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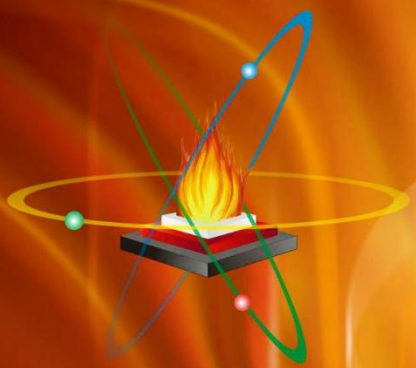

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Impact of Yagya on Particulate Matters

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Abstract. Particulate Matters (PM) is a result of air pollution and associated with health hazards. Studies support mild or strong association of PM with lung diseases including cancer, cardiovascular diseases, cognitive diseases, newborn mortality rate, etc. Particles of size < 2.5µM are declared as health hazard as they penetrate deep into lungs and lodge themselves there. Ineffective clearance of this PM results in a chronic, low-grade inflammatory response leading to various disease. Current efforts to control PM are scarce and demanded to find solutions which can prevent or control the increasing PM levels. Ancient texts including Vedas and Upanishads mentioned a technique called Yagya, which has application to purify the environment specifically polluted air. Preliminary evidences suggested that Yagya reduces air pollution generated SO_2 and NO_2 level along with biological air pollutants such as microorganisms. The present study examined the Yagya's effect on air PM. The present study, conducted two indoor case study experiments to find the effect of Yagya on PM in indoor environment in December 2017. The study showed trend of decrease of PM 2.5, PM 10, and CO_2 after performing Yagya inside the residences of 2 case studies. The present study introduced Vedic technique-Yagya as a solution to reduce indoor air pollutants specifically PM and CO_2, and laid the foundation for further research.

Keywords. Particulate Matter, Yagya, hazards, Air pollution, CO_2

Introduction

In 1979, the *American Journal of Epidemiology* devoted an entire issue to a review of the health effects of particulate air pollution. The authors, well known British epidemiologists, concluded that there was no evidence for negative health effects from particulate pollution at levels seen in the United States (1). Yet, less than 30 years later, the Environmental Protection Agency reported "Inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis" (2).

The ever increasing Particulate Matter (PM) levels around the world including India, especially in Delhi, have raised serious concerns. Particulate matter are fine particles, which remain suspended in the air for a long time and enter our lungs through inhalation. The fine particles of size < 2.5µM are declared as health hazard as they penetrate deep into lungs and lodge themselves there. Ineffective clearance of this PM from the airways could cause particle retention in lung tissues, resulting in a chronic, low-grade inflammatory response that may be pathogenetically important in both the exacerbation, as well as, the progression of lung disease (3).

Recent studies indicate that PM can probably cause oxidative injury to the airways, leading to inflammation, remodeling, and increased risk of sensitization (4). Exposure to a wide range of air pollutants gives rise to oxidative stress within the lung, and this appears to initiate responses that are particularly dangerous to susceptible members of the population. One of these responses is the influx of inflammatory cells to the lung. In the absence of any invading organisms to kill, these free radicals attack local tissue components and cause cell injury (5)**.** Thus, there is now compelling evidence that chronic and acute exposure to ambient fine particulate matter (PM2.5) air pollution increases cardiopulmonary mortality. However, the role of PM2.5 in the etiology of lung cancer is less clear, particularly at concentrations that prevail in developed countries and in never-smokers (6).

The latest estimate from the WHO reported that in 2012, approximately 3.7 million people died from outdoor urban and rural sources (7). The cause of deaths was broken down as follows: stroke (40 %), ischemic heart disease (40 %); chronic obstructive pulmonary disease (COPD) (11 %), lung cancer (6 %) and acute lower respiratory infections in children (3 %). These figures are based not only on a greater understanding of the diseases caused by poor air quality, but also on more accurate exposure assessment that utilizes sophisticated measurement and modeling technology. The overall mortality estimates have more than doubled recently and it reveals that the vast majority of deaths stem from cardiovascular disease.

