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Go-Kashth: A Pioneering Approach for Alternate Fuel in Crematoriums

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Cremation is an irretrievable part of Indian culture especially Hinduism contributing to increasingly vexatious issue of environment pollution and cutting of millions of trees every year. However, there are hardly a few studies seeking to converse about and initiate solutions in this subject to provide a better approach to lives of people. The aim of this study was to develop an innovative approach for preparing cow dung logs named as Go-Kashth and use as an alternate fuel in crematoriums in place of fire wood. For the study a new model of service called '*The Go-Kashth Bhopal model*' was developed accompanied with collection of essential information from crematorium organizers and cow-shed managers through composed questionnaires. The comparative study of parameters of combustion and emission characteristics for Go-Kashth & fire wood has reinforced its use as energy resource in cremation. The emission concentration of air pollutants-PM, SO_2 and NO_X were reduced by 30.5%, 44.8% and 13% respectively for Go-Kashth than that observed for fire wood. Thus, through stipulation, speculation and demand, mutually with analytical studies an alternate solution for crematoriums is presented conjuring with identification of possible improvements thereon. Also, the study opens scope for further studies for its application as an alternate fuel for industrial boilers and designing of Air Pollution Control Device for Crematoriums.

Keywords: Biomass fuel, Cow-dung logs, Environmental management, Go-Kashth Bhopal model, Sustainable development

Introduction

The ancient folks had belief that life and death are part of the concept of rebirth and cremation is an inextricable part of Indian culture for reducing a corpse to its five essential elements-water, soil, air, fire and sky.[1] The beliefs about the soul and body and the concept that microcosm of all living beings is a reflection of a macrocosm of the universe in Hinduism formed the basis of cremation.[2] The western world was introduced with the practice of cremation in open fire by Greeks around 1000 BCE which was followed by Romans.[3] While in India as referenced in Rigveda it was first affirmed in around 1900 BCE.

In India, every year more than seven million Hindus die and the sight of corpses surrendering to the flames of traditional funeral pyres is part of the country's daily cycle of life. Traditionally, body is cremated in open near a water source using firewood. Fifty to sixty million trees are burned during cremations every year in India and burning those trees emitting about eight million tons of carbon dioxide or greenhouse gas emissions in the environment.[4] At Varanasi, considered to have the most pious Cremation Ghats at the bank of holiest river the Ganges alone records around 73,000 cremations every year that consumes around 36,500 tonnes of wood.[5] At New Delhi alone around 400 and at Mumbai around 300 cremation grounds are available.

Air pollution and deforestation are not the only environmental threats caused by cremation. They also generate large quantities of ash, which are later thrown into rivers, and may leads to the toxicity of their waters if contains heavy metal.[6] Also, many other materials used during cremation rituals in India like hairs, bamboos, metals, clothes, flowers, food items, plastics etc. is a subject of prime concern as proper management of these items is further important for complete environmental management of crematoriums.

Biomass is one alternative resource that presents high potential to be introduced for heat generation. At present, there are several biomass technologies that can be applied for thermal generation.[7,8] In India, 69.9% population resides in rural areas (The Hindu 2011), where cow (*Bos indicus*) is major cattle and generates 9–15 kg dung/day.[9] The total population of female cows in India is 190.90 million out of which 151 million are indigenous whilst 39 million are crossbreed (Livestock Census 2012).

Cow dung, excreta of bovine animal, is a cheap and easily available bio-resource. Cow dung waste contains a wide range of applications and many

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beneficial constituents, if used effectively. Many traditional uses of cow dung such as burning as fuel, mosquito repellent, as cleansing agent, organic manure, as a pesticide, in plastering of walls and floor in rural houses for providing insulation during winter and summer etc. are already known in India. Nowadays, there is an increasing research interest in developing the applications of cow dung as bio fuel production and management of related environmental pollutants.[10]

In last few decades with urbanization, emerging modern technology and changing living standards, the decade's long utility of cow dung has been altering. Presently cow dung is commonly used to make bio-fertilizer and bio-gas generation.[11] But, these measures were not found sufficient to handle the large amounts of waste generated and have related environmental concerns, as if not utilized properly may contributes to water pollution, methane generation, foul smelling, growth of micro-organisms etc.[12, 13]

Cow dung wood/logs named as Go-Kashth can be used as an effective solution to both the problems. Use of cow dung wood in crematoriums not only will have potential to serve as an alternative of wood but, this will also help to manage cow dung effectively. The revenue so generated by cow sheds (Go-Shala) will surely help to fulfill the perspective of improving condition of cows and cow-sheds in the country.

