RESEARCH ARTICLE

REVISED Can indoor plants reduce formaldehyde levels in the anatomy dissection hall? A study to evaluate the practicality of using plants in reducing formaldehyde levels

[version 3; peer review: 2 approved, 2 approved with reservations]

Adish G Joshi, Dhiren Punja, Rohini Punja

Kasturba Medical College, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, 576104, India

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Abstract

Background

Formaldehyde a commonly used embalming fluid for the preservation of cadavers, produces numerous short and long-term side effects on the students and staff working with it. Indoor plants have been shown to reduce atmospheric formaldehyde levels. The purpose of the study was to compare the efficacy of indoor plants in reducing formaldehyde levels in ambient air to levels deemed safe by WHO standards

Methods

The study was conducted in the storage room of the Anatomical dissection hall. 7 potted plants of one variety were kept in the storage room for 14 days and the Formaldehyde reading was measured using a VOC (Volatile Organic Compound) monitor. Then the same was done with no plant. This cycle was repeated 2 more times, with two different plant species. The three spieces of plants used for this study were as follows: *Dracaena trifasciata*, *Epipremnum aureum*, *Spathiphyllum.*

Results

The results were analysed and compared and it was determined that the effect of having a plant present versus having no plant present on

Open Peer Review

Approval Status ✓ ? ? ✓

	1	2	3	4
version 3 (revision) 22 Jul 2025				✓ view
version 2 (revision) 27 Nov 2024	✓ view		? view	? view
version 1 18 Oct 2024	? view	? view		

1. **Kumar Satish Ravi**, All India Institute of Medical Sciences, Gorakhpur, India
2. **Ranganath Vallabhajosyula**, Nanyang Technological University Singapore, Singapore,, Singapore
3. **Yasar Sajjad**, COMSATS University Islamabad, Islamabad, Pakistan
4. **Choy Ker Woon**, Universiti Teknologi MARA, Shah Alam, Malaysia

Any reports and responses or comments on the article can be found at the end of the article.

the Formaldehyde concentration in the air was inconclusive as *Dracaena trifasciata* failed to reject the null hypothesis altogether (p-value>0.05), while *Epipremnum aureum* and *Spathiphyllum* rejected the null hypothesis (p-value<0.05), however they both had a weak positive correlation with formaldehyde concentration.

Conclusion

The efficacy of indoor plants in reducing formaldehyde levels in ambient air needs to be further explored and validated since all the prior studies conducted were in controlled environment and should be done in a real time scenario for its practical and beneficial uses.

Keywords
Air quality; anatomical dissection hall, indoor plants, indoor air, volatile organic compound, workspace environment, cadaver, formaldehyde

This article is included in the Plant Science gateway.

This article is included in the Manipal Academy of Higher Education gateway.

Corresponding author: Rohini Punja (rohini.punja@manipal.edu)

Author roles: Joshi AG: Data Curation, Formal Analysis, Investigation, Writing – Original Draft Preparation; **Punja D**: Conceptualization, Methodology, Project Administration, Software, Validation, Visualization, Writing – Review & Editing; **Punja R**: Conceptualization, Methodology, Resources, Supervision, Validation, Writing – Review & Editing

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REVISED **Amendments from Version 2**

This version incorporates significant methodological improvements based on peer review feedback.

The methodology section has been strengthened with specific technical details about the VOC monitor (Forbix Semicon air quality monitor with 0.005 ppm detection limit) and explicit statement of statistical tests used (paired t-tests). We have also enhanced the data analysis section to clearly describe the analytical approach and added regression analysis results to supplementary data files. We have included standard error bars in Figure 2 and added p-values with significance symbols directly to Table 1 to improve clarity of statistical relationships between control and experimental groups.

Additional improvements include expanded discussion of measurement limitations and reliability concerns regarding VOC meters, addressing potential false positive/negative results. The conclusion section now explicitly identifies future research directions, including the need for studies comparing scenarios with operational versus non-operational exhaust fans to better simulate real teaching environments, and recommendations for longer-term studies (3-6 months) to assess plant adaptation effects.

Any further responses from the reviewers can be found at the end of the article

Introduction

Formalin is an ideal embalming fluid used in the preservation of the human body since it acts as a biocide by coagulating the bacterial protoplasm and is a powerful germicide. It preserves tissues by making new complex molecules that are unfit for the growth of microorganisms.

