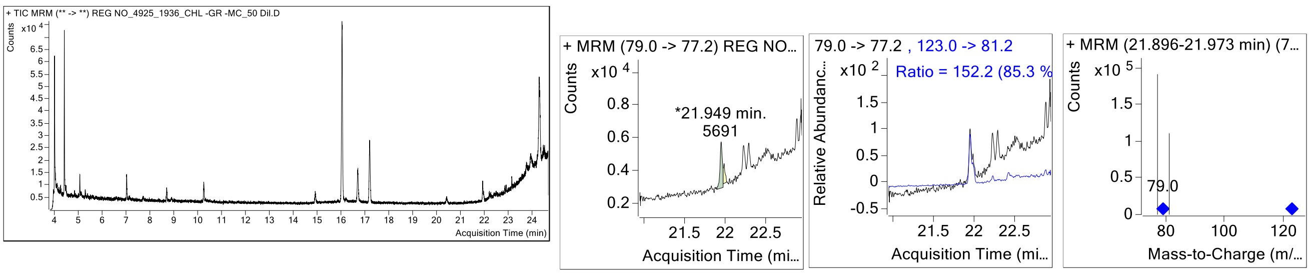

Fig 10 : Absorption of Allethrins by Chlorophytum comosum - Set 1

Table 10 : Quantitation Results for Chlorophytum				
Compound	**RT**	**Response**	**Conc**	
Allethrin	21.949	5691	1014.0565	µg/L

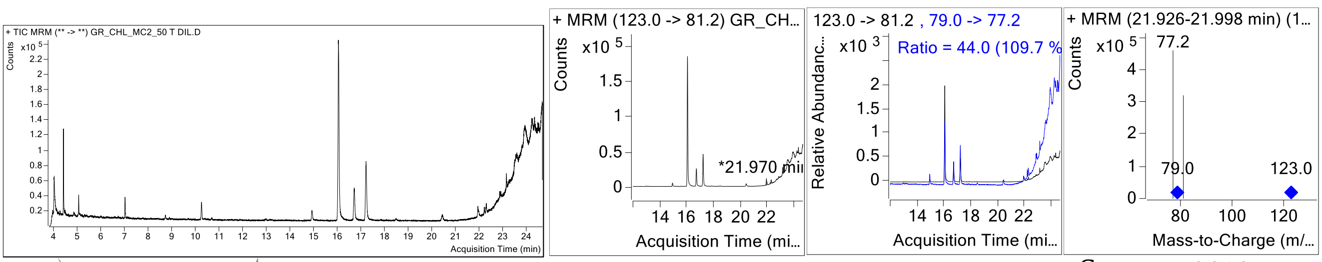

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Fig 11 : Absorption of Allethrins by Chlorophytum comosum - Set 2

