Journal of Bioremediation & Biodegradation

Research Article Open Acces

Reduction of Nicotine, released from Smoking, in Indoor Conditions Using House Plants

Seemaa Ghate*

Host Institute: Know Foundation, Bavdhan, Pune-21, MS, India

ABSTRACT

Many low light survivor house plants were tested for reduction of nicotine, released from smoking, in indoor conditions. A cigarette may produce 7,000 chemicals. Out of which, hundreds of chemicals are harmful to human health and at least 69 of them have been linked to cancer. *Spathiphyllum wallisii*, *Syngonium podophyllum, Sansevieria trifasciata* and *Epipremnum aureum* were tested in the glass chamber, to see their ability to absorb nicotine, a poisonous pollutant released through cigarette smoke. All plants were exposed to the cigarette smoke and quantification of nicotine was done for each set of plants. Quantification analysis was done by LCMS technique. All four house plants tested, showed ability to absorb nicotine, *Epipremnum aureum* (Pothos), showed highest capacity of nicotine absorption which was 0.865 ppm. Easy growth of plants with low maintenance and pollution absorbing capacity of plants, are some of the encouraging points to accept these plants, in improving indoor air quality. Willingness to grow plants indoors can be an advantage to accept this research. Path of absorbed nicotine, its conversion in the plant body and release, are some of the areas where further research is needed. Looking at the absorbing ability of studied plants, we may consider these plants as potential remedies for indoor pollution especially in the indoor areas where smoking is a major activity.

Key words : Indoor pollution, house plants, cigarette smoke, nicotine, quantification

Introduction

There are approximately 120 million smokers in India. According to the World Health Organization (WHO), India is home to 12% of the world's smokers. More than 1 million people die every year due to tobacco related illnesses. There are approximately 120 million smokers in India. More than 10 million die each year due to tobacco in India. According to a 2002 WHO estimate, 70% of adult males in India smoke [1].

The smoke from combustible tobacco products contains more than 7,000 chemicals. Nicotine is the primary reinforcing component of tobacco. Hundreds of compounds are added to tobacco to enhance its flavor and the absorption of nicotine. Nicotine is a dangerous and highly addictive chemical [2].

A single cigarette may contain about 6 mg-28 mg of nicotine. It is the estimate that we probably inhale about 1.2 to 1.8 mg of nicotine at the end of one cigarette. That means in a pack of 20 cigarettes, we may inhale between 22 to 36 mg of nicotine [3].

Nicotine is a dangerous and highly addictive chemical. It can cause an increase in blood pressure, heart rate, flow of blood to the heart and a narrowing of the arteries. Nicotine may also contribute to the hardening of the arterial walls, which in turn, may lead to a heart attack. This chemical can stay in your body for six to eight hours depending on how often you smoke. Smokers aren't the only ones affected by tobacco smoke. Second hand smoke and vapour is a serious health hazard for nonsmokers, especially children [2].

Phytoremediation is defined as the use of green plants to remove pollutants from site of contamination or render them harmless. This technology makes use of naturally occurring processes by which plants and their microbial rhizosphere flora degrade and/or sequester organic and inorganic pollutants. It is more cost-effective than alternative mechanical and chemical methods of removing hazardous contaminants [4].

Potted-plants have a capacity to contribute to the improvement of indoor air quality, by reducing air-borne contaminants such as VOCs, nitrogen oxides and dust [5]. In the report of the National Aeronautics and Space Administration (NASA) it is stated that low-light-requiring houseplants such as Bamboo palm, English ivy have the potential for improving indoor air quality by removing trace organic pollutants as well as VOCs from the air in energy-efficient buildings [6].

Plants and smoking cigarettes could be a way to filter indoor air to make it healthier for human residents. Plants can absorb nicotine and other toxins from cigarette smoke. In the study, researchers exposed peppermint plants to cigarette smoke. After just two hours, the plants had high levels of nicotine in them. The plants absorbed nicotine from the smoke through their leaves but also through their roots. The incorporated nicotine was subsequently metabolized by the plants [7].