Medical students who are exposed to formaldehyde (FA) during their dissection course (Shiraishi 2006) have reported various physical symptoms, such as burning eyes, lacrimation, irritation of airways, and dermatitis. FA has attracted attention as a health hazard for students and instructors, as FA concentrations in the air of gross anatomy laboratories often exceed permissible limits. On an average, students and instructors are exposed to 5.59 ppm FA, for which the maximum permissible exposure limit, according to OSHA PEL guidelines, is 0.75 ppm—essentially more than 7 times the maximum amount—and is more than 69 times greater than the recommended levels of FA exposure in the short-term and long-term (0.08 ppm) according to the Indoor Air Quality Guidelines set by the WHO (Zuber et al. 2022; CDC n.d.; Nielsen et al. 2017). Long-term FA exposure in indoor air has been found to be carcinogenic, potentially leading to nasopharyngeal carcinoma and leukemia (Shiraishi 2006; Zuber et al. 2022; CDC n.d.; Nielsen et al. 2017; Matheson et al. 2023). High-quality indoor air cleaners can be utilized to reduce FA levels in the air with various types of air cleaners, such as activated carbon, negative ion and photocatalytic cleaners; however, these cleaners consume vast amount of electrical power (between 39.1 W and 79.2 W), can cause secondary FA pollution, are very expensive (between $147 and $721), and are inadequate for reducing FA concentrations to meet WHO guidelines. This makes them ineffective to use in an anatomy dissection hall (Chen et al. 2007). Students and faculty utilize N95 masks as a precautionary method against the COVID-19 pandemic and wear them even in the anatomy dissection hall; however, N95 masks seem to be ineffectual at reducing FA levels to WHO standards, and hence, they fail to provide any additional benefit against the effects of FA (Chan et al. 2016). Plants affect the levels of volatile organic compounds (VOCs) in indoor environments; thus, they represent a potentially cheaper, non-electricity-consuming and greener solution for improving indoor air quality (Shaham et al. 2003; Peterson et al. 2023). Studies of plants that reduce indoor pollution have recommended that 15 to 18 plants in 6 to 8-inch-diameter containers are required to clean the air in an average of 1,800 square foot houses. There is approximately one plant per 100 square feet of floor space (Dela Cruz et al. 2014). Studies have indicated that the average FA absorption rate of certain plants is 674 micrograms per hour for *Spathiphyllum* (peace lily) and 1304 micrograms per hour for *Dracaena trifasciata/Sansevieria* (variegated snake plant) (Wolverton and Wolverton 1993). The FA concentration in the atmosphere is affected by and directly proportional to the temperature and humidity of the air, the correlation coefficient between temperature and emission factors is greater than 0.83, and the correlation coefficient between relative humidity and emission factors is greater than 0.98 (Parthasarathy et al. 2011).

Previous studies have mentioned the usage of potted ornamental plants in the reduction of FA pollution in indoor settings, and the deleterious effects of FA on individuals, especially medical students and teaching faculty in the anatomy dissection hall, no study thus far has dealt with uniting the two, by utilizing a cheap, effective and green way of reducing FA concentration in the anatomy dissection hall.

Methods

Ethical approval

The protocol was approved by the Institutional Ethics Committee (IEC 343/2022) Kasturba Medical College and Kasturba Hospitals, Manipal on July 14, 2022. Though the study did not involve cadavers directly, however the specimen

storage room was utilized and written informed consent was given by the body donors for teaching and research when they were alive.

Study design and data collection

The study was conducted in the cadaveric specimen storage room in the Anatomy Department, Kasturba Medical College, Manipal. In this study, we used formalin with a standard concentration of 10% formaldehyde solution, prepared according to our department's established preservation protocol. All cadavers were preserved using identical formalin preparation methods to ensure consistency in formaldehyde exposure. The specimen storage room contained 15 preserved cadaveric specimens stored in metal preservation chambers, each measuring approximately 2 m × 1 m × 1.5 m, with a total storage area volume of 21 cubic meters. The preservation chambers utilized 10% buffered formaldehyde solution for specimen maintenance. The traffic into the storage room was restricted during the study period to minimize errors in recording FA levels. The storage room of the anatomy dissection hall has an area of 700 sq feet with two open windows, which were kept closed at all times, and two exhaust fans, which were not switched on during the study period. This setup was chosen to establish baseline measurements without ventilation; in real-world teaching environments, these exhaust fans would typically be operational. The VOC monitor, Forbix Semicon air quality monitor with a detection limit of 0.005 ppm (5 parts per million) ppm, installed in this room was initially used to assess the basal levels of FA fumes in the room. The values were recorded twice daily (at 9:00am and 4:00pm) for two weeks. Following which, 7 potted plants all of a particular plant species were kept in the room. Hence, there was one potted plant for every 100 sq. feet. The three species of plants used for this study were *Dracaena trifasciata/Sansevieria* (snake plant), *Epipremnum aureum* (golden pothos), *Spathiphyllum* (peace lily). We selected these three plant species based on their prior reported capabilities in air purification. *Dracaena trifasciata* (Snake Plant), *Epipremnum aureum* (Golden Pothos), and *Spathiphyllum* (Peace Lily) have been previously documented in scientific literature for their potential to absorb volatile organic compounds (Wolverton and Wolverton 1993). The plants were in uniform pots with a frustum shape, with a top circumference of 79 cm and a bottom diameter of 44 cm. The height of the pot was 25 cm. The pots were kept equidistant from each other at a distance of 25 cm. However, the dimensions of the plants per se were variable. All the potted plants were placed around the cadaveric specimen storage room as seen in Figure 1. The distance between plants and storage units was approximately 50 cm and the plants were centrally positioned in the storage room to ensure uniform distribution designed to ensure uniform distribution and minimal interference with specimen storage. The plants were kept here for 2 weeks, based on practical considerations, and the FA values were recorded twice daily. These potted plants received natural indirect sunlight for ten hours. This study was conducted during the summer season, and the temperature and humidity were noted along with the FA levels. The plants were subsequently removed, and a two-week interval was established before the plants of the next species were transferred to allow the FA concentrations to once again reach basal levels. The daily temperature and humidity were also noted.

