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Combustion studies of Agnihotra Yajnya

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ABSTRACT

Agnihotra is a traditional domestic solemnity, performed to maintain harmony between living beings and nature, without harming and by giving respect. Agnihotra, the simplest forms of yajnya performed at sunset/ sunrise in which cow dung is burnt in the copper pot by using cow ghee (clarified butter) and brown rice as oblations along with chanting of mantras of sun and fire. Combustion studies of Agnihotra raw material was done with the analysis of fuel gases using Orsat Analyzer, proximate analysis by Proximate Analyzer, ultimate analysis by CHONS Analyzer and calorific value estimation by using Bomb Calorimeter. Combustion rate was analyzed of by Thermogravimetry Differential Scanning Calorimeter. The fuel analysis of Agnihotra raw material shows incomplete combustion with low calorific value. As raw material is mainly lignocellulosic, combustion takes place with four major steps. Initially Moisture and Volatile Matter get combusted then Cellulose and Hemicellulose material then Lignin compounds and finally Char.

Key words: *Agnihotra, Combustion, Lignocellulosic*

Introduction

Agnihotra is a traditional domestic solemnity, performed to maintain harmony between living beings and nature, without harming and by giving respect. Agnihotra, the simplest forms of Yajnya performed at sunset/ sunrise in which cow dung is burned in the copper pot by using cow ghee and brown rice as oblations along with chanting of mantras of sun and fire. The Agnihotra is simplest form of fire based technique moving down from the ancient Vedic literatures. Agnihotra is the process of removing toxic state of affairs from the atmosphere through the various energies coming through fire, which has positive effects on creatures (Paranjpe, 1989). The ash and fumes produced by the Agnihotra has ascribed with remedial properties (Abhang *et al.*, 2015 and Abhang *et al.*, 2016).

According to Paranjpe, (1989) and Abhang and Pathade *et al.*, (2017), the desired spiritual, physiochemical and biological behoofs of Agnihotra can be achieved through combination of heat energy engendered during burning of Agnihotra raw material and sound energy generated by chanting of mantras while performing Agnihotra. The evolution of energies may be due to the raw materials used while performing Agnihotra, which may be accountable for chemical changes in an ambient environment. The other form of yajnya viz. Somyag Yajnya (Abhang, 2015) also shows similar kind of changes in the ambient environment as that of Agnihotra Yajnya (Abhang *et al.*, 2015).

Chandra, 2004 and Abhang *et al.*, 2016, had tried to explain combustion during Agnihotra. According to the report, raw materials burnt during Agnihotra process get diffused in the ambient atmosphere and after that they go through various photochemical reactions of disintegration, reduction or oxidation. Fatty substances (mostly butterfat) help in the hasty combustion of cellulosic matter. Fumes of yajnya purify the ambient atmosphere by eradicating odors by substituting with various volatiles. Due to very low calorific value and base fire temperature of raw material used in Agnihotra, there is meticulous creation of oxides of nitrogen. The pyramidal shape of pot ensures the supply of sufficient oxygen which is essential for complete combustion of Agnihotra raw material. Oxides of elements and other volatiles get released during combustion of Agnihotra. Carbon dioxide released during Agnihotra acts as a greenhouse gas, but due to timings (sunrise/sunset) of Agnihotra, released carbon dioxide may get consumed by surrounding plants and may get converted into molecular oxygen. Base fire disrupts the molecular bonding within raw materials; as a result they may get boiled away without sovereign the combustion process.

Vadakayil, (2012), has mentioned the role of cow's dung, cow butterfat and copper pot during Agnihotra. The hydrogen sulphide (H_2S) and nitric oxide (NO) are released due to cows' dung and ghee (hump-backed Indian cow) during yajnya process, both H_2S and NO act as bio-signaling (communication of cells with surrounding) molecule and involved in growing of new blood vessels, control of Alzheimer disease, etc. The cow butterfat is having various fat-soluble vitamins like A, D, E and K, which work as antioxidant, anti-aging and anti-cholesterol. The pyramidal shape of copper pot has importance to generate, hoard and transmute energies during yajnya process. Also, copper is having oligodynamic action and is a good conductor of energy with antimicrobial properties.