Table 11 : Quantitation Results for Chlorophytum

Compound	RT	Response	Final Conc	
Allethrin	21.970	20249	15.5901	µg/L

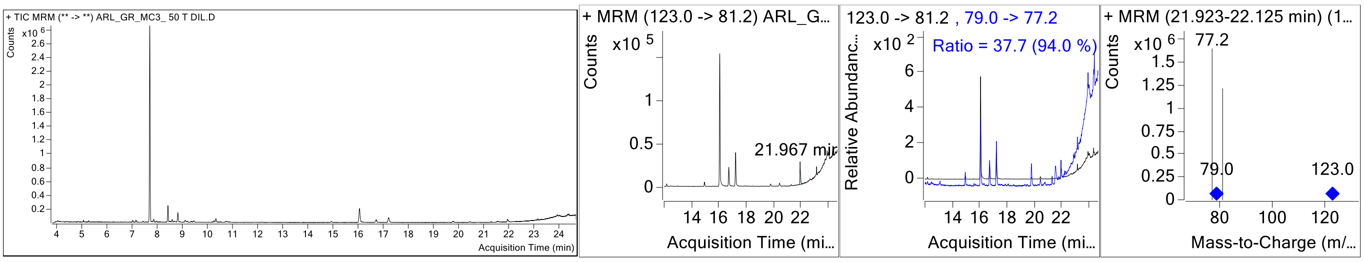

Fig 12 : Absorption of Allethrins by Chlorophytum comosum - Set 3

Table 12 : Quantitation Results for Chlorophytum

Compound	RT	Response	Final Conc	
Allethrin	21.969	30879	23.3039	µg/L

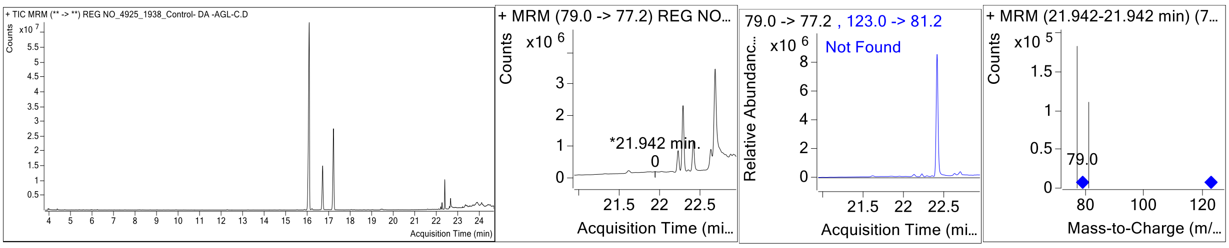

Fig 13 : Control of Polysia fructicosa. No absorption

Table 13 : Quantitation Results for Polyscia

Compound	RT	Response	Conc	
Allethrin	21.942	0	0.0000	µg/L

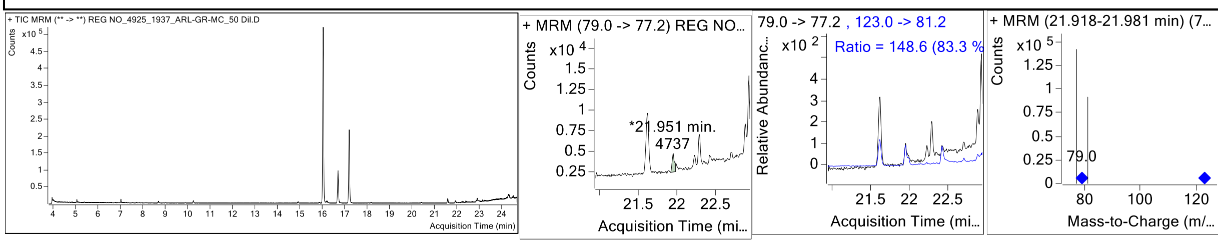

Fig 14 : Absorption of Allethrins by Polyscia fructicosa - Set 1

Table 14 : Quantitation Results for Polyscia

Compound	RT	Response	Conc	
Allethrin	21.951	4737	904.0239	µg/L

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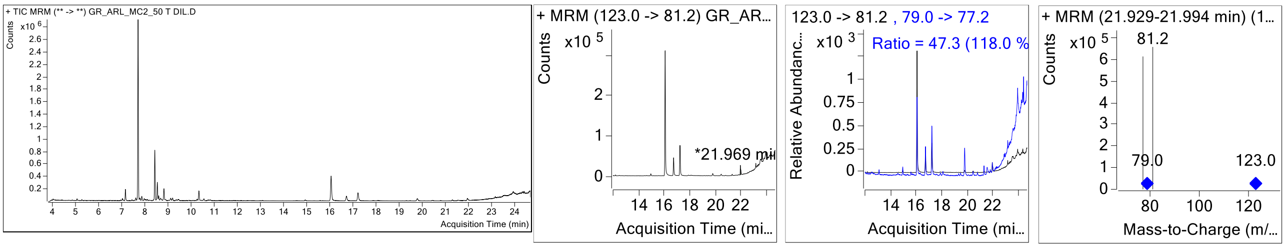