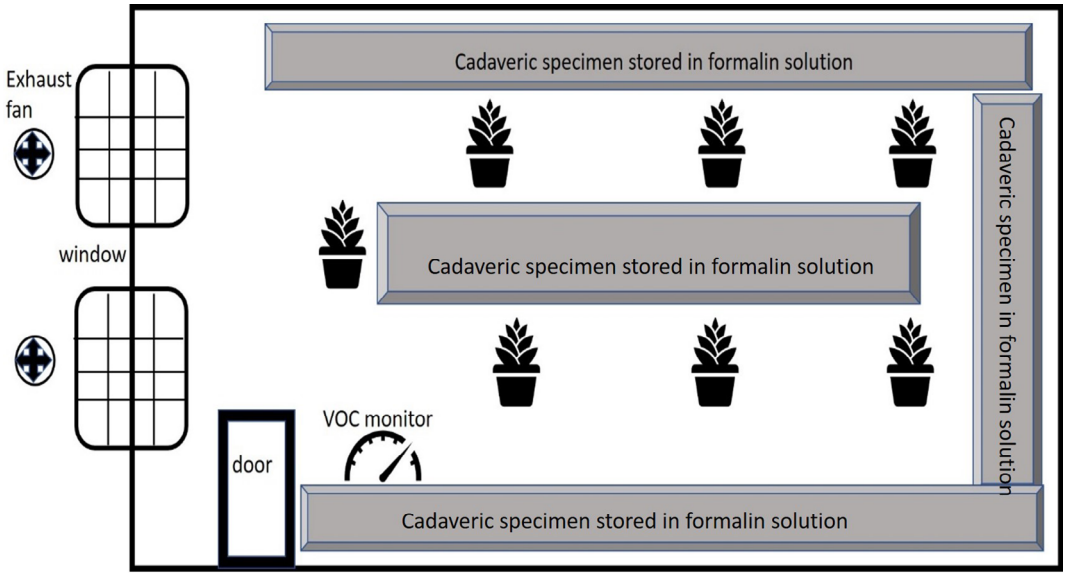

Figure 1. Diagram depicting the storage room with the position of the plants, the cadaveric specimen stored in formalin and the ventilation of the room.

Data analysis

The readings documented were tabulated, and the statistical analysis was done using IBM SPSS Statistics for Windows Version 20.0 (USA). Paired t-tests were used to compare formaldehyde levels with and without plants for each plant species. The P value for each of the plant species was calculated separately to determine whether any of the plants had a statistically significant effect on the FA concentration in the storage room. The P value ranges from 0 to 1, where a value closer to 0 means that there is a good chance of statistical significance, while a value closer to 1 indicates a null hypothesis; i.e., there is no statistical significance.

Results

On observing Figure 2, plotted with the plants across the x-axis and concentration of FA across the y-axis and values from Table 1, the following inference could be made regarding the FA concentration measured in the storage room:

1. When *Dracaena trifasciata* is present, the concentration in the room was 0.03 ppm less than when there is an absence of the plant.

2. When *Epipremnum aureum* was present, the concentration in the room was 0.01 ppm greater than that when no *Epipremnum aureum* was present.

3. When *Spathiphyllum* is present, the room has 0.03 ppm more than when no *Spathiphyllum* is present.

Hence, according to the results obtained, *Dracaena trifasciata* had the greatest negative effect on FA levels and helped to reduce FA concentration, while *Epipremnum aureum* and *Spathiphyllum* had a comparatively different effect in its efficacy of reducing FA levels.

The P value for *Dracaena trifasciata* was 0.06, that for *Epipremnum aureum* was 0.02, and that for *Spathiphyllum* was <0.01.

The regressions of *Epipremnum aureum* and *Spathiphyllum* were calculated, and both had nonsignificant increase in formaldehyde levels in the air compared with the absence of plants in the storage room.

