eISSN:2581-4885
DEV SANSKRITI VISHWAVIDYALAYA PUBLICATION

RESEARCH ARTICLE

Particulate Matter and Gaseous Emissions from Yagya Fume in Open and Closed Door Environment

Dev Ashish Giri[1*], Pooja Priyadarshani[2], and Priyanka Bist[3]

[1]Scientist, Yagyavalkya Center for Yagya Research, Dev Sanskriti Vishwavidyalaya, Haridwar, India
[2]Postgraduate Student, Dept. of Psychology, Dev Sanskriti Vishwavidyalaya, Haridwar, India
[3]Research Assistant, Yagyavalkya Center for Yagya Research, Dev Sanskriti Vishwavidyalaya, Haridwar, India

Abstract. The practice of Yagya, a traditional Vedic ritual involving the combustion of specific materials, has significant therapeutic potential through its fume. We examined the Yagya fume for particulate matter (PM) and various gas levels. In the open-room environment (n= 40) PM1, PM2.5, and PM10 levels exceeded 1000 µg/m3. However, these levels returned to the baseline of 250 µg/m3 just after the Yagya. Carbon dioxide (CO_2) remained consistent, with median concentrations of 2000 ppm with or without Yagya. Carbon monoxide (CO) levels increased to 20 ppm during the Yagya but remained at 0.4 ppm after the Yagya, like normal air conditions. In the closed-room environment (n= 3), immediate increases in PM levels above 1000 µg/m3 were observed, which gradually decreased to 250 µg/m3 after around 15 hours of Yagya. CO_2 and CO levels initially rose and decreased to normal levels after 6 to 7 hours. Nitrogen oxides (NOx) and Ozone (O_3) exhibited slight increases during Yagya, while Sulfur Dioxide (SO_2) levels remained unchanged. We suggest that the high PM levels during Yagya are unique to the source, viz., medicinal wood, *Ghee*, and *Hawan samagri* (herbal mixture), necessitating further investigation.

Keywords. Yagya, Air quality, Particulate matter, Gaseous emissions, Traditional practice

**CORRESPONDENCE
Address Yagyavalkya Center for Yagya Research, Dev Sanskriti Vishwavidyalaya, Haridwar, India
Email dev.ashish@dsvv.ac.in

PUBLISHED BY
Dev Sanskriti Vishwavidyalaya Gayatrikunj-Shantikunj Haridwar, India

Introduction

Yagya is a traditional Vedic ritual involving the combustion of specific medicinal herbs (*Hawan samagri*: a mixture of sacred herbs and other ingredients), *Ghee* (clarified butter), wood, etc. in a controlled environment. It is also commonly known as *Agnihotra* or *Hawan*, has been performed in India for centuries, and is believed to have both spiritual and therapeutic benefits [1]. It is traditionally conducted in a *Yagyashala* or Yagya room, which typically has an open setting that allows for the release of emissions generated during the ritual. The fume produced during Yagya is considered to have therapeutic and purifying properties. Experimental studies show that the incidences of physical ailments, sickness, and/or diseases decrease in houses where the Yagya or *Agnihotra* is regularly performed [2]. It is also reported to purify the blood and prevent the growth of pathogenic bacteria [3]. The therapeutic advantages of Yagya are believed to significantly arise from the specific composition of the herbal medicinal fumes and their interaction with the environment and living organisms [4]. While Yagya has been revered for its potential health benefits and environmental purification (antimicrobial effect), there is a need to evaluate its impact on air quality and human health scientifically. Previous studies have explored the effect of Yagya on air quality parameters such as particulate matter and gases, but a comprehensive understanding of Yagya fume emission and its implications is still lacking [5, 6]. Furthermore, the unique composition of the emitted particulate matter, derived from the combustion of medicinal wood, *Ghee*, and *Hawan samagri* (a medicinal herb mixture), requires further investigation to determine its chemical properties and potential health effects. We aimed to examine the levels of PM1, PM2.5, PM10, CO_2, CO, NO_2, O_3, and SO_2 in both open and closed-room settings.

Materials and Methods

Materials

The materials used for the experiment included a square-shaped *Yagyakund*, 200 gms of mango wood with bark, 40 gms of *Ghee*, and 75 gms of *Hawan samagri*. The *Hawan samagri* (herbal mixture) consisted of Giloy *(Tinospora cordifolia)*, Bakuchi *(Psoralea corylifolia)*, Cheed *(Pinus roxburghii)*, Kapoor kachari *(Hedychium spicatum)*, seeds of Palash *(Butea monosperma)*, and Nagarmotha *(Cyperus scariosus)* in equal quantities, with a smaller percentage (approximately 2%) of castor oil and camphor.