According to Richa, (2009) and Pathade *et al.*, (2014), use of dung of cow, brown rice, butterfat of cow, copper pot, specific timings and inchantation of mantras during performance of Agnihotra has synergetic and significant effect on ash. In order to producing various positive effects, the ash of Agnihotra prepared by performing it at exact timings of sunrise/sunset with inchantation of mantras and with the help of proper raw materials possesses various micronutrients and macronutrients.

By considering the above mentioned articles here in this research paper we have explained the combustion process of Agnihotra Yajnya and its raw material.

Materials and Methods

Agnihotra Procedure

Agnihotra Yajnya was performed as per the procedure given by Paranjpe, (1989) and Potdar, (1993). In brief, the 100 g of dried dung of *Gir* cow (*Bos (primigenius) indicus*) was lit in an inverted copper pyramid with specific dimensions (14.5 cm at top, 5.25 cm at bottom and 6.25 cm in height). The offerings of about 0.5 g of brown rice with 2 ml of pure cow ghee were given at the time of sunrise/sunset by chanting of sunrise mantra as *'Suryaya swáahá| Suryáya idam na mama|| Prajápataye swáahá| Prajápataye idam na mama||'* and sunset mantra as *'Agnaye swaáhá| Agnaye idam na mama|| Prajápataye swaáhá| Prajápataye idam na mama||'*

Combustion study of Agnihotra

The combustion study of raw material (cow's dried dung, brown rice and cow ghee) of Agnihotra was done as per AOAC, 1990

Fuel gas (O_2, CO_2, CO and H_2O) analysis was done by using Orsat Analyzer; Moisture, Volatile Matter, Fixed Carbon and Ash analysis was done by using Proximate Analyzer as per IS 1350 Part I, 1984. Ultimate analysis of elements was done by using Elemental CHONS Analyzer as per ASTM D5373–02, 2003. The calorific value was estimated by using Bomb Calorimeter as per ISO-1928, 2009.

Thermogravimetry Differential Scanning Calorimeter (TGA-DSC) Analysis of Agnihotra raw material was done by providing 0 ml/min (without oxygen) to 50 ml/min (complete combustion) of air flow.

Statistical analysis was done with IBM SPSS software and the variation of data is expressed in terms of the standard error of mean (Mean ± SE) along with the number of observations (n).

Results and Discussion

Combustion study performed on raw materials of Agnihotra

Orsat analysis, proximate analysis, ultimate analysis and calorific value of raw materials offered in Agnihotra experiments were as per Table 1.

As the burning of Agnihotra raw materials showed formation of CO (about 1.5 ppb), it was an indication of incomplete combustion process (Table 1A). But our results are not concurrent with Chandra, (2004) as they postulated that the pyramidal shape of pot ensures the supply of sufficient oxygen which is essential for complete combustion of Agnihotra raw material. Carbon dioxide released during Agnihotra acts as a greenhouse gas, but due to timings (sunrise/sunset) of Agnihotra, released carbon dioxide may get consumed by surrounding plants and may get converted into molecular oxygen (Chandra, 2004).

According to proximate analysis, Agnihotra raw material contains maximum amount of volatile matter and less amount of moisture (Table 1B). Our results were concurring with proximate analysis of dried cow dung [i.e. moisture (7.47%), volatile matter (60.77%), fixed carbon (16.44%) and ash (15.35%)] as well as rice husk [i.e. moisture (7.20%), volatile matter (61.80%), fixed carbon (14.60%) and ash (16.40%)] (Bhavsar *et al.*, 2018).

According to the ultimate analysis, Agnihotra raw materials contained maximum carbon and lower sulphur (Table 1C). Our results were in agreement with ultimate analysis of cow dung [i.e. C (31.60%), H (5.18%), O (37.8%), N (6.12%) and ash (19.3%)] H (4.98%), O (54.99%), N (1.40%), S (0.03%) and ash (5.87%)] (Lim *et al.*, 2016).