This paper presents the result of studies on the ability of four low light survivor house plants, to absorb nicotine released through cigarette smoke. Quantification studies on LCMS are also carried out to know the exact quantity absorbed by these plants.

Role of *Sphingomonas*, bacteria helping phytoremediation process is also highlighted. Effective use of activated charcoal in the medium is also discussed.

Material and Methods

Syngonium podophyllum (Arrow head vine), *Spathiphyllum wallisii* (Peace lily), *Sansevieria trifasciata* (Mother in laws tongue) and *Epipremnum aureum* (Pothos) are commonly cultivated species as house plants are chosen as a test plants. Plants are native to humid,

***Corresponding author:** Ghate S, Host Institute: Know Foundation, Bavdhan, Pune-21, MS, India, E-mail:drseemaaghate@gmail.com

Received date: March 01, 2020; **Accepted date:** March 15 2020; **Published date:** March 22, 2020

shady tropical habitat. Plants were chosen due to their easy growthin all types of mediums tested in the laboratory. Plants require less maintenance, are fast growing.

Chosen experimental plants were purchased from local vendors. One year old experimental plants were grown in 4 inches 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 broth/froth *Sphingomonas* consortium. Activated charcoal is added to expand the absorption surface for pollutants.

Consortium of *Sphingomonas* is added to help the plant in metabolism of pollutants. *Sphingomonas* a group of bacteria helpingin the process of phytoremediation is isolated in the laboratory from known sources. Horticultural practices were taken care of. The factors such as local growing conditions, growth pattern were studied.

Plants used in these experiments were kept for several weeks so that *Sphingomonas* gets translocated in different plant parts like leaves, stem etc. in more or less the same environmental conditions of lighting and temperature to minimize any stress resulting fromthe change in environment. A glass chamber, of $1m^3$ is used for the exposure experiments. Dimensions of glass chamber for control were $1m^3$. A battery-operated fan was placed in the chamber for continuous air circulation representing *in situ* conditions. Thermo-hygrometer (Hu midity and temperature meter 920 p) was kept in the chamber for monitoring temperature and humidity (Photo 1 and 2).

Photo 1: Experimental set up with *Spathiphyllum wallisii*

Photo 2: Experimental set up (Treatment chamber)

Reading for light intensity was taken on photometer. Test plants with all standards were kept in the treatment chamber (Figures 3 and 4). Photos are representative of all test plants exposed.

Four cigarettes were lit and placed in front of the fan and chamber door was kept closed. It was arranged so that smoke of the cigarette will be passed through test plant with the help of fan. Plants were exposed till all cigarettes were burnt. A control was placed in the control chamber without burning any cigarette. The air filled with gaseous pollutants was monitored with the advanced air quality meter (MAKE: SMILEDRIVE) before burning of cigarettes, during burning of cigarettes and after all cigarettes were burnt up. Three replicates of plants were exposed for testing.

Plants were removed from the chamber after exposure and the leaves were studied for any visible injury symptom after eight days. For each exposed plant, the following parameters were considered: (1) Visible injury after eight days (2) PII (3) LCMS 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) × 100. After each treatment leaves of treated plants were collected for analysis. All samples were analysed on a LCMS at MAARC Lab, Nanded phata, Pune. Analysis was done by following method.

Sample extraction for LCMS

2 g sample is taken in 20 mL methanol with 1% formic acid in a50 mL centrifuge tube. The tube is vortexed and centrifuged at 5000 rmp. Out of the centrifuged material, 500 µL is taken and 500 µl of Acetonitrile is added to it. The sample is injected to LC/MS/MS after vortexing against 10 µg/kg to 200 µg/kg calibration levels.

Results and Discussion

All plants were monitored for visible injury after exposure. Visible injury was not observed in all three replicates of plants as compared to control even after ten days. Treated plants did not show change in leaf color even after ten days. PII calculated after the treatment was 0. Initially air quality showed low level of pollution on advanced air quality meter, but after burning cigarettes it reached high level and at the end of the experiment it showed low level of pollution. These were encouraging results.