Room (Yagyashala)

The experimental room *(Yagyashala)* had a volume of 120 m3. The room's opening area, including doors and windows, was approximately 50 square feet, allowing air exchange in the open room setting.

Experimental Design:

a: Open-room environment

In the open-room settings, a total of 108 offerings were made using the *Gayatri Mantra*. Yagya was performed [7] daily between 8:00 a.m. and 10:00 a.m. for 40 days. Air quality readings were taken continuously for 24 hours each day, measuring PM1, PM2.5, PM10, CO_2, CO, NO_2, O_3, and SO_2 using a sensor-based air quality monitor (Prana Air). Standard air monitoring was carried out without Yagya for 14 days in the open room setting as the control.

b: Closed-room environment

This involved burning wood, *Ghee* (clarified butter), and *Hawan samagri* (a herbal mixture). The burning of *Hawan samagri* in the closed room was conducted at 4:00 p.m., and air quality readings were taken from 3:00 p.m. to 6:00 a.m. on the following day, totalling 15 hours of monitoring. After the monitoring period, the room was ventilated. This process was repeated three times. The same air quality parameters were measured using a sensor-based air quality monitor.

Results

The experiment was conducted in both open and closed-room settings to evaluate the impact of Yagya on air quality with and without ventilation. The particulate matter (PM) levels in the open room settings during Yagya increased significantly—above 1000 µg/m3 during the period when Yagya was performed (8 a.m. to 10 a.m.), while the PM levels decreased and remained around 250 µg/m3 during the rest of the day, that was similar to the levels taken in the normal air without Yagya (Figure 1). In the closed-room setting, the PM levels immediately rose above 1000 µg/m3 and started to decrease after 8 hours, reaching around 250 µg/m3 after around 15 hours. The PM levels might have started decreasing steadily in the closed room, but were only observed when they dropped below the sensing levels of 1000 µg/m3 after 8 hours (Figure 2).