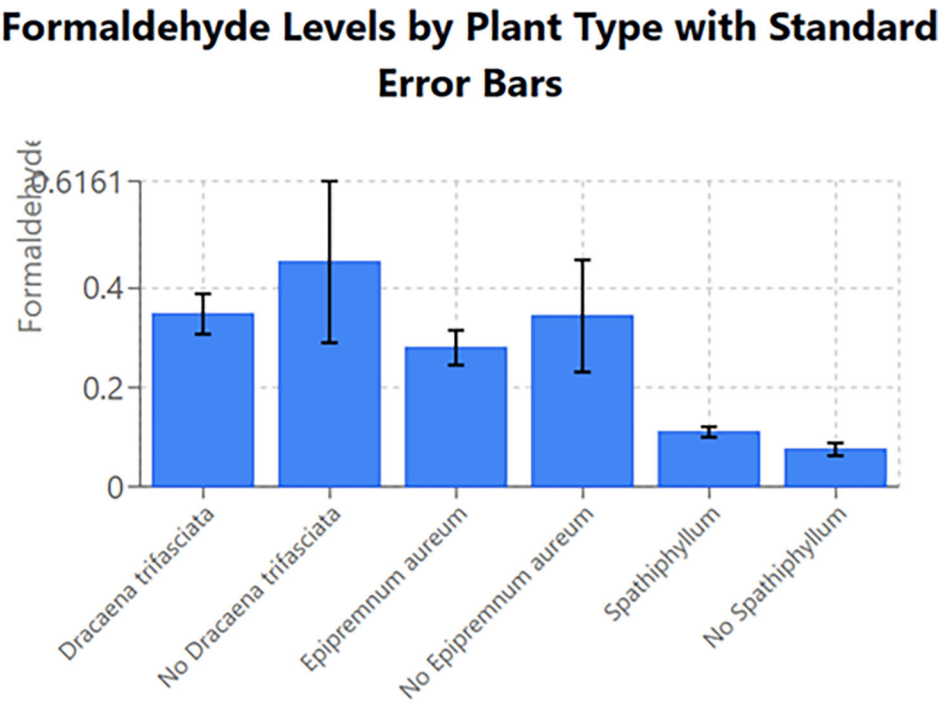

Figure 2. Efficacy of 3 plant species in reducing FA levels in the storage room of the anatomy dissection hall. (Note: Error bars represent standard deviation (SD)).

Table 1. The average temperature, humidity and FA concentrations with/without the plants.

	No plant			With plant		
	Avg. Temperature (°C)	Avg. Humidity	Avg. Formaldehyde (ppm)	Avg. Temperature (°C)	Avg. Humidity	Avg. Formaldehyde (ppm)
1. *Dracaena trifasciata*	33.4	69%	0.31	32.8	69%	0.28 ($p = 0.06$)
2. *Epipremnum aureum*	31.4	67%	0.23	32.5	72%	0.24 ($p = 0.02$*)
3. *Spathiphyllum*	27.0	82%	0.08	26.3	85%	0.11 ($p < 0.01$**)

*$p < 0.05$.
**$p < 0.01$.

Hence, *Dracaena trifasciata* fails to reject/invalidate the null hypothesis, while *Epipremnum aureum* and *Spathiphyllum* reject/invalidate the null hypothesis but have a slight positive effect on the FA level, there was an increase in the FA levels in the storage room, which is contrary to what we were trying to establish.

Additional spatial analysis revealed subtle variations in formaldehyde concentration relative to plant placement. While plants were arranged equidistantly, micro-variations in ambient formaldehyde levels were observed, suggesting potential localized absorption effects that warrant further investigation.

Discussion

Earlier studies conducted by multiple authors such as Teiri et al. (2018), Dela Cruz et al. (2014), Kim et al. (2008) and Wolverton and Wolverton (1993) have shown that potted ornamental plants seem to have a significant negative correlation with the FA levels. *Spathiphyllum* and *Dracaena trifasciata* in question have been shown to reduce FA significantly (Wolverton and Wolverton 1993); however, these same results were not reciprocated in this particular study. We did find a decrease in FA levels when *Dracaena trifasciata* was kept in the storage room; however, this change was not the same for the other 2 species of plants. While the efficacy of the *Epipremnum aureum* has not been particularly accurately described or reviewed in the literature, it is expected to reduce FA as well. All 3 plants failed to bring the average FA concentration in the storage room to levels deemed safe by WHO standards. However, the average FA levels in the storage room, whether there were any of the 3 plants or no plants at all, satisfied the OSHA standards. A similar result was also observed in previous studies (Gahukar et al. 2014). The weak positive correlation observed might be attributed to complex environmental interactions. Factors such as room temperature (ranging from 26.3-33.4°C), humidity variations (67-85%), and specific room configuration could significantly influence plant performance in formaldehyde absorption.

Temperature and humidity have a positive correlation with FA concentration, as observed in earlier literature (Parthasarathy et al. 2011), which indicates a similar positive correlation. The efficacy of the indoor plants *Spathiphyllum*, *Dracaena trifasciata* and *Epipremnum aureum* in reducing FA levels in ambient air contradicts the findings of earlier studies and can be explained on the basis of the following hypothesis. In previous studies (Teiri et al. 2018; Dela Cruz et al. 2014; Kim et al. 2008; Wolverton and Wolverton 1993), a constant amount of FA was pumped into a chamber; however, in the present study the FA present in the storage room in the anatomy dissection hall was evaluated and we wanted to determine the true efficacy of using potted plants in a real-time scenario. It is also important to note that our study was conducted with the exhaust fans turned off, which was necessary to establish baseline measurements, but differs from normal teaching conditions. Future studies might consider comparing formaldehyde levels with and without ventilation to better simulate actual classroom environments. Humidity and temperature are clearly positively correlated with FA concentration, both in this study and in earlier studies (Parthasarathy et al. 2011). However, the effects of these compounds on plant FA absorption and metabolism have not been determined. During the study period, conducted in the summer season, temperature ranged between 26.3-33.4°C with humidity levels of 67-85%. Movement within the storage room was strictly controlled, maximum 2-3 personnel entries per day, entry duration limited to 5 minutes were the protocols implemented to minimize air disturbance and maintain experimental integrity.