Results of GCMS analysis showed promising values. Average nicotine levels for all experimental plants are as follows, 0.1763 ppm for *Syngonium podophyllum*, 0.0162 ppm for *Sansevieria trifasciata* and 0.865 ppm for *Epipremnum aureum*. and 0.216 ppm for *Spathiphyllumwallisii*. Out of all plants tested, *Epipremnum aureum*, showed highest absorption of nicotine, a poisonous VOC released from a smoke of cigarette. Nicotine absorption capacity of all experimental house plants is well depicted in the graphs (Figure 1-5) and Table 1.

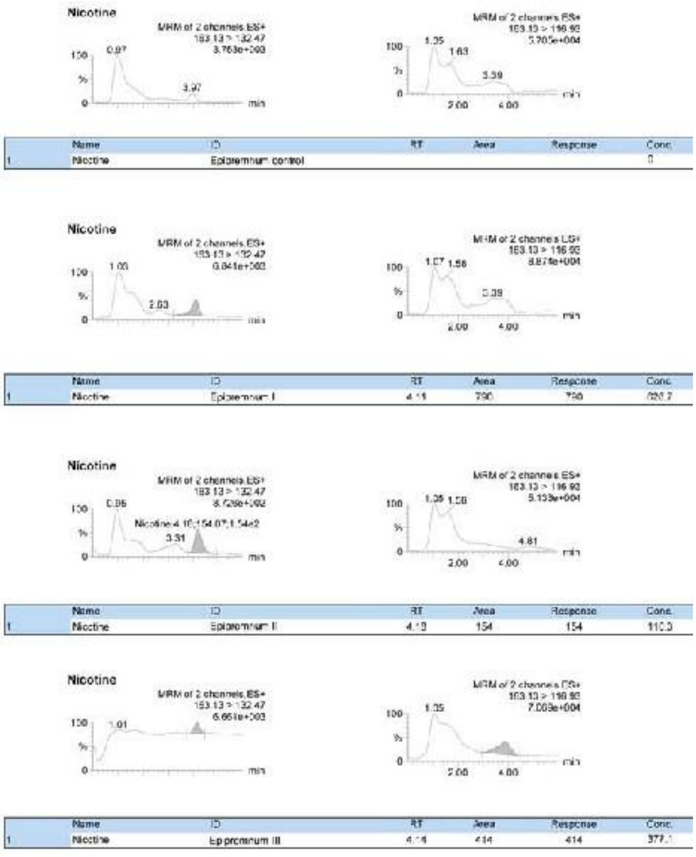

Fig 1: Nicotine absorption by Epipremnum aureum on L.C.M.S.

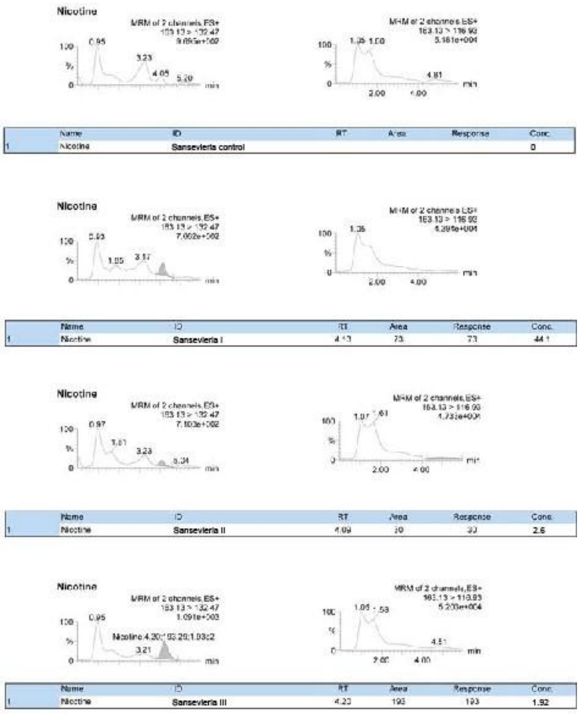

Fig 2: Nicotine absorption by Sansevieria trifasciata on L.C.M.S.