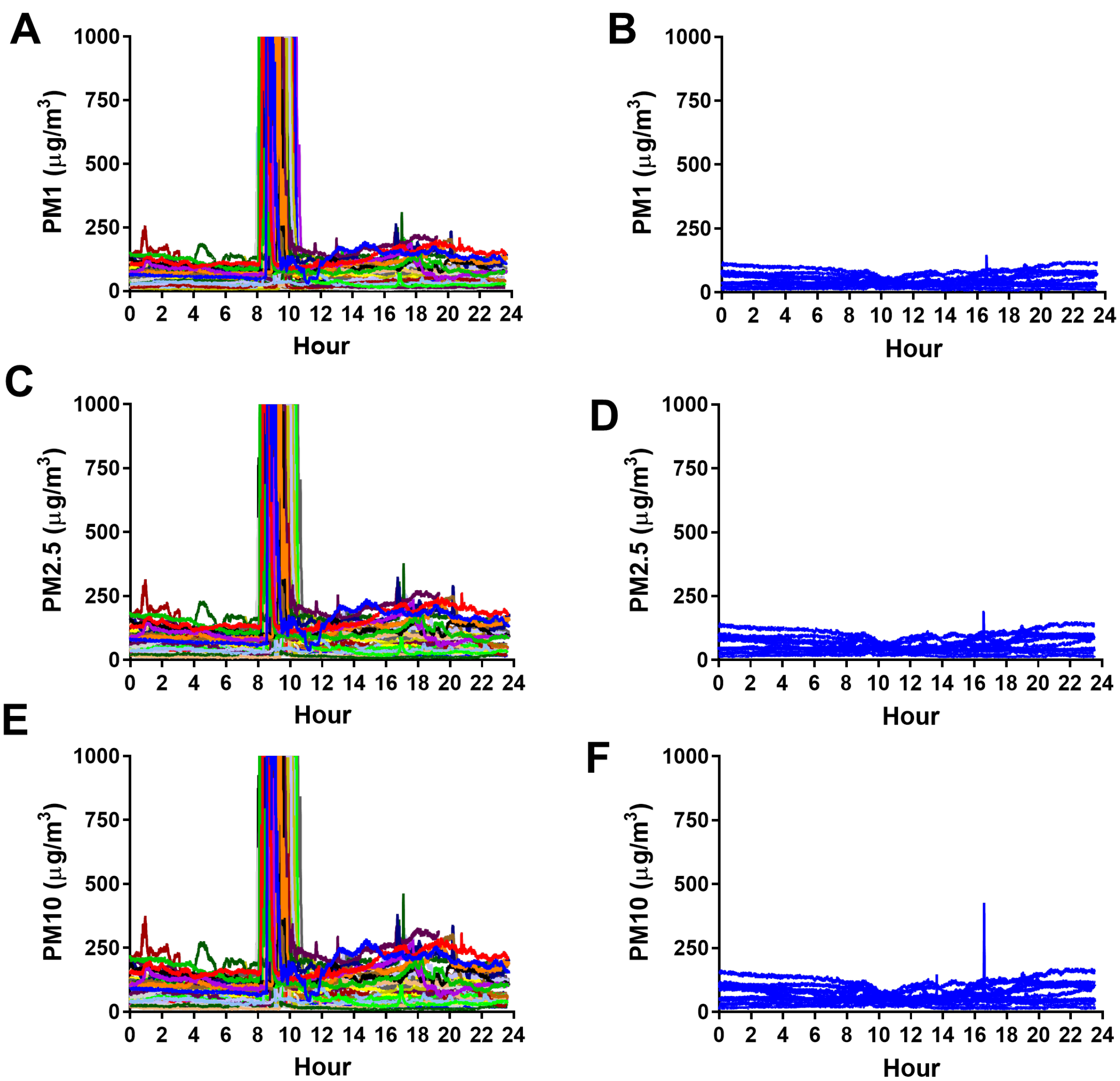

Figure 1: Particulate Matter of Yagya fumes in an open room setting. Left Panel A, C, and E represent particulate matters (PM1, PM2.5, and PM10) in Yagya fumes in open room settings (n = 40); fire is lit between 8 and 10 hours; right Panel B, D and F represent particulate matters (PM1, PM2.5, and PM10) of normal air (without Yagya) in the same open room settings (n = 14). 1000 ug/m3 is the sensor's limit.