In comparison with calorific value of cow dung (15581 KJ/Kg) and rice husk (13920 KJ/Kg) (Kumar *et al.*, 2014), calorific values of raw materials offered in Agnihotra (Table 1D) were lower. Due to very low calorific value and base fire temperature of raw material used in Agnihotra, there is meticulous creation of oxides of nitrogen (Chandra, 2004).

Thermogravimetry Differential Scanning Calorimeter (TGA-DSC) Analysis of Agnihotra raw material

Haykiri-Acma, (2003) studied the kinetics of combustion of biomass. According to this report, when the biomass gets burned, the moisture with volatile matter gets released in the beginning and followed by moisture with volatile matter removal, the cellulosic, hemi-cellulosic and lignin matters get combusted and then fixed carbon gets carbonized. The process ends with combustion of carbonized char. These four phenomena were observed from DSC-DTG curves (Figure 1). According to curves obtained by TGA-DSC analysis, the four major peaks (denoted as P1, P2, P3 and P4) were obtained as recorded in Table 2. The peak P1 denotes combustion of moisture and volatile matter (40 ^oC – 200 ^oC); Peak P2 denotes combustion of cellulose and hemi-cellulose (200 ^oC – 350 ^oC); Peak P3 denotes combustion of lignin (350 ^oC – 800 ^oC); and Peak P4 denotes combustion of char (800 ^oC – 1000 ^oC).

The results showed that as oxygen (air flow) supplied to Agnihotra raw material decreases the ignition temperature during TGA-DSC analysis but the peak temperature increases while that of peak combustion rate decreases. This is because of lack of oxygen causes delay in ignition and combustion processes, which will form CO instead of CO_2.

As the heat rate increases, ignition temperature, peak temperature and peak combustion rates increase and because of this shift or delay, combustion of char also falls in that regime of temperature.

No other change such as structural transformation or formation of new compounds has been ob-

Table 1. Orsat analysis (1A), proximate analysis (1B), ultimate analysis (1C) and calorific value (1D) of raw materials offered in Agnihotra experiments; (values expressed as Mean ± SE where n = 3)

1A. Orsat analysis of raw materials offered in Agnihotra experiments(in ppb)

Average O_2	Average CO_2	Average CO	Average H_2O
9.5 ± 0.1	20.8 ± 0.2	1.5 ± 0.1	1.1 ± 0.1

1B. Proximate analysis of raw materials offered in Agnihotra experiments(in %)

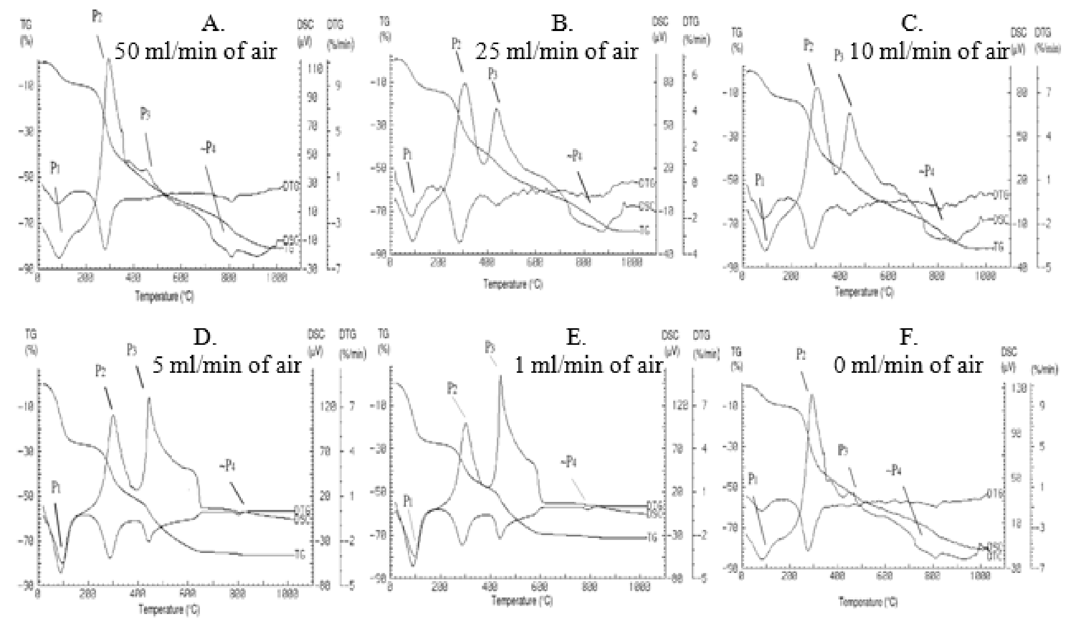
Average Moisture	Average Volatile Matter	Average Fixed Carbon	Average Ash
4.03 ± 0.01	65.65 ± 0.05	13.02 ± 0.03	17.30 ± 0.8