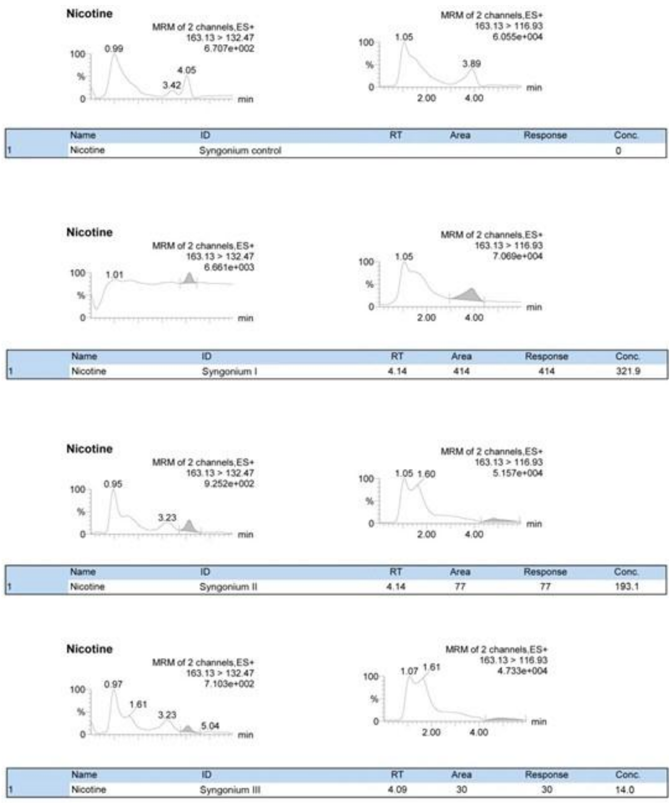

Fig 3: Nicotine absorption by Syngonium podophyllum on L.C.M.S

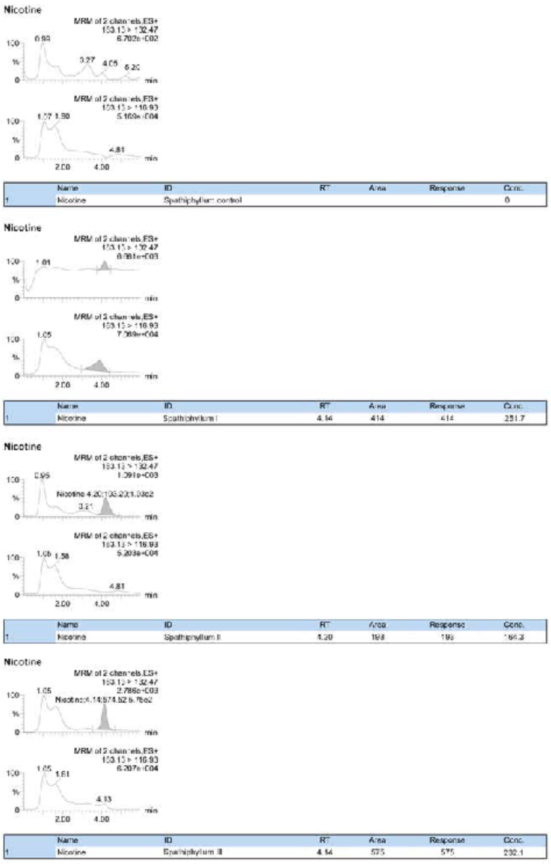

Fig.4: Nicotine absorption by Spathiphyllum wallisii on L.C.M.S.