These controlled conditions aim to minimize external variables that might influence formaldehyde concentration and plant absorption capabilities. Future studies could explore how varying environmental parameters impact plant-mediated formaldehyde reduction. Previous studies (Dela Cruz et al. 2014) have indicated the use of 1 plant per 100 sq. feet, which is the rationale behind putting 7 plants in the 700 sq. feet storage room, the conditions in the earlier study (controlled

environment with known, constant quantities of FA) and this particular study (a real-time environment) differed, and a greater number of plants could impact the results of the study in a radically different way. While utilizing indoor plants for air purification, we should acknowledge potential health risks associated with certain species. Epipremnum aureum and Spathiphyllum contain calcium oxalate, which can cause mild toxicity if ingested. To mitigate risks plants should be positioned away from direct human contact areas and warning signs should be placed near plant locations on the inhibition of ingestion along with regular monitoring ensuring minimal risk to students and faculty.

Studies conducted for longer duration could yield different results, as potted ornamental plants become sensitized to FA and hence metabolize and remove more FA over time if they are constantly exposed to it (Wolverton and Wolverton 1993).

Considering the ill effects which long term exposure to FA could lead to as an occupational hazard (Onyeka et al. 2018); causing decreased pulmonary functions in faculty and medical students exposed to FA during anatomy dissection (Homwutthiwong and Ongwandee 2017) we hope to bring about a change in the working environment naturally. We plan to continue this study bearing the confounding factors in mind, scaling up the number of potted plants and hope that we could get an ideal environment where FA concentrations would not affect our health and learning would continue as usual. Researchers can explore the potential beneficial effects of indoor plants on reducing atmospheric pollutants, namely, FA, by such cost-effective methods. By delving deeper into this field and obtaining an ideal number and variety of plants for economically improving the air quality, especially in places with maximum exposure to FA, we hope to bring a positive change to those exposed to FA.

Conclusion

The efficacy of using indoor plants for reducing FA levels needs to be further explored since studies conducted in ambient air are rare, unlike prior studies conducted in controlled environments. While our initial study used a 14-day exposure period, future research should explore longer-term plant interactions with formaldehyde to comprehensively understand their air purification potential as well as increase the number of potted plants utilized. Additionally, more accurate formaldehyde measurement techniques should be employed, as conventional VOC meters may have limitations in sensitivity and specificity for formaldehyde detection. Future research should also compare scenarios with exhaust fans operational versus non-operational to better simulate actual teaching conditions. Future studies with expanded plant varieties, and implementing longer exposure periods (3-6 months) as well as investigating environmental variable impacts on plant air purification efficiency would enhance indoor air management.

Ethics and consent statement

The protocol was approved by the Institutional Ethics Committee (IEC 343/2022) Kasturba Medical College and Kasturba Hospitals, Manipal on July 14, 2022. Though the study did not involve cadavers directly, however the specimen storage room was utilized and written informed consent was given by the body donors for teaching and research when they were alive.

Data availability

Underlying data

Fig share: Can indoor plants reduce formaldehyde levels in the anatomy dissection hall? A study to evaluate the practicality of using plants in reducing formaldehyde levels. https://doi.org/10.6084/m9.figshare.25911100.v3 (Joshi et al. 2024)

This project contains the following underlying data:

- EX sheet – Master Sheet.xlsx

Reporting guidelines

Figshare: STROBE checklist 'Can indoor plants reduce formaldehyde levels in the anatomy dissection hall? A study to evaluate the practicality of using plants in reducing formaldehyde levels. https://doi.org/10.6084/m9.figshare.25911100.v3 (Joshi et al. 2024)

Acknowledgments

This project was undertaken as a part of the short-term studentship program conducted by the Indian Council of Medical Research (ICMR),on submission and approval of the project report, the student was provided with a stipend of INR 25,000/month for two months by ICMR. We would like to thank the Head of the department to allow us to conduct the study in the specimen storage room.

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Open Peer Review

Current Peer Review Status: ✔ ? ? ✔

Version 3

Reviewer Report 05 August 2025

https://doi.org/10.5256/f1000research.185228.r399863

✔ **Choy Ker Woon**
Department of Anatomy, Faculty of Medicine, Universiti Teknologi MARA, Shah Alam, Malaysia

I have made recommendation to accept this manuscript for indexing.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 2

Reviewer Report 04 February 2025

https://doi.org/10.5256/f1000research.175209.r348114

? **Choy Ker Woon**
[1] Department of Anatomy, Faculty of Medicine, Universiti Teknologi MARA, Shah Alam, Malaysia
[2] Department of Anatomy, Faculty of Medicine, Universiti Teknologi MARA, Shah Alam, Malaysia

1) Is there any significant differences between control and experimental group? Include the p value and its significant symbols in the table.