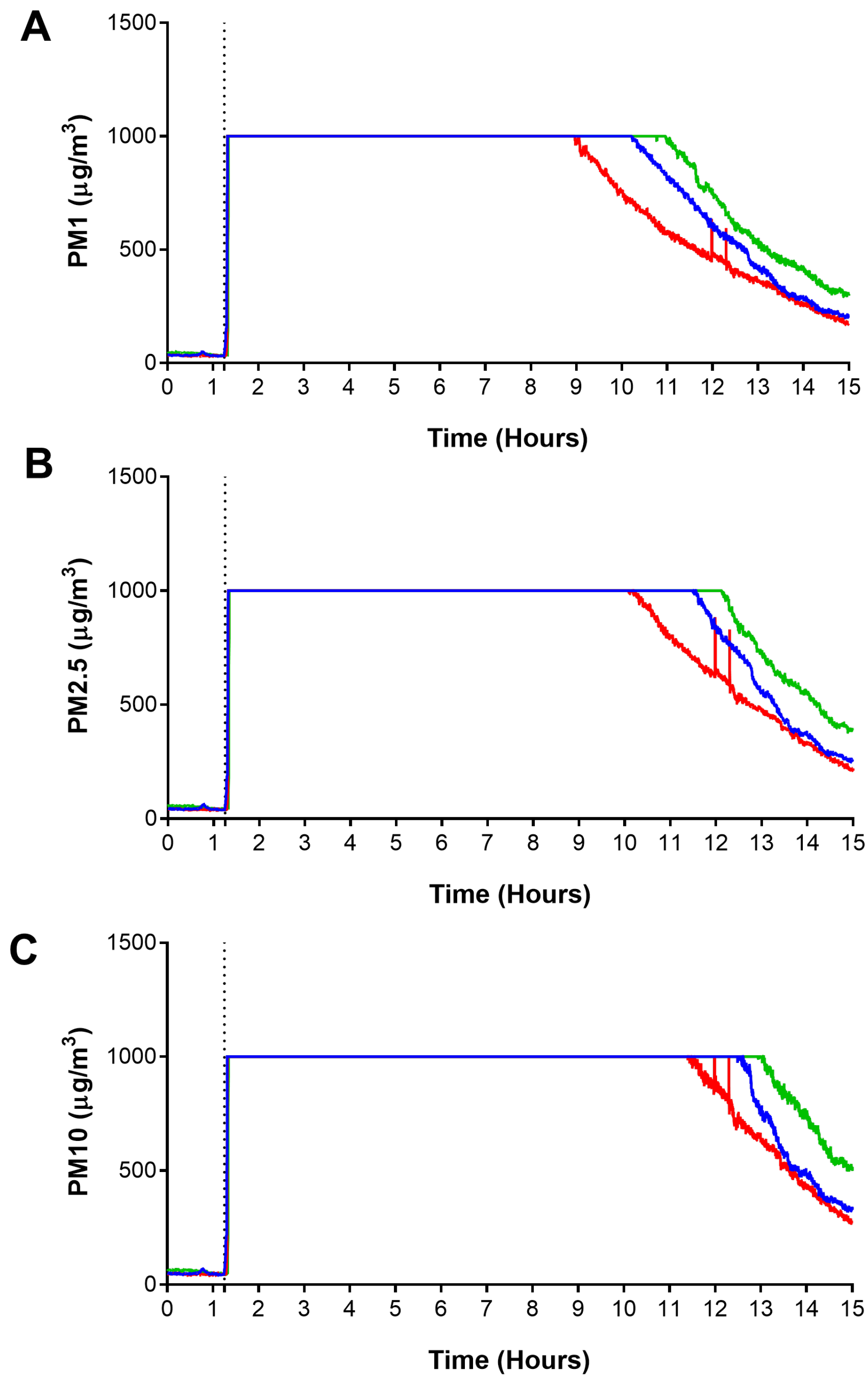

Figure 2: Particulate Matter of fumes of wood, *Ghee* and hawan samagri (W+G+H) in a closed-room setting. A, B and C represent particulate matter (PM1, PM2.5, and PM10) of W+G+H fumes in closed-room settings (n = 3); the dotted line at 1.25 hours indicates the start of the fire in the closed room. 1000 ug/m3 is the sensor's limit.

Although Carbon monoxide (CO) increased to 20 ppm (median) during the Yagya period from 8 a.m. to 10 a.m. in the open room settings, it remained similar to normal air levels (0.4 ppm) during the rest of the day. In the closed room, CO levels went above the sensor's detection limit (above 40 ppm) immediately after the fire was lit and started decreasing after 6 to 7 hours, returning to normal levels around 15 hours later (Figures 3 and 4).

The carbon dioxide (CO_2) levels remained consistent with or without Yagya in the open room settings, with a median of 2000 ppm during Yagya and 2100 ppm during normal air. In the closed room, the peak median CO_2 level was 3000 ppm, and the highest was near 6000 ppm which was reached after the burning of *Hawan samagri* (Figures 3 and 4).

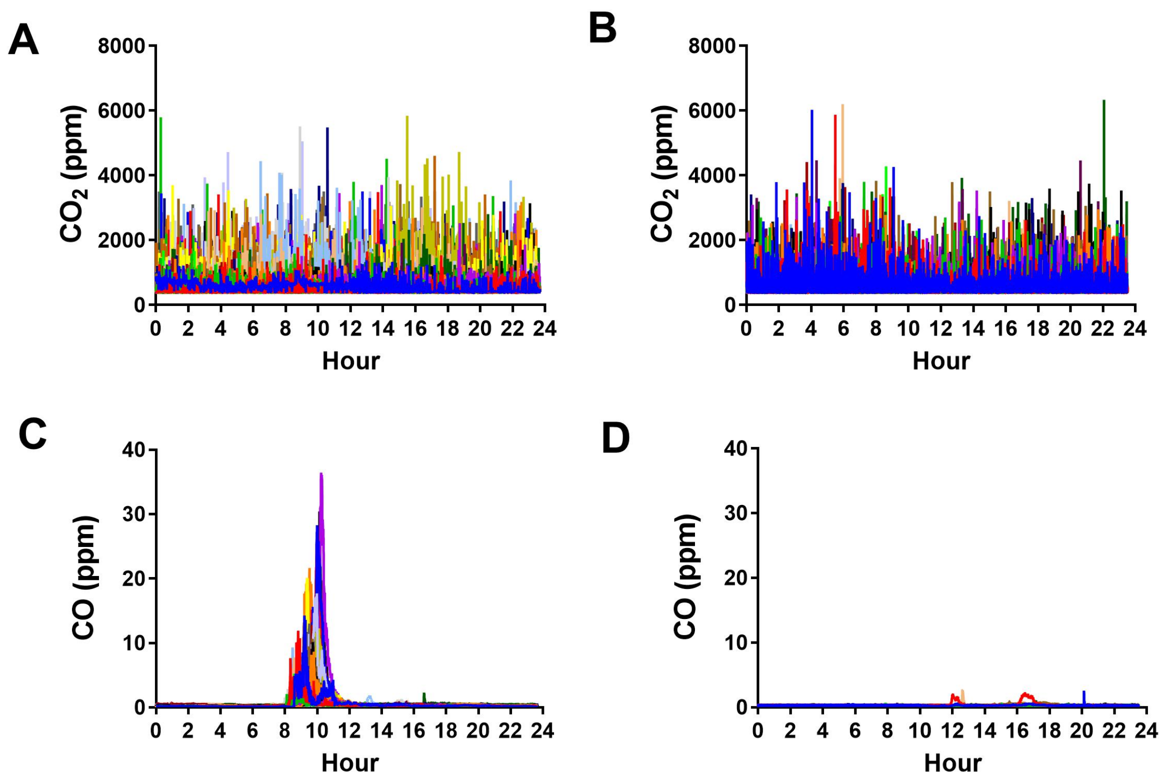

Figure 3: Carbon dioxide (CO_2) and Carbon monoxide (CO) of Yagya fumes in an open room setting. Left Panel A and C, represent Carbon dioxide (CO_2) and Carbon monoxide (CO) in Yagya fumes in open room settings (n = 40); fire is lit between 8 and 10 hours; right Panel B and D represent Carbon dioxide (CO_2) and Carbon monoxide (CO) of normal air (without Yagya) in the same open room settings (n = 14)