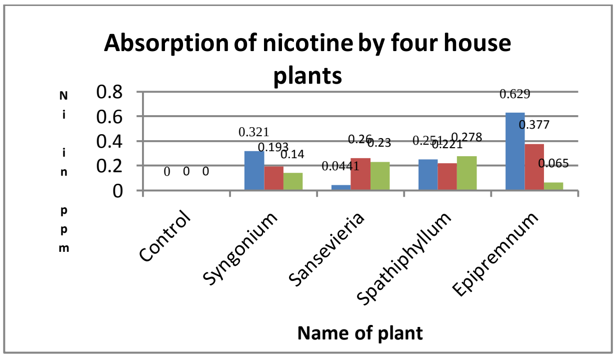

Figure 5: Absorption of nicotine by four house plants by LCMS

House plants were used in reducing levels of CO2, VOCs, PM10 [8]. Similar experiments were carried out with the help of different house plants which could absorb poisonous nicotine released through cigarette smoke. Results were promising showing *Epipremnum* as highest absorber.

Wolverton et al. [9,6] reported that leaves, soil, and plant-associated microorganisms reduce indoor air pollutants like cigarette smoke, organic solvents, and bio aerosols. In our experiments conducted, bacteria helping in the process of phytoremediation were isolated and inoculated in the medium in which plants were growing. The activity of *Sphingomonas* has demonstrated good results as seen in the absorption level of nicotine. Due to addition of activated charcoal, area of absorptive surface increased which has also affected the nicotine absorption.

	Syngonium	Sansevieria	Spathiphyllum	Epipremnum
	SD ± .13	SD ± 0.1	SD ± 0.1	SD ± .2
Control	0	0	0	0
Set I	0.321	0.0441	0.251	0.629
Set II	0.193	0.26	0.221	0.0377
Set III	0.014	0.23	0.278	0.065

Table I : Absorption of nicotine in ppm by test plants with SD

Soreanu et al. [10] conducted an experiment regarding phytoremediation and detected spider plants (C. *comosum* L.) among 120 plant species to be effective in taking up and degrading/detoxifying various pollutants in the air. Gawronska and Bakera [11] reported that spider plants have the potential to accumulate airborne particulates. In experiments conducted, *Chlorophytum* showed potential to absorb nicotine effectively.

Ornamental plants were studied for their potential to uptake VOCs [12]. Several plant species have been recognized to have the ability to remove VOCs from air. The VOCs are removed by absorption and biotransformation. In this process, aerial plant parts especially leaves, the root system, growing medium plays a vital role. The microbes present within the rhizosphere also help this process. When peppermint plants were exposed to cigarette smoke, plants had high levels of nicotine after two hours. The plants absorbed nicotine from the smoke through their leaves but also through their roots. It was also observed that nicotine was subsequently metabolized by the plants [13].

Yang et al [14] screened twenty-eight commonly used ornamental species for their ability to remove five volatile indoor pollutants, out of which Hemigraphis, Hoya carnosa, and Asparagus densiflorus showed excellent absorption capacity for VOCs. Kim has recommended Ornamental plants as an efficient system to reduce the VOC concentration for indoor environments [15]. It is also observed that potted plants also carry out decomposition of VOC [16].

Our experiments with four house plants proved that all plants could absorb nicotine effectively. *Epipremnum aureum*, showed highest c apacity of nicotine absorption which was 0.865 ppm. Endophytic and rhizospheric bacteria have been reported to assist plants in removing toxic compounds from soil. In experiments conducted effective use of*Sphingomonas* and activated charcoal is observed.

Conclusion

Many low light survivors, maintenance free indoor plant have demonstrated the ability to absorb significant quantity of nicotine, a poisonous pollutant released from smoke of cigarette. It is also observed that plant leaves and microorganisms are involved in removing and digesting this poisonous chemical. Activated charcoal has also helped in adsorption. The level of absorption of nicotine ranged between 0.01 to 0.865 ppm. Specific pot size, potting mixture with bacterial inoculum, quantity of activated charcoal, age of plant play significant role in removal of nicotine from indoor environment. The potential of plants to absorb pollutants also depends on many environmental factors. Inoculation of *Sphingomonas* and addition of activated charcoal, in the medium has a potential for improving indoor air quality, either by metabolizing, sequestering, or degrading.