2) Under data analysis, state the type of the test done.

3) Is there any differences compare with or without the exhaust fans switched on, which mimic the real environment where the students are in?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: comparative anatomy, forensic antheopology and medical education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 16 Jul 2025

Rohini Punja

Reviewer comment:
Is there any significant differences between control and experimental group? Include the p value and its significant symbols in the table.
Response: We appreciate this suggestion and have now added the p-values directly to Table 1, along with significance symbols (* for p<0.05, ** for p<0.01) to improve clarity of statistical significance between control and experimental groups.

Reviewer comment:
Under data analysis, state the type of the test done.
Response: We have now explicitly stated in the data analysis section that paired t-tests were used to compare formaldehyde levels with and without plants for each plant species.

Reviewer comment:

Is there any differences compare with or without the exhaust fans switched on, which mimic the real environment where the students are in?
Response: This is an excellent point. Our current study focused on establishing baseline measurements without ventilation, which is why the exhaust fans were switched off during the experiment. We have now addressed this limitation in the methodology and conclusion sections, noting that future studies should compare scenarios with exhaust fans operational versus non-operational to better simulate actual teaching conditions.

Competing Interests: No competing interests were disclosed.

Reviewer Report 03 January 2025

https://doi.org/10.5256/f1000research.175209.r348122

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Yasar Sajjad
[1] COMSATS University Islamabad, Islamabad, Islamabad Capital Territory, Pakistan
[2] COMSATS University Islamabad, Islamabad, Islamabad Capital Territory, Pakistan

The idea to test the indoor plants for their removal efficiency in real environment is appealing. The experiment was conducted carefully, and the article is also well written. I am concerned about the reliability of technique used to measure the formaldehyde. Conventionally used VOCs meters are not so accurate, and sometimes may produce false positive/negative results. I suggest to address this point for future study in the conclusion section as well.

The clarity in the few sections is also required as follows.
Materials and methods: Mention the model of VOC (Volatile Organic Compound) monitor with its detection limit. Whether this monitor is specialized for formaldehyde only or for all general VOCs ?.

Results: Need to add the SE/SD on bars in fig 2.
Also add the results of regression in supplementary data file

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Plant Stress physiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 16 Jul 2025

Rohini Punja

Reviewer Comment:
The idea to test the indoor plants for their removal efficiency in real environment is appealing. The experiment was conducted carefully, and the article is also well written. I am concerned about the reliability of technique used to measure the formaldehyde. Conventionally used VOCs meters are not so accurate, and sometimes may produce false positive/negative results. I suggest to address this point for future study in the conclusion section as well.
Response: We thank the reviewer for acknowledging the value of our real-environment testing approach. We agree with the concern about VOC meter reliability and have added information addressing this limitation in both the methodology and conclusion sections. We have now specifically mentioned this as a direction for future research in the conclusion.

Reviewer Comment on Material and Methods:
Mention the model of VOC (Volatile Organic Compound) monitor with its detection limit. Whether this monitor is specialized for formaldehyde only or for all general VOCs ?.
Response: We have now added this information in the methods section, specifying that we used a Forbix Semicon air quality monitor with a detection limit of 0.005 ppm (5 parts per million) ppm.

Reviewer Comment on Results:
Need to add the SE/SD on bars in fig 2.
Response: We have now added SE information in the fig2 .

Competing Interests: No competing interests were disclosed.

Reviewer Report 12 December 2024

https://doi.org/10.5256/f1000research.175209.r343897

Kumar Satish Ravi
[1] All India Institute of Medical Sciences, Gorakhpur, Uttarakhand, India
[2] All India Institute of Medical Sciences, Gorakhpur, Uttarakhand, India

Authors have addressed my queries. Article may be accepted.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Anatomy, Cytogentics, Medical Education, Neuroanatomy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 14 November 2024

https://doi.org/10.5256/f1000research.167255.r333503

Ranganath Vallabhajosyula
[1] Nanyang Technological University Singapore, Singapore,, Singapore
[2] Nanyang Technological University Singapore, Singapore,, Singapore
[3] Nanyang Technological University Singapore, Singapore,, Singapore

The authors have conducted an interesting study on role of indoor plants in reducing the formaldehyde levels in the cadaveric labs. Interesting though, there are few questions, that authors would need to address.

Introduction: The authors have brought interesting statements on exposure of the quantum of FA concentrations and its effects. At this point, the authors need to emphasize on the composition of the formaldehyde to embalm the cadavers in general as well as experimental site.
Material and methods: The authors have explained the size of the plants and arrangement of

positions in the cadaver lab. However, they did not indicate the number of specimens (full cadavers, dissected specimens etc, amount of storage solution in the storage areas (if any), size of the storage units and chambers at the experimental site. It is suggestible to add this information in the manuscript.
Results: The authors have mentioned that the arrangement of plants is equidistant from one another. However, did the authors observe the distance between the plants and storage areas? Are the plants arranged equidistantly to storage places? If so, please indicate that in the manuscript and report the correlation.
Discussion: Requires improvement particularly on the timeline and rationale of the climatic conditions that the authors have focused on this study. The authors have indicated that they have restricted the movement to minimize the error. What is the permissible limit of movement if any? And did the authors notice any changes then.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: science of learning (metacognition and self-regulated learning), gamification and learning, anatomy and cytogenetics and evidence based anatomy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Nov 2024

Rohini Punja

We sincerely appreciate the reviewer's thoughtful and constructive feedback, which has provided valuable insights for improving our manuscript.