Although, many modern cremation methods have already been evolved over few decades, the acceptability for these methods by peoples is very less due to sensitive religious reasons and strict culture beliefs related to phenomenon of death.[14] So, the proposed Go-Kashth Bhopal model not only having acceptability among common people due to sacred figure of Cow in India but is supposed to have manifold benefits like alternate of wood in crematoriums prevents deforestation, reduced fuel consumption, reduced cost of cremation, effective management of cow dung, improving present condition of cow sheds, future scope of its use as alternate fuel in other areas like Holi bonfire, small industries boilers, puja/ havan, hotel tandoors etc.

Previous studies shows that no such efforts have been made to use cow dung logs as exclusive energy source for cremation in place of wood. This research aims to completely replace the use of wood in cremation and will help in economic management of cow dung waste contribute to reducing damage caused to the environment.

Study Area

Bhopal, also called city of lakes is a city in central India and the capital of the state of Madhya Pradesh. The location details are given in Fig. 1. It is roughly 360 miles south of the Indian capital, New Delhi, located within the Co-ordinates 23° 15' 0" N, 77° 25' 0" E and at elevation of 1729 Ft. (527 M). As per world population review, the current population of the city is around 2,389,574 with Crude Death Rate around 5.8 per 1000. Hinduism as a major religion constitutes around 69.20% of total population[15] of the city, so selected as the area of study for this project. The city is having 10 major crematoriums and 10 big or small cow-sheds sheltering around 4000 cows. There was no specific use of generated cow dung except for making cow dung cakes which are used as household so, large volumes of waste had accumulated as mountains in the sheds, also contributing to greenhouse gas emissions and pollution of natural drains or water bodies during rainy season. The management of such large volumes of accumulated cow dung by cow-sheds without any financial assistance was a major concern for cow shed owners in the city. The concept of producing Cow dung logs (Go-Kashth) from cow dung by installing a specially designed machine at cow-sheds and using the Go-Kashth for cremation in crematoriums of Bhopal city has emerged as an effective solution for the underlying issues.

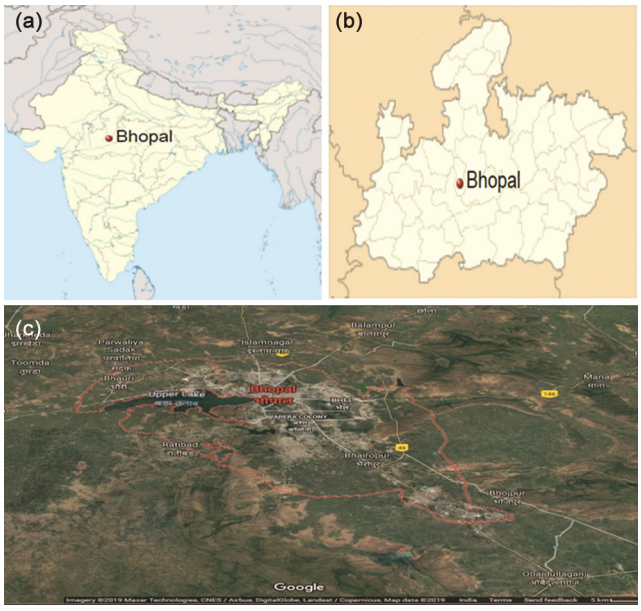

Fig. 1 — (a) Location of Bhopal in the Country-India; (b) Location of Bhopal in Central Indian State- MP; (c) Google location of Bhopal city

Material and Methodology

Materials

For the study, cow dung accumulated at various cow sheds of the city was used as raw material to produce specially designed cow dung logs which were named as "Go-Kashth" for use as a source of energy for crematoriums of the city.

The study was initiated with the detailed survey of the city including all crematoriums and cow sheds present in the city based on prepared questionnaire. As per collected information from the various crematoriums, there are 10 major crematoriums in the city which reports around 1000 cremations per month that used to consume around 5000 quintal of wood per month and around 60,000 quintals of wood over a year. While, the city is having around 10 big or small cow-sheds sheltering around 4000 cows which generating around 17520 tons of cow dung over a year that was left as waste and had accumulated as mountains in the sheds.

Machine Standards and Method for Producing "Go-Kashth"

The machine (Fig. 2) used for manufacturing cow dung logs is a simple electricity based machine that weighs approximately 208 Kg. The average dimensions of Go-Kashth machine include Length (2.6 ft.), Width (3 ft.) and Height (4 ft.) and to have a frequency of 50 to 60 Hz. The top of the machine is fitted with a Hopper of dimensions Length 16 inch, Width 16 inch and Height 14 inch through which the cow dung is fed in to the machine. The hopper is fitted with a screw mechanism that helps in thorough mixing of the cow dung and then compresses it to extrude out the moisture from it. The bottom of the hopper is provided with die to produce cow dung logs. The die was designed in two sizes 4 × 4 inch square die and 4 inch diameter round die. The die is specially designed to have a solid rod of 1 inch at the center that produces the logs with a hollow cavity of size 1 inch at center which helps for easy and efficient circulation of air during combustion of logs to ensure its complete combustion.