Fig 15 : Absorption of Allethrins by Polyscia fructicosa - Set 2

Table 15 : Quantitation Results for Polyscia

Compound	RT	Response	Final Conc	
Allethrin	21.969	52149	38.7388	µg/L

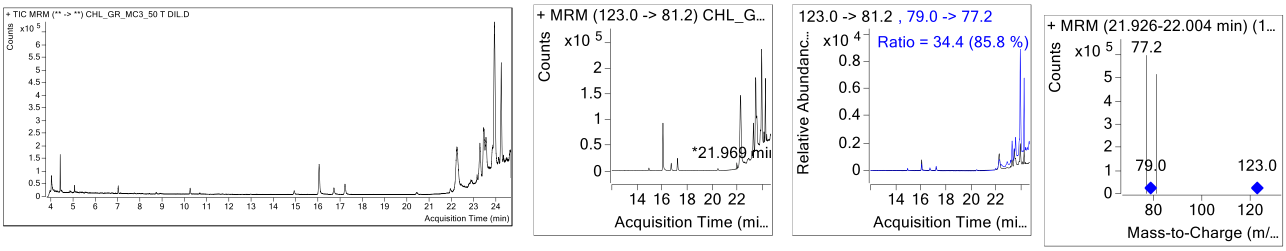

Fig 16 : Absorption of Allethrins by Polyscia fructicosa - Set 3

Table 16 : Quantitation Results for Polyscia

Compound	RT	Response	Final Conc	
Allethrin	21.967	84973	62.5573	µg/L

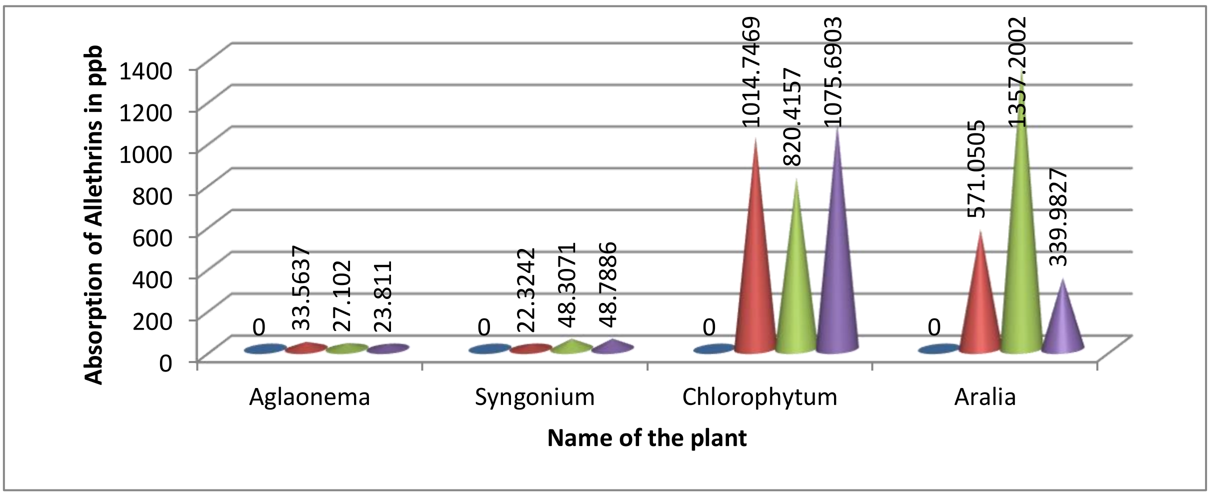

Fig 17 : Individual absorption of allethrins by four selected plants.

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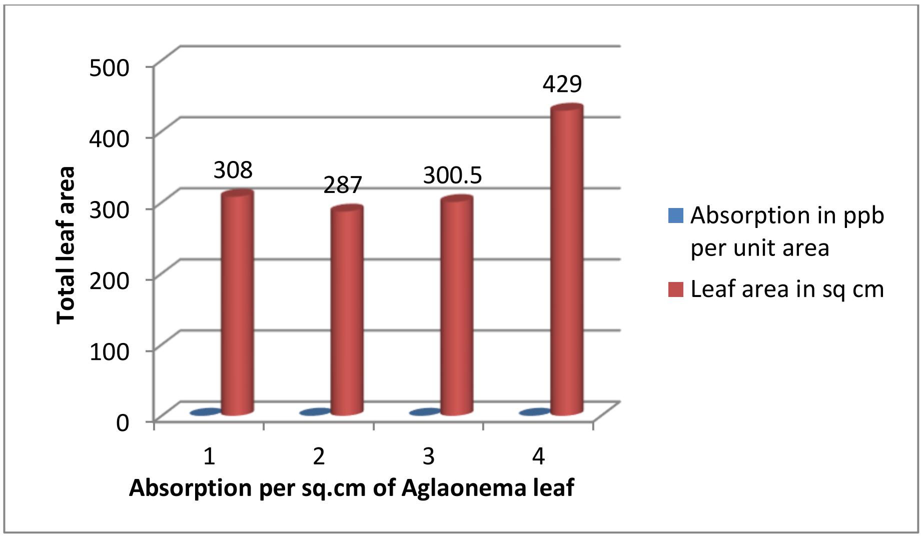