In a recent study (8), authors have strongly advocated for an integrated approach to air quality and climate policies. Similarly, another study (9) strongly suggests that PM effects have no threshold within the studied range of ambient concentrations, which can occur at levels close to PM2.5 background concentrations following mostly linear concentration–response function. Now the evidence is well-established for outdoor exposure to air pollution with reduced lung function, heightened severity of symptoms in individuals with asthmatics, COPD and ischemic heart disease which includes heart attacks (9,10). They have also recommended that translating the correct scientific evidence into realistic, bold and effective policies has the potential to reduce air pollution so that it does not pose a damaging and costly toll on public health.

A study examined 10,565 births at Sir Ganga Ram Hospital, Delhi, India to assess the link between air pollution and birth outcomes between 2007 and 2012 in the Indian capital (11). For this, maternal and neonatal data was gathered and linked to air pollution data — based on distance to the nearest air quality monitoring station. The study was conducted to assess if there were any gaps in the information maintained by city hospitals for environmental public health tracking. It concluded that information related to the mother's socio-economic position, substance abuse, exposure to second-hand tobacco smoke and nutritional status were crucial to identifying environmental factors, and were linked to the health of the baby and the mother.

Surprisingly, the study threw up another unexpected and alarming trend that Delhi's toxic air is shrinking newborns with the air not only adversely affecting the growth of the fetus, but also, resulting in premature births.

Harmful effects have been shown for low birth weight, small for gestational age and preterm birth (12,13). A small number of studies have investigated traffic-related air pollution exposure at participants' residential address as a novel risk factor for type 2 diabetes mellitus (T2DM). Although not conclusive, results suggest an association between risk of T2DM and exposure to PM (10,14,15). However, evidence is stronger for NO_2 and distance to road (16) that the deleterious effects of PM air pollution may extend to the brain have only recently been discovered and research in this area is currently limited and results inconclusive (17). For example, a study of women (68–79 years old) who lived for more than 20 years in the same residence showed a significant reduction in mild cognitive function (associated with a high risk of progression to Alzheimer's Disease) in those who were 74 years old or younger and lived within 50 meter to the next busy road with a traffic density of more than 10,000 cars per day (14). However, no effect in cognitive function was found for PM_{10} concentrations.

Current efforts to control PM are scarce. Indoor environment of houses suffer a lot due to external increasing PM. There is an imperative need to find solutions which can prevent or control the increasing PM levels.

Ancient texts including Vedas and Upanishads mentioned a technique called Yagya to purify the environment specifically polluted air. Yagya is a process in which herbs are sacrificed in fire with rhythmic chanting of mantras (18-20). Besides this, proof of concept studies have been carried out. Previously, preliminary studies indicated that Yagya reduced SO_2 and NO_2 level. In addition, Yagya was cited as to reduce air borne biological pollutants such as microbial growth in indoor environment (21, 22). However, Yagya's effect on air PM is not studied yet. The present study, conducted two indoor experiments to find the effect of Yagya on PM in indoor environment in December 2017. The two sites of the study of residents were at Najafgarh, Delhi and at Gurgaon, Haryana.

Materials and Methods

Yagya procedure and Yagya material

Yagya was performed as per the procedure given in the book *Sankshipt Gayatri Hawan Vidhi* (23) and referred from a web page http://www.yagyaopathy.com. For the experiments we used 100gm hawan samagri, 100 gm pure cow ghee and 500 gm mango wood as samidha. Special herbal preparation *(hawan samagri)* for air purifying was adopted from the description as mentioned elsewhere and herbs were obtained from Khari Baoli, Delhi and were made powdered. For making the air purifying special hawan *samagri*, its two parts were mixed with one part of common purpose hawan *samagri,* which was obtained from Shantikunj Pharmacy, Shantikunj, Haridwar. Of this, 100 grams were taken for the experiment. Oblations were given in an inverted shaped copper *kund* in rooms of size 9 feet by 10 feet. Around 3 participants were there during Yagya experiment. The Yagya was conducted with 24 *ahuties* through Gayatri Mantra and 3 *ahuties* with Mahamrityunjaya mantra. The total duration of experiment was around 25 minutes.