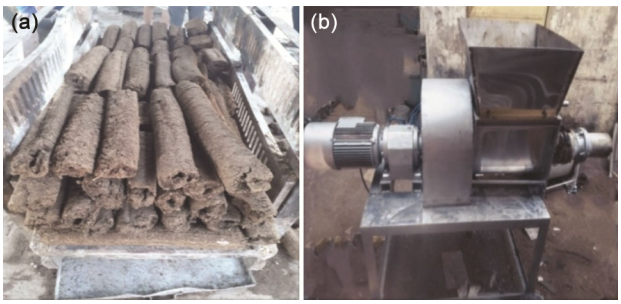

Fig. 2 — (a) Design of Go-Kashth Making Machine

The machines operation is done with a motor of 5 HP that requires 440 V of AC power. Machine with above standard specifications consumes around 1500 Kg of cow dung in 8 hours working with the production speed of 50 logs/ hour.

Analytical Study of Cow Dung Logs "Go-Kashth" for Parameter of Combustion

The cow dung logs were analysed for various parameters of combustion commonly used to characterise solid biomass fuels including proximate analysis, ultimate analysis and calorific value[16]. For this investigation, Go-Kashth prepared from cow dung collected from various cow sheds of the city was considered to have representative sample which was after complete drying pulverized till the 30 mm size and was analysed for the required parameters. The results of analysis are presented in Table 1.

Proposed Go-Kashth Bhopal Model

For using cow dung logs, Go-Kashth as an alternate of wood in crematoriums of the Bhopal city, a simple service model was developed where initially the Go-Kashth making machine was installed at some of the large cow sheds of the city at no cost. The cow shed people were trained for operating the machine by engaging their own manpower to turned cow dung waste into Go-Kashth which were dried and sent for crematoriums for use as biofuel in place of wood for cremation. For the development of a basic system it is very important to accumulate knowledge and distribute it to the crematorium management people to

Table 1 — Parameter of combustion analysis of cow dung logs "Go-Kashth"

Parameter	Test Method	Result
	Calorific Value	
GCV	IS 1350 (Part 2) 2017	2890 Kcal/Kg
NCV	IS 1350 (Part 2) 2017	2703 Kcal/Kg
	Proximate Analysis	
Moisture	IS 1350 (Part 1) 1984	8.29 g/100g
Volatile Matter	IS 1350 (Part 1) 1984	50.82 g/100g
Fixed Carbon	IS 1350 (Part 1) 1984	8.69 g/100g
Ash	IS 1350 (Part 1) 1984	32.20 g/100
	Ultimate Analysis	
Carbon	ASTM D-3176	25.63 g/100g
Hydrogen	ASTM D-3176	3.53 g/100g
Oxygen	ASTM D-3176	28.17 g/100g
Nitrogen	ASTM D-3176	1.38 g/100g
Sulphur	ASTM D-3176	0.80 g/100g

coax them to adopt for the change. The first phase of model focused mainly on concept design and service process. The methodology adopted for model design includes macrophases, each having a particular purpose including knowledge sharing, survey, cost estimation, R&D done for designing of Go-Kashth making machine and very important was mass awareness to make people ready for the change. The blueprint model that sought to provide a framework and conceptual design of the service for the entire process of the proposed model for its effective operation is shown in Fig. 3.

To study the acceptance and effectiveness of designed model, data were collected from the crematoriums of the city for three years from 2019 to 2021. The experiences of crematorium people were also collected to check the potential of Go-Kashth for replacing fire wood in cremation.

To evaluate the level of emission from combustion of Go-Kashth and its comparison with that of wood combustion was also performed in a closed controlled experimental setup. The combustion chamber of the boiler was used for burning of go-Kashth and wood to assess the emission. The port hole for the sampling was made in the duct before installed flue gas treatment system. The monitoring was done for the parameters- Particulate Matter (PM), Sulphur di-oxide (SO_2) and Oxide of Nitrogen (NO_x).

Results and Discussion

Go-Kashth, the cow dung logs prepared exclusively from cow dung by using a simply designed machine with minimum human intervention. This innovative green step has not only resolve the issue of managing tones of cow dung generated in the city and its dumping, but has also fighting with the problem of deforestation and air pollution and providing better opportunity for cow sheds operating people in the city to stand on their legs and to earn wealth from waste.