The Nitrogen oxide (NOx) levels were slightly increased during Yagya in the open room settings, reaching 0.06 ppm (median) compared to the normal air range (i.e. before and after Yagya) of 0.02 to 0.04 ppm. In the closed room, the NOx levels increased to a little less than 3 ppm for approximately 2 hours, which is interesting considering that PM and CO took around 10 to 15 hours to return to baseline levels in the closed room. Ozone levels followed a similar pattern to Nitrogen oxide. In the normal air, Ozone ranged from 0.01 to 0.04 ppm, while during the 2 hours of Yagya, it slightly increased to 0.06 ppm in the open room settings. In the closed room,

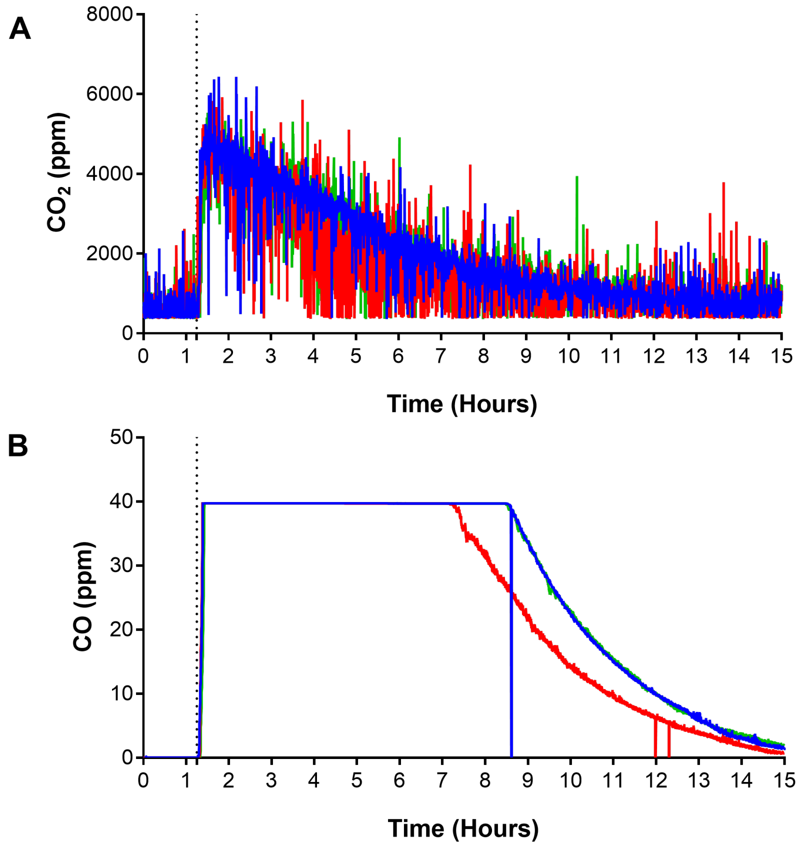

Figure 4: Carbon dioxide (CO2) and carbon monoxide (CO) fumes of wood, *Ghee* and hawan samagri (W+G+H) in a closed-room setting. A and B represent Carbon dioxide (CO2) and carbon monoxide (CO) of W+G+H fumes in closed-room settings (n = 3); the dotted line at 1.25 hours indicates the start of the fire in the closed room.

Ozone levels increased for 2 hours, with a peak of 1.5 ppm.

The Sulfur Dioxide (SO_2) levels remained unchanged throughout the day with or without Yagya in the open room settings (Figure 5).

Discussion

The findings of our study shed light on the impact of Yagya fumes on air quality, with a specific focus on particulate matter (PM) and various gases in open and closed room settings. During Yagya, there was a significant increase in PM levels, while the levels of Carbon dioxide (CO_2), Carbon monoxide (CO), Nitrogen oxide (NOx), Ozone (O_3), and Sulfur dioxide (SO_2) fluctuated but remained generally within permissible limits [8, 9] which are consistent with findings from other studies [5, 10, 11] suggesting that Yagya does not have a significant adverse impact on these gas levels. The increase in PM levels during Yagya can be attributed to the burning of Mango wood, *Ghee* and *Hawan samagri.* PM is a mixture of heterogeneous components that varies substantially by place, source and season. Organic carbon (OC), elemental carbon (EC), Nitrate, Sulfate, and trace elements are among their constituents. These chemical substances come from various anthropogenic and natural sources, including sea salt, road dust, biomass gasification, automobile exhaust, and forest fires [12]. A study of the effect of Yagya on air quality found that SO_2, NOx, O_3, NH_3, CO_2, O_2, and the values of PM decreased [10]. We consistently found that the PM increases in both the open and closed-room settings. However, it is important to note that the specific composition of the *Hawan samagri*, which includes medicinal herbs and other ingredients, may have further influenced the nature and composition of the emitted particulate matter [13].