Reviewer Comment on Introduction:
Response: We have added the details on formaldehyde composition and information about the standard concentration of formalin used for cadaver preservation in our institution, typically a 10% buffered formaldehyde solution, in the methods section. We have also specified the exact concentration of formaldehyde in the storage solution and its potential contribution to ambient formaldehyde levels.
"In this study, we used formalin with a standard concentration of 10% formaldehyde solution, prepared according to our department's established preservation protocol. All cadavers were preserved using identical formalin preparation methods to ensure consistency in formaldehyde exposure."

Reviewer Comment on Material and Methods:
Response: We acknowledge the importance of providing comprehensive contextual information about the experimental environment to enhance the study's reproducibility. In the methodology section these additional details have been included:
- Number of cadaveric specimens: Total of 15 preserved specimens
- Storage solution details: 10% buffered formaldehyde solution
- Storage unit dimensions: Metal preservation chambers, each approximately 2m x 1m x 1.5m
- Total storage area volume: Approximately 21 cubic meters
- Distance between plants: 25 cm (as originally stated)
- Distance between plants and storage units: Approximately 50 cm
- Plant arrangement: Centrally positioned in the storage room to ensure uniform distribution

Reviewer Comment on Results:
Response: We have modified the results to include specific spatial relationships and added a supplementary analysis examining potential correlations between plant placement and formaldehyde concentration variations:
"Additional spatial analysis revealed subtle variations in formaldehyde concentration relative to plant placement. While plants were arranged equidistantly, micro-variations in ambient formaldehyde levels were observed, suggesting potential localized absorption effects that warrant further investigation."

Reviewer Comment on Discussion:
Response: We have attempted to improve the discussion by providing more context about seasonal conditions during the study (summer season, specific temperature and humidity ranges) and clarifying movement restriction protocols:
* No more than 2-3 personnel entries per day
* Maximum 5 minutes per entry
* Strict protocol to minimize air disturbance

Competing Interests: No competing interests were disclosed.

Reviewer Report 05 November 2024

https://doi.org/10.5256/f1000research.167255.r333509

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Kumar Satish Ravi
[1] All India Institute of Medical Sciences, Gorakhpur, Uttarakhand, India
[2] All India Institute of Medical Sciences, Gorakhpur, Uttarakhand, India
[3] All India Institute of Medical Sciences, Gorakhpur, Uttarakhand, India

Review Feedback on Manuscript

Title: “Can indoor plants reduce formaldehyde levels in the anatomy dissection hall? A study to evaluate the practicality of using plants in reducing formaldehyde levels”

This study presents an interesting and valuable investigation into the potential for using indoor plants to reduce formaldehyde (FA) levels in an anatomy dissection hall, a setting known for its high levels of this toxic substance. The study design, while sound, would benefit from some additional details and clarifications to provide a more comprehensive understanding of the research approach and its potential implications.

My remarks:

1. Description of Formalin/Preservative Used in Cadaver Preservation:
- The manuscript could have been more informative with a clear explanation of the formalin (or other preservative) used in the preservation of cadavers. While formaldehyde is commonly used for this purpose, a brief description of the specific formulation, concentration, and the conditions under which it is used would provide additional context and clarity to the study.
- It is important to clarify whether all cadavers in the study were preserved in the same manner and if variations in formaldehyde concentrations were considered.

2. Methodology:
- While the methodology is generally well structured, it could benefit from further elaboration. For example, more details about the selection process for the plant species would help readers understand why *Dracaena trifasciata*, *Epipremnum aureum*, and *Spathiphyllum* were chosen over other plants.
- Additionally, the duration of the plant exposure (14 days) and its rationale should be more thoroughly explained. Is this duration based on prior studies, or was it selected based on practical considerations? Longer exposure periods may have yielded more meaningful results, and discussing this would strengthen the interpretation of the findings.

3. Potential Health Concerns Regarding Plant Species:
- A notable concern is that both *Epipremnum aureum* (Golden Pothos) and *Spathiphyllum* (Peace Lily) are known to contain calcium oxalate, which can be toxic and cause allergic reactions or skin

irritation in humans. These plants are mildly toxic if ingested and can cause oral irritation, particularly in children and pets.
- Given that these plants will be placed in an environment that involves human activity (i.e., the anatomy dissection hall), the authors should review the safety implications of using these species in such settings. This could include a discussion on the potential for allergic reactions, skin irritation, or other health concerns for individuals who may come into direct contact with the plants.
- It is crucial to address this concern by justifying their use in the study, especially in a setting where students and faculty are working for extended hours. The authors should also explore the potential risks and whether there are safer alternatives available. A more thorough review of the literature on the toxicity of these plants in work environments would be helpful.