Measurement of particulate matters and CO_2, temperature and humidity

Measurement of the PM 2.5, PM 10, CO_2, temperature were taken using digital sampler (Airveda, Ghaziabad, Uttar Pradesh, India; model no. PM2510 CTH).

Case study 1 experiment procedure

The first indoor study was conducted at Najafgarh in Delhi. The air concentrations of PM 2.5, PM 10, CO_2, temperature and humidity were recorded using digital PM sampler a day before, on the day and till two days after the Yagya to see the effect of Yagya. In these experiments, the inputs used were dry mango wood as *Samidha*, air purifying *hawan samagri* and cow's *ghee*. In order to take the whole day average, three reading were taken for each day (before, during, and 2 consecutive after days) i.e. morning, noon and evening. The average was taken for analyses.

Case study 2 experiment procedure

The second study was conducted in December 2017 in Gurgaon, Haryana. In this study, the monitoring was done simultaneously both indoor and outdoor using the same sampler mentioned before for PM 2.5, PM 10 and CO_2, on a day before, on the day and till two days after the Yagya to see the effect of Yagya on indoor and outdoor PM and CO_2 level. In order to take the whole day average, three reading were taken for each day (before, during, and 2 consecutive after days) i.e. morning, noon and evening. The average was taken for analyses.

Results

Case study 1

In the case study 1, readings of the PM 2.5 PM 10, CO_2, temperature and humidity were taken before, during and after Yagya. The readings taken before conduction of Yagya were considered as background readings depicted as day -1. The actual day of Yagya was experiment day and readings on that day was depicted as day 0. Two consecutive days readings taken days after Yagya was depicted as Day 1 and Day 2 respectively.

Considering the variability of the readings of the parameters of air, 3 readings were taken at 3 different time i.e. morning, noon, evening at Day -1, 0, 1, and 2, and averages were used for analyses (Figure 1, Table 1). Though the variability was high among morning, noon and evening readings, the trend was evident that Yagya reduced PM 2.5, PM 10, and CO_2 level after Yagya i.e. day 1 and day 2. There was no apparent change seen between before (day -1) and during Yagya (day 0).

In the case study 1, percentage change i.e. 5% increase in the PM 2.5 was negligible on day 0 (during Yagya) compared to day -1 (before Yagya i.e. background). (Table 2). However, after Yagya was performed at day 1 and day 2, there was apparent decrease in PM 2.5 which was 74% and 71% respectively compared to that of day -1. (Table 2, Figure 1). Similarly, PM 10 decreased by 19% at day 0 (during Yagya), 63% at day 1 (after Yagya) and 61% at day 2 (after Yagya) compared to background reading taken at day -1 (before Yagya). Along with PM 2.5 and PM 10, CO_2, which is a Greenhouse gas, followed the same trend. It was decreased by 24% and 25% after Yagya was performed on day 1 and day 2 respectively as compared to background readings taken on day -1 (before Yagya), while there was negligible increase 8% on the day 0 of Yagya experiment compared to that of background readings taken before Yagya on day -1 (Table 2, Figure 1).

Case study 2

This study was conducted inside residence at Gurgaon, Haryana in December 2017. In this case study experiment PM 2.5, PM 10 and CO_2 were recorded both indoor and outdoor (outdoor reading in the balcony) of the residence. Daily average of three recordings as mentioned in the methods section had been taken (Table 3) and plotted (Figure 2).

Level of indoor PM is dependent on the level of outdoor PM, while level of outdoor PM depends on many factors. In our study, it was interesting finding that levels of indoor PM (both PM 2.5 and PM 10) were higher than the levels of outdoor PM before Yagya was performed, which were reversed on the day of Yagya (Table 3-4). After the Yagya was performed, the outdoor PM level kept on increasing. Indoor PM (both PM 2.5 and PM 10) also increased slightly on day 1 but decreased on the day 2. The gap between outdoor and indoor PM (PM 2.5 and PM 10), reversed and was maintained on first and second day after Yagya that was the outdoor PM was higher than indoor PM on both the days after Yagya (Table 3-4 and Figure 2). This indicated the effect of Yagya to reduce PM inside the house through resisting the change in the outer environment to some extent (Table 3-4 and Figure 2)

CO2 level followed the trend to that of in case study 1 i.e. during and after Yagya CO2 level was decreased both indoor and outdoor environment (Table 3-4 and Figure 2).