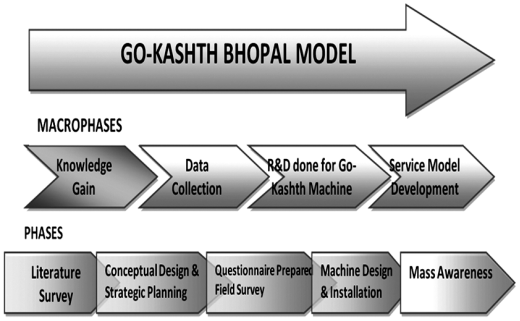

Fig. 3 — Framework Designed for the Go-Kashth Bhopal Model

The analysis of combustion parameters of Go-Kashth are also in support of effective use of this biomass fuel in cremation for energy generation. The produced logs are having a good net calorific value of 2703 Kcal/kg which is a direct measure of chemical energy stored in the fuel. Also, the value of fixed carbon 8.69g/100g, percent Oxygen 28.17g/ 100g and percent Carbon 25.63g/ 100 g those represent main heat generator parameters were also observed reasonable for prepared cow dung logs, G-Kashth. However, the ash generation was found 32.20 g/ 100g for cow dung logs.

The comparative emission study (Table 2) of Go-Kashth with respect to wood shows decrease in emission concentration of air pollutants- PM, SO_2 and NO_x has reinforced its use as energy resource in cremation and also supports the model. The emission concentrations of PM, SO_2 and NO_x were calculated 238 mg/ NM^3, 3.25 mg/ NM^3 and 7.15 mg/ NM^3 respectively when Go-Kashth was used as fuel. While when wood was used as fuel the concentrations of PM, SO_2 and NO_x were observed 342.5 mg/ NM^3, 5.89 mg/ NM^3 and 8.22 mg/ NM^3 respectively. The emission concentration of air pollutants- PM, SO_2 and NO_X were reduced by 30.5%, 44.8% and 13% respectively for Go-Kashth than that observed for fire wood.

To discuss about the application and implementation of proposed Go-Kashth model in the Bhopal city, it is laudable to comment that the model has proven a success story for the city. In the year 2018, after the model being proposed more than 32000 cremations had been done in the city by cow dung logs that resulted into saving of around 160000 quintals of wood in the city that corresponds to around saving a forest land of around 180 acres. The three major cremation ground in the city that includes Bhadbhada vishram ghat, Chhola vishram ghat and Subhash vishram ghat had shown an extreme interest in the model from the day first and now has become an important part of this change.

These three Crematoriums have now become almost 95 percent free from use of wood in

Table 2 — Comparative study of emission characteristics of Go-Kashth & Wood

Emission Parameter	Test Method	Result (mg/ NM^3)	
		Go-Kashth	Wood
PM	USEPA-17, 3rd ed., 1998	238	342.5
SO_2	USEPA- 6, 3rd ed., 1998	3.25	5.89
NO_X	USEPA- 7, 3rd ed., 1998	7.15	8.22

cremations. The comparative study of number of cremations done with Go-Kashth and with wood at major crematoriums of Bhopal city is depicted in Fig. 4, also prop up the successful adoption of Go-Kashth by people of Bhopal city.

As per the experience of crematorium working people, use of Go-Kashth in cremation has many advantages over the use of fire wood. To cremate a body being less dense only 250–300 Kg Go-Kashth is required as compared to 400–600 Kg of fire wood. With Go-Kashth the complete cremation process takes only 4–5 hours whereas the same with wood needed 7–8 hours. This is simply because of the specific design of cow dung logs having a central cavity which supports easy circulation of air and helps to catch the fire easily and efficiently in all directions. Also, if we compare economically the use of Go-Kashth in cremation is more cost-effective. Cremation of a body with wood costs around INR 5000-6000 while the use of 'Go-Kashth' in cremation costs around INR 3000-4000 for people.

In terms of cost benefit analysis, the use of cow dung for preparing Go-Kashth has also been found much profitable for cow shed. A single cow gives an average 13 Kg of cow dung daily; out of that 40% water is removed and 60% i.e. 7.8 Kg dry Go-Kashth is produced which is sold to crematoriums for Rs. 7.0 per kg. Therefore, from each cow there is a gross earning of Rs. 55 per day and after deducting all other expenses including labor, electricity and transportation there is a net saving of Rs. 40 per cow. Also, there is no specific prior investments are required by cow shed owners for making Go-Kashth. Whereas, initially cow dung were used for making cow dung cakes which were sold to locals only for Rs. 2/ Kg demand of which has reduced drastically after introduction of Ujjwala Yojna. While, some large sized cow sheds were selling the cow dung to bio-gas manufactures for just Rs. 1 per kg.