Regarding the levels of other gasses, we found that CO_2 levels remained consistent with or without Yagya in the open room settings, while in the closed room, the peak median CO_2 level was higher after the burning of *Hawan samagri* that took longer to come to normal levels evidently due to lack of ventilation as was observed for all the emissions. This observation aligns with previous research indicating that the burning of organic materials results in the release of Carbon dioxide [14].

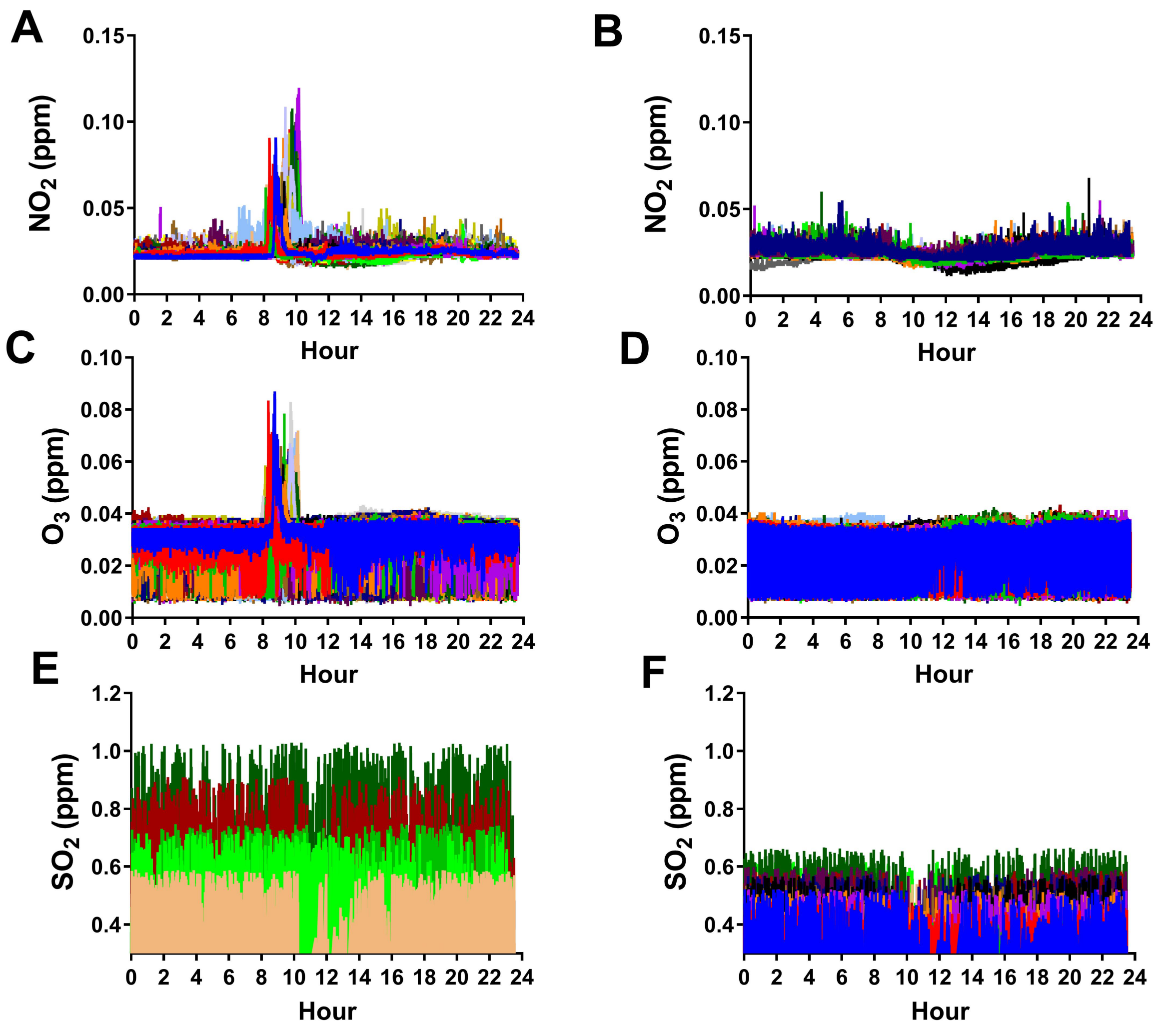

Figure 5: Nitrogen oxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2) of Yagya fumes in an open room setting. Left Panels A, C, and E represent (NO_2, O_3, and SO_2, respectively) in Yagya fumes in open room settings (n = 40); fire is lit between 8 and 10 hours; right Panels B, D, and F represent (NO_2, O_3, and SO_2, respectively), of normal air (without Yagya) in open room settings (n = 14).