Specific plant species and specific microorganisms pose huge potential to purify indoor environment.

Standards of phytoremediators can be established with the help of results obtained e.g. potting mixture, size of the plant and number of leaves required to achieve specific levels of phytoremediation in the presence of specific concentrations of pollutants in the specific area.

Acknowledgement

Author deeply thanks D.S.T., New Delhi for sponsoring the WOS-B research project and Know How Foundation, Bavdhan, Pune for providing all necessary facilities. Author is indebted to Prof. S.B. Chaphekar for his valuable guidance and suggestions.

Funding

The financial support for the research is by the Department of Science and Technology, Kiran Division, Women Scientist Scheme, New Delhi, INDIA

Declaration of conflicting interests

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Chandrupatla, Siddardha G, Tavares, Mary, Zuhair S (2017) Tobacco use and effects of professional advice on smoking cessation among youth in India. Asian Pacific J Cancer Prev. 18 (7): 1861–1867.
2. Kapp Robert (2005) Tobacco Smoke. Encyclopedia of Toxicology. 4(2): 200–202.
3. Benowitz Neal L, Brunetta Paul G (2010) Smoking Hazards and Cessation. 1(5).
4. Nwoko Chris O (2010) Trends in phytoremediation of toxic elemental and organic pollutants . Afri J Biotech .9 (37):6010-6016.
5. Pipal AS , Anoop Kumar, Rohi Jan, Taneja Ajay (2012) Role of plants in removing indoor air pollutants in book: Chemistry of phytopotentials: Health, Energy and Environmental Perspectives. 319-321.
6. Wolverton BC, Johnson A, Bounds K (1989) Interior landscape plants for indoor air pollution abatement.
7. Selmar D, Engelhardt UH, Hänsel S, Thräne C, Nowak M, et al (2015) Nicotine uptake by peppermint plants as a possible source of nicotine in plant-derived products. Agronomy for sustainable development. 35(3):1185-1190.
8. Pegas PN, Alves CA, Nunes T, Bate-Epey EF, Evtyugina M, et al (2012) Could houseplants improve indoor air quality in schools?.J toxicology and environmental health, Part A. 75 :1371-1380.
9. Wolverton BC (1984) The role of plants and microorganisms in assuring a future supply of clean air and water. National Aeronautics and Space Administration.
10. Soreanu G, Dixon M, Darlington A (2013) Botanical biofiltration of indoor gaseous pollutants: A mini review. Chem engineer j. 229:585-594.
11. Gawrońska H, Bakera B (2015) Phytoremediation of particulate matter from indoor air by Chlorophytum comosum L. plants. Air Quality, Atmosphere & Health. 8(3):265-272
12. Cruz MD, Christensen JH, Thomsen JD, Müller R (2014) Can ornamental potted plants remove volatile organic compounds from indoor air?: A review. Environmental Sci and Pollution Res. 21(24):13909-13928.
13. Selmar D, Engelhardt UH, Hänsel S, Thräne C, Nowak M, et al (2015) Nicotine uptake by peppermint plants as a possible source of nicotine in plant-derived products. Agronomy for sustainable development. 35(3):1185-1190.
14. Yang DS, Pennisi SV, Griffin GA, Ki-Cheol S, Kays SJ (2009) Screening indoor plants for volatile organic pollutant removal efficiency. Hortscience 44(5):1377–1381.
15. Kim KJ, Kil MJ, Jeong MI, Kim HD, Yoo EH, et al (2009) Determination of the efficiency of formaldehyde removal according to the percentage volume of pot plants occupying aroom. Korean J. Hortic. Sci. Technol. 27(2):305-311.
16. Lim YW, Kim HH, Yang JY, Kim KJ, Lee JY, et al (2009) Improvement of indoor air quality by houseplants in new-built apartment buildings. J Japanese Society for Horticul Sci