4. References:
- The manuscript cites older studies, which is acceptable to an extent, but it would be beneficial to include more recent references. The field of indoor air quality and phytoremediation is rapidly evolving, and more up-to-date studies could provide additional support for the findings or reveal emerging trends.
- In particular, newer research on plant-based air purification, formaldehyde absorption rates, and indoor air quality in educational settings could be included to strengthen the context and relevance of the study.

5. Statistical Analysis:
- The statistical analysis is clearly presented, but the interpretation of the p-values and correlations could be made clearer. Specifically, the discussion on the weak positive correlation with formaldehyde levels should be more thoroughly addressed. Given the results, the authors could explore the reasons why certain plant species did not show a significant reduction in FA levels, despite previous studies suggesting their effectiveness. This could involve discussing the environmental factors (e.g., temperature, humidity) or other variables not accounted for in the study.

6. Conclusion and Future Research:
- The conclusion is well-written and appropriately acknowledges the limitations of the current study. However, it would be beneficial to provide more specific recommendations for future research. For instance, the authors could suggest conducting a follow-up study with a larger sample of plants or extended exposure periods to better assess the long-term effectiveness of indoor plants in reducing formaldehyde levels.
- Additionally, exploring how different plant species interact with environmental variables (e.g., light, humidity, temperature) would help refine the understanding of which plants are most effective for reducing air pollutants in real-world settings.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Anatomy, Cytogentics, Medical Education, Neuroanatomy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Nov 2024

Rohini Punja

We sincerely thank you for the constructive feedback and have tried to address the concerns as pointed.
1. Description of Formalin/Preservative:
Response: We have added a more detailed explanation of the formalin used in cadaver preservation in the Methods section. We have specified the concentration, formulation, and standard preservation conditions used in our anatomy department. We have also added that all cadavers were preserved using the same standardized protocol.
"In this study, we used formalin with a standard concentration of 10% formaldehyde solution, prepared according to our department's established preservation protocol. "All cadavers were preserved using identical formalin preparation methods to ensure consistency in formaldehyde exposure."

2. Methodology:
Response: We appreciate the feedback on our methodology. We have justified the rationale for selecting *Dracaena trifasciata (Sansevieria), Epipremnum aureum*, and *Spathiphyllum*, including their previously reported air purification capabilities.The duration of 14-day exposure period was due to time constraints and this has been included explaining our practical considerations. We have discussed the potential benefits of longer exposure periods in the limitations and future research sections.
"Plant Selection Rationale: "We selected these three plant species based on their prior reported capabilities in air purification. *Sansevieria trifasciata* (Snake Plant), *Epipremnum aureum* (Golden Pothos), and *Spathiphyllum* (Peace Lily) have been previously documented in scientific literature for their potential to absorb volatile organic compounds."

3. Potential Health Concerns Regarding Plant Species:

Response: We acknowledge the important safety considerations raised. We have included in the discussion the potential toxicity of *Epipremnum aureum* and *Spathiphyllum*, explaining the ideal placement of plants to minimize direct human contact. Since this was conducted in the specimen storage room and students do not have access to this area, except the staff handling these specimens/cadavers the risk of exposure is minimum though we have to keep these points in mind if we plan to replicate this study in an environment where students would be present.

4.References:
Response: We have updated our references with more recent studies on indoor air quality and phytoremediation and included newer research on plant-based air purification, particularly focusing on studies conducted in educational settings after 2018.
17. Matheson S, Fleck R, Irga PJ, Torpy FR. Phytoremediation for the indoor environment: a state-of-the-art review. Rev Environ Sci Biotechnol. 2023;22(1):249-280. doi: 10.1007/s11157-023-09644-5. Epub 2023 Feb 27. PMID: 36873270; PMCID: PMC9968648.
18. Peterson G, Jones T, Rispoli D, Haddadi S, Niri V. Investigation of simultaneous volatile organic compound removal by indoor plants using solid phase microextraction-gas chromatography-mass spectrometry. RSC Adv. 2023 Sep 7;13(38):26896-26906. doi: 10.1039/d3ra04015a. PMID: 37692358; PMCID: PMC10483372.

5. Statistical Analysis:
Response: We have provided a more detailed interpretation of the weak positive correlations and discussed potential environmental factors that might have influenced plant performance and also explored why our results differed from previous studies, considering variables like temperature, humidity, and room configuration

"The weak positive correlation observed might be attributed to complex environmental interactions. "Factors such as room temperature (ranging from 26.3-33.4°C), humidity variations (67-85%), and specific room configuration could significantly influence plant performance in formaldehyde absorption."

6. Conclusion and Future Research:
Response: We have expanded our conclusion to include more specific recommendations for future research; suggestions for follow-up studies with larger plant samples and extended exposure periods and exploration of how environmental variables interact with plant performance in air purification

Competing Interests: No competing interests were disclosed.