doi.org/10.36018/ijyr.v6i1.105

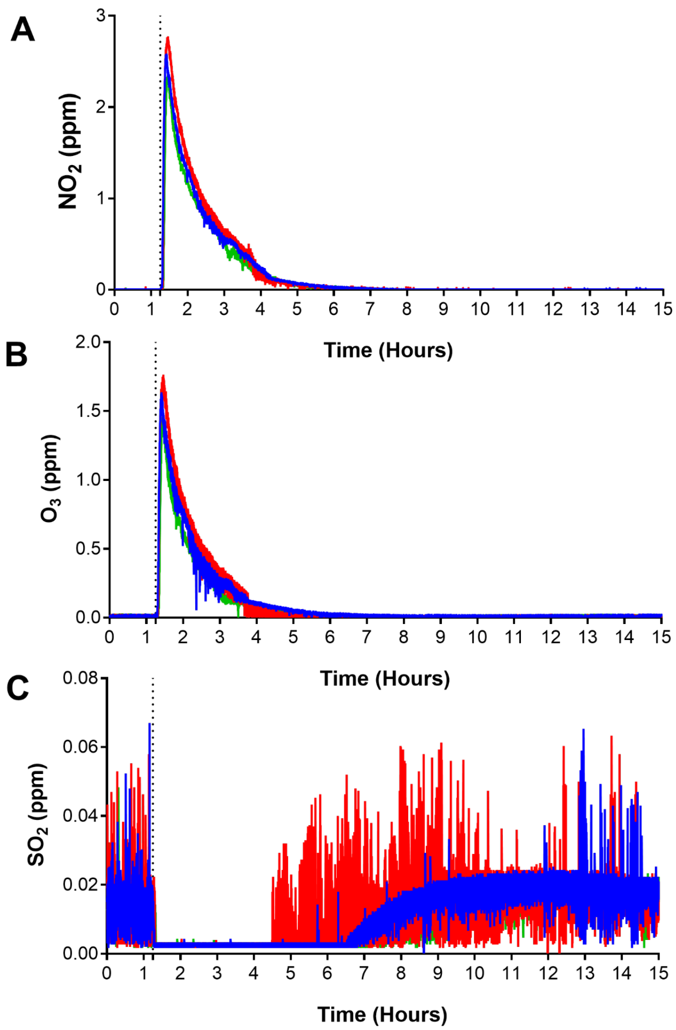

Figure 6: Nitrogen oxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2) of wood, ghee, and hawan samagri (W+G+H) in a closed-room setting. A, B, and C represent NO_2, O_3, and SO_2, respectively, of W+G+H fumes in closed-room settings (n = 3); the dotted line at 1.25 hours indicates the start of the fire in the closed room.

The increased CO levels in the closed room suggest the unavailability of Oxygen due to a lack of ventilation. A study observed the NO_2 and SO_2 levels before, during and after the Yagya were, respectively, 0.61 ppm, 0.6 ppm and 0.54 ppm, and 1.27 ppm, 1.07 ppm and 0.31 ppm [15].

We observed that the SO_2 levels remain unchanged, whereas the NO_2 level increases during Yagya in both the open and closed-room settings. The sudden decrease in SO_2 level after the initiation of the Yagya in closed-room settings was not understandable and required more repetitions to confirm (Figure 6).

In the case of Yagya, the particulate matter is likely to consist of organic compounds, trace elements, and potentially bioactive substances derived from the burning of medicinal wood, *Ghee*, and *Hawan samagri*. These factors may contribute to the therapeutic benefits associated with Yagya and could have implications for human health [13]. Future studies should consider analyzing the chemical composition of the emitted particulate matter, including the identification of organic compounds, trace elements, and potential bioactive substances. Furthermore, assessing the size distribution and morphology of the particulate matter would provide insights into its behaviour in the atmosphere and its potential to penetrate the respiratory system. While this study focused on one aspect of Yagya, namely its fumes' impact on air quality, it is important to consider further studies to understand its chemical composition [16, 17]. Yagya has been practised for centuries and is deeply rooted in ancient Indian traditions and culture. It has been revered for its potential therapeutic benefits, environmental purification, and spiritual significance. Given its time-tested nature and potential applications, Yagya warrants a comprehensive evaluation encompassing various aspects, including its impact on air quality, chemical composition of fume, human health, and overall well-being.