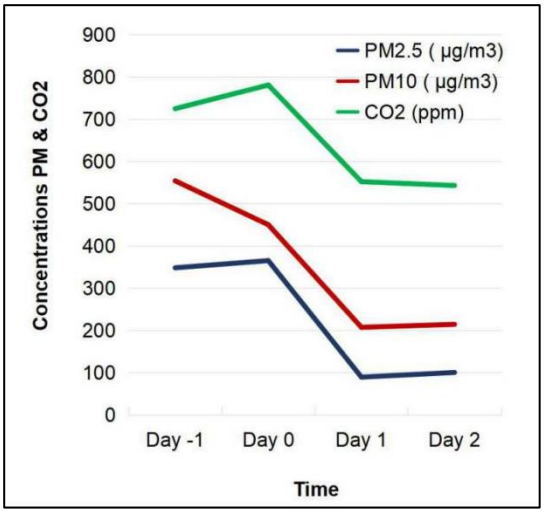

Figure 1. Effect of Yagya on indoor air. Mean values of changes in the air parameters i.e. PM 2.5, PM 10, CO_2, were plotted against before, during and after Yagya inside resident of case study 1.

Condition	Indoor Air pollutant (Mean ± SD)			Outdoor Air pollutant (Mean ± SD)		
	PM2.5	PM10	CO_2	PM2.5	PM10	CO_2
Before Yagya (Day -1)	199 ± 75	324 ± 83	486 ± 151	163 ± 54	281 ± 37	495 ± 100
During Yagya (Day 0)	222 ± 74	350 ± 92	448 ± 28	270 ± 109	419 ± 156	426 ± 31
After Yagya (Day 1)	240 ± 79	357 ± 112	457 ± 89	246 ± 56	378 ± 99	431 ± 40
After Yagya (Day 2)	186 ± 105	301 ± 117	407 ± 45	215 ± 80	397 ± 117	486 ± 108

Table 1. Effect of Yagya on indoor air. Mean values of changes in the air parameters i.e. PM 2.5, PM 10, CO_2, temperature and humidity were measured before, during and after Yagya inside resident of case study 1. Temperature unit is ^oC. PM 2.5 and PM 10 2.5 - Counts from 5th Dec.2017 to 8th Dec. 2017. PM – particulate matters; SD – Standard deviation.

Air pollution parameters	% Change compared to background readings at day -1		
	During Yagya (Day 0)	After Yagya (Day 1)	After Yagya (Day 2)
PM 2.5	-5	74	71
PM 10	19	63	61
CO_2	-8	24	25

Table 2. % Change in the PM and CO_2 inside house during and after Yagya. % change in PM 2.5 and PM 10 during Yagya at day 0 and after Yagya at day 1 and 2, was calculated compared to the background reading taken at day 0 before Yagya at case study 1 resident.

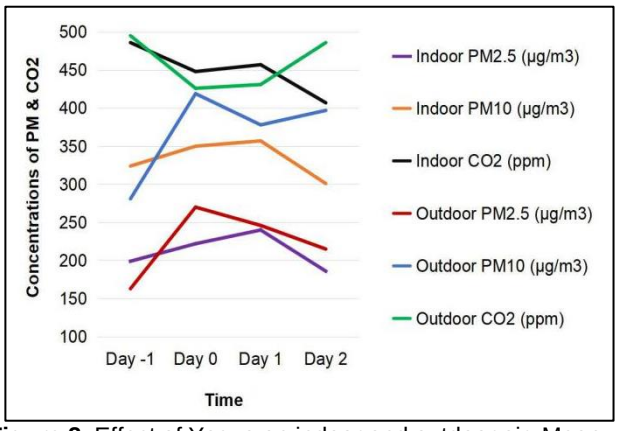

Figure 2. Effect of Yagya on indoor and outdoor air. Mean values of changes in the air parameters i.e. PM 2.5, and PM 10 were plotted against before, during and after Yagya inside resident of case study 2.