Fig 18 : Absorption of allethrins per square cm for Aglaonema

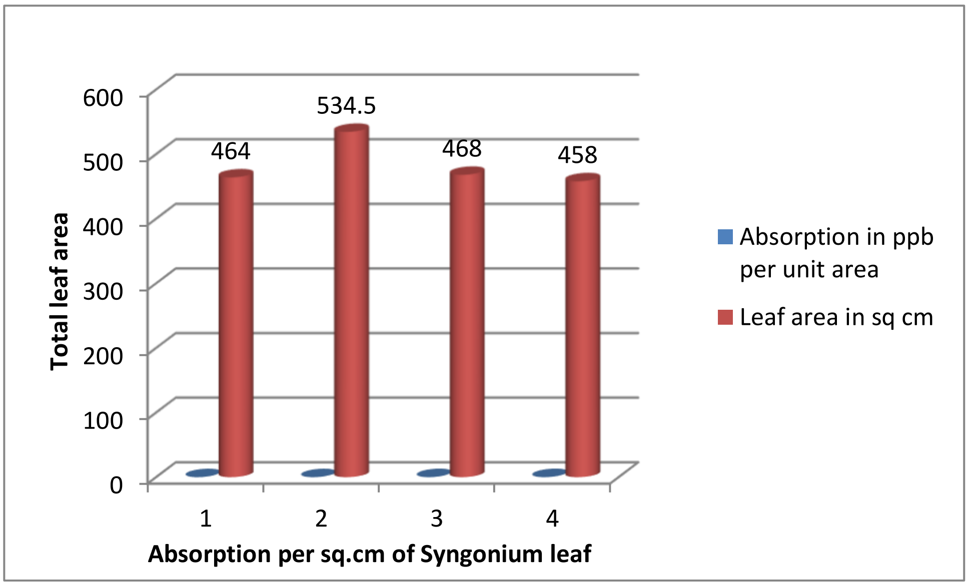

Fig 19 : Absorption of allethrins per square cm for Syngonium

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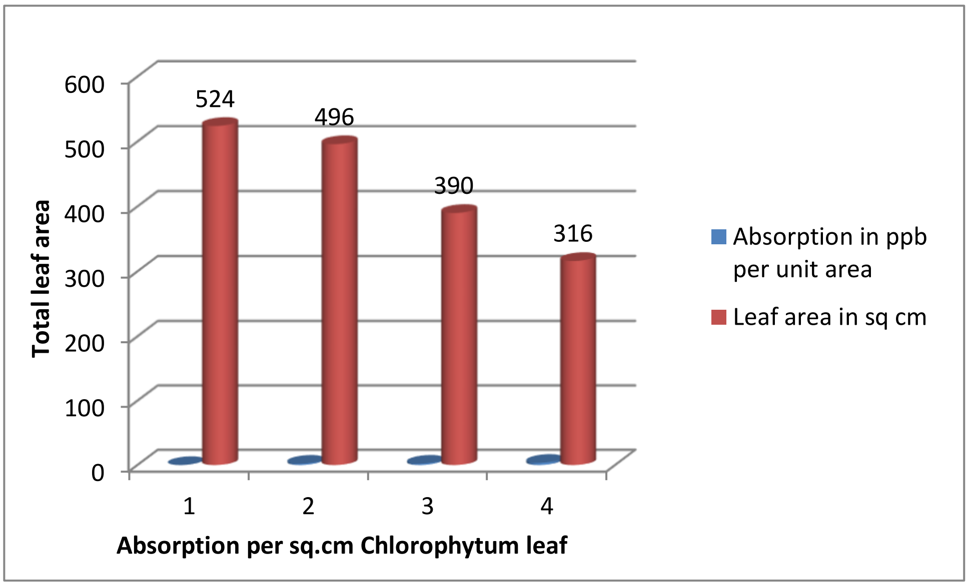

Fig 20 : Absorption of allethrins per square cm for Chlorophytum

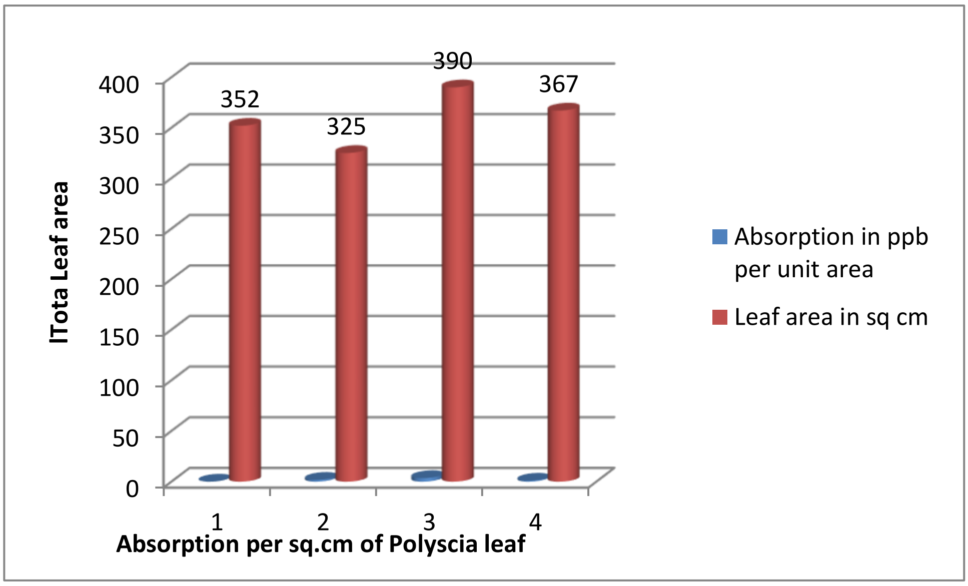

Fig 21 : Absorption of allethrins per square cm for Polyscia