1C. Ultimate analysis of raw materials offered in Agnihotra experiments(in %)

Average C	Average H	Average O	Average N	Average S	Average Ash	Average Moisture
39.06 ± 0.05	6.24 ± 0.01	30.18 ± 0.06	2.44 ± 0.01	0.75 ± 0.02	17.3 ± 0.07	4.03 ± 0.03

1D. Calorific value of raw materials offered in Agnihotra experiments(in KJ/Kg)

Average Higher CV	Average Lower CV	Average Specific CV (Ho)	Average Net CV (Hu)
17.54 ± 0.11	17.40 ± 0.09	12490 ± 0.3	11630 ± 0.4



Air Flow (ml/min)	P1	P2	P3	P4
50	-27.0 (21-180)	-24.1 (180-388)	-23.9 (388-676)	-1.4 (616-880)
25	-27.4 (21-175)	-20.1 (175-380)	-21.9 (380-631)	-1.6 (631-835)
10	-12.7 (19-186)	-30.9 (186-390)	-15.7 (390-568)	-21.5 (568-950)
5	-14.6 (19-203)	-26.5 (203-369)	-17.4 (369-586)	-20.7 (586-950)
1	-9.6 (19-166)	-32.7 (166-348)	-22.6 (348-693)	-10.6 (693-1000)
0	-8.8 (19-154)	-33.6 (154-340)	-17.5 (340-577)	-20.3 (577-1000)

Fig. 1. DSC-DTG curves of Agnihotra raw materials with different air flow,
A: 50 ml/min, B: 25 ml/min, C: 10 ml/min, D: 5 ml/min, E: 1 ml/min and F: 0 ml/min
TG: Thermogravimetery, DTG: Derivative Thermogravimetery,
DSC: Differential Scanning Calorimetery, DTA: Differential Thermal Analysis

Table 2. Peak representing combustible matter with energy and temperature

Peak	Combustible matter in Agnihotra raw material	Temperature (in °C)	Activation Energy (in kcal/mol)	Reference Temperature k(300) (in min^{-1})
P1	Moisture & Volatile Matter	40 – 200	9.49	43.14
P2	Cellulose & Hemicellulose	200 – 350	24.70	0.18
P3	Lignin	350 – 800	19.76	0.01
P4	Char	800 – 1000	0.43	0.05

served with the increase in temperature. The shifting of baseline of thermogram at higher temperature is possibly due to change of surface properties of silica (Borthakur *et al.*, 1980) present in Agnihotra ash.

Conclusion

As the burning of Agnihotra raw materials showed formation of CO, it was an indication of incomplete combustion process. Agnihotra raw material contains maximum amount of volatile matter and carbon while less amount of moisture and sulphur. The calorific values of raw materials offered in Agnihotra were lower. The fuel analysis of Agnihotra raw material showed incomplete combustion with low calorific value. As raw material is mainly lignocellulosic, combustion took place with four major steps. Initially Moisture and Volatile

Matter got combusted then Cellulose and Hemicellulose material then Lignin compounds and finally Char.

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Conflict of Interest

Authors do not have any conflict of interest to declare.

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