Air parameters	Before Yagya (Day -1) Mean ± SD	During Yagya (Day 0) Mean ± SD	After Yagya (Day 1) Mean ± SD	After Yagya (Day 2) Mean ± SD
PM 2.5 (µg/m3)	348 ± 90	365 ± 334	89 ± 235	100 ± 134
PM 10 (µg/m3)	554 ± 122	450 ± 325	207 ± 289	214 ± 184
CO_2 (ppm)	725 ± 193	781 ± 132	552 ± 287	543 ± 314
Temperature	16 ± 205	20 ± 3.0	19 ± 2.3	19 ± 2.3
% Humidity	73 ± 12	49 ± 17	45 ± 18	45 ± 18

Table 3. Effect of Yagya on indoor and outdoor air pollutants. Mean values of changes in the air parameters i.e. PM 2.5, PM 10, and CO_2 were measured before, during and after Yagya inside and outside of the resident of case study 2. PM – particulate matters; SD – Standard deviation.

Condition	Indoor % change compared to background at day -1 (Mean ± SD)			Outdoor % change compared to background at day -1 (Mean ± SD)		
	PM 2.5	PM 10	CO_2	PM 2.5	PM 10	CO_2
During Yagya (Day 0)	11	8	-8	65	49	-14
After Yagya (Day 1)	21	10	-6	51	35	-13
After Yagya (Day 2)	-7	-7	-16	32	41	-2

Table 4. % Change in the PM and CO_2 inside and outside of resident during and after Yagya. % change in PM 2.5 and PM 10 during Yagya at day 0 and after Yagya at day 1 and 2, was calculated compared to the background reading taken at day 0 before Yagya at case study 2 resident.

Discussion

Governments all over the world are now sensitized and alert to the issue of air pollution and hazards of PM on health. They are taking due steps to reduce the PM air pollution. However, with increasing population, rising numbers of industries and transport vehicles, burning of crackers and farm stubble, coal, oil & gas combustion, construction and demolition activities, and roadside dust, the PM levels have been severe during most part of the year in Delhi according to delhiair.org. Air purification of the air inside indoor environment is immediate solution, where as purifying outdoor environment needs major efforts by government and social-welfare organizations. The present study proposed an ancient vedic method- Yagya and showed its potential to purify indoor environment especially from PM and CO_2.

The study showed that indoor environment of two of residents taken for study had presence of PM, which had trend of decrease after the Yagya at day 2 (Figure 1-2). Study 1 showed clear trend besides having high standard deviation of values, while for study 2, it had started decreasing at day 2 (Table 1-4). In addition, decrease of PM at day 1 at case study 1 was apparent but was not for case study 2, this might be due to the observation that outdoor environment might had affected the indoor environment in case study 2. It was noted that outdoor PM was even less than indoor environment before Yagya in case 2 resident was increased after Yagya very high and remained high (Table 3-4). However, besides these possibilities, study indicated the potential of Yagya to reduce indoor environment pollutants such as PM2.5 PM 10 and CO_2 and laid the foundation for further research. Moreover, the present study had only two case studies, hence, statistical analysis was out of its scope. However, future studies with statistical analyses will shed further light in this aspect.

These findings are significant in view of the fact that Yagya experiment comprises of a process where combustion of wood and dry herbs takes place with the help of Ghee. As it is known that when any combustion takes place particulate matters are emitted and CO_2 is also released. Here, in the first experiment, it was seen that PM increased during Yagya, but immediately after Yagya it started decreasing. Similarly, CO_2, though increased during Yagya, decreased subsequently on both the days.

One speculation for decrease in PM and CO_2 after the Yagya could be that ghee, when put along with herbs during oblation, might had volatilized into very fine droplets, and particulate matter might stick on their surface. Then, it might get settled alongside the room walls or any surface in that area. Thus, it might lead to reduction of indoor PM. These droplets might have kept absorbing further PM that entered into room and hence the decrease was maintained for next two days. However, further days follow up i.e. more than 2 days, could be done in future experiments. Another speculation could be traced for low production of PM that *hawan samagri* was pre-soaked in the ghee and therefore burnt readily and completely, thereby, producing minimum PM in the process. These speculations suggest to study the nature of PM produced in Yagya to find exact mechanisms of action.

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