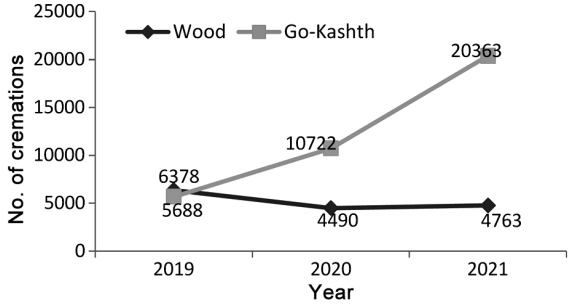

Fig. 4 — Comparison of number of cremations done with Go-Kashth and with fire wood at major Crematoriums of Bhopal city between the Years- 2019 and 2021

The proposed model has also being successfully adopted in the city for festival of Holi where Go-Kashth was being used for Holi bonfire in place of wood and cuts off around 90% use of wood during this festival that already have saved 75000 quintals of wood in the city.

The data collected from the major crematoriums of the Bhopal city for the last three years from 2019 to 2021 assisting the successful acquisition of the Go-Kashth Bhopal model in the city. In the year 2019, total 6378 cremations were done with Wood while cremations done with Go-Kashth were little less to 5688; but in 2020 and 2021 there is a significant increase in the numbers for Go-Kashth.

In the city only 4490 & 4763 cremations were done with firewood as compared to 10722 & 20363 cremations where Go-Kashth is used in the years 2020 & 2021 respectively. The Comparison of number of cremations done monthly with Go-Kashth and with fire wood at major Crematoriums of Bhopal city between the Years -2019 and 2021 is given in Fig. 4 and Fig. 5

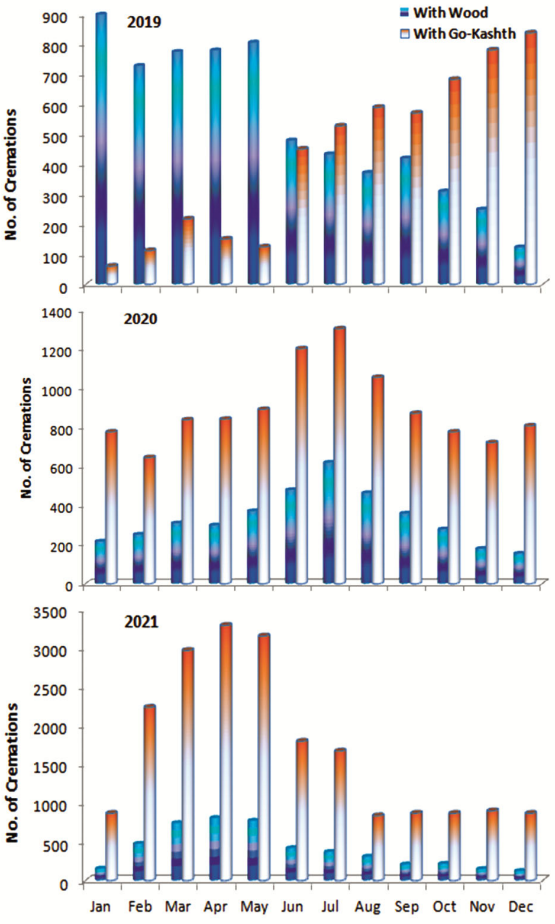

Fig. 5 — Month wise Trend in use of Go-Kashth as an alternate fuel in Bhopal city as compared to firewood from Years 2019–2021

illustrating the trend in of Go-Kashth as an alternate fuel in Bhopal city as compared to firewood.

The study of current status of the city reveals that the instigation of Go-Kashth model in the city as an alternate for wood use in cremation has come up with multitudinous benefits not only to save forest cover and efficient management of large volumes of cow dung, but also embrace reduced cost of cremation, reduced time in cremation, eco-friendly, generating revenues for cow sheds and making them self-sufficient, pollution control, control deforestation, fixed the issue of stray cows and also creating alternates to earn for local people for machine operation.

Conclusions

Corpse cremation is a common practice in Hinduism that consumes million tons of wood every year in India adding to deforestation and contributes to air pollution. Cow dung logs termed 'Go-Kashth' has raised as a successful option for replacing wood in cremation and more than 32000 cremations in the city have already been done with Go-Kashth, thus saving 25,600 tons of wood. Three major Crematoriums of the city have swapped the wood completely with Go-Kashth