Compliance with ethical standards Not required.
Conflict of interest The authors declare that they have no conflict of interest.

References

[1] Raghuvanshi M, Pandya P, Joshi RR. Yagyopathic Herbal Treatment of Pulmonary Tuberculosis Symptoms: A Clinical Trial. Alternative and Complementary Therapies 2004;10:101–5. https://doi.org/10.1089/107628004773933352.

[2] Kaur RP, Bansal P, Kaur R, Gupta V, Kumar S. Is There Any Scientific Basis of Hawan to be Used in the Alzheimer's Disease Prevention/Cure? CTM 2016;2:22–33. https://doi.org/10.2174/2215083802666160722160733.

[3] Mishra S, Shrivastava V, Batham L, Mishra A. Supportive Care In A Patient With Acute Myeloid Leukemia Through An Integrated Approach Including Yagya Therapy. Interdis J of Yagya Res 2019;2:20–8. https://doi.org/10.36018/ijyr.v2i2.27.

[4] Chaube RK, Chaube VK, Saxena P, Solanki K, Chandra Tiwari RV, Tiwari, H. Scientific rationale of Yagya: a review. Int J Community Med Public Health 2020;7:2831. https://doi.org/10.18203/2394-6040.ijcmph20203022.

[5] Mamta S, Kumar B, Matharu S. Impact of Yagya on Particulate Matters. Interdis J of Yagya Res 2018;1:01–8. https://doi.org/10.36018/ijyr.v1i1.5.

[6] Liu X, Zhang Y-L, Peng Y, Xu L, Zhu C, Cao F, et al. Chemical and optical properties of carbonaceous aerosols in Nanjing, eastern China: regionally transported biomass burning contribution. Atmos Chem Phys 2019;19:11213–33. https://doi.org/10.5194/acp-19-11213-2019.

[7] Sharma S, editor. Saral Aur Sarvopyogi Gayatri Yagya Vidhi (Hindi). Revision. Mathura: Yug Nirman Yojana Vistar Trust, Gayatri Tapobhumi; 2012.

[8] Central Pollution Control Board, Ministry of Environment and Forests, India. Guidelines for the Measurement of Ambient Air Pollutants Volume 1: National Ambient Air Quality Series: NAAQMS/36/2012-13. 2012, Page 7.

[9] United States Environmental Protection Agency (USEPA). NAAQS Table. 2023. Available from: https://www.epa.gov/criteria-air-pollutants/naaqs-table

[10] Kumar P, Pinky, Shalu Saini, Kumar V, Kumar S. IMPACTS OF YAGYA ON AIR QUALITY. Zenodo 2022. https://doi.org/10.5281/ZENODO.6874820.

[11] Rastogi V, Swami Krishnanand, Panwar RB, Chacko KM, Prem R, Vijay C, et al. Quality analysis, Anti-bacterial activity and Chemical Characterization of Ethnobotanical (Hawan) Medicinal Fumes. Interdis J of Yagya Res 2022;5:01–19. https://doi.org/10.36018/ijyr.v5i1.79.

[12] Mirowsky J, Hickey C, Horton L, Blaustein M, Galdanes K, Peltier RE, et al. The effect of particle size, location and season on the toxicity of urban and rural particulate matter. Inhalation Toxicology 2013;25:747–57. https://doi.org/10.3109/08958378.2013.846443.

[13] Bansal P, Kaur R, Gupta V, Kumar S, Kaur R. Is There Any Scientific Basis of Hawan to be used in Epilepsy-Prevention/Cure? J Epilepsy Res. 2015 Dec 31;5(2):33-45. https://doi.org/10.14581/jer.15009

[14] Martin WJ, Glass RI, Araj H, Balbus J, Collins FS, Curtis S, et al. Household Air Pollution in Low- and Middle-Income Countries: Health Risks and Research Priorities. PLoS Med 2013;10:e1001455. https://doi.org/10.1371/journal.pmed.1001455.

[15] Rathi P. Effects of Yagya on Environment Purification and Human Health: A Review. Res J Chem Environ Sci. 2019;7(5-6):46-49.

[16] Brook RD, Rajagopalan S, Pope CA III, Brook JR, Bhatnagar A, Diez-Roux AV, et al. Particulate Matter Air Pollution and Cardiovascular Disease. Circulation 2010;121:2331–78. https://doi.org/10.1161/cir.0b013e3181dbece1.

[17] Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A. The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature 2015;525:367–71. https://doi.org/10.1038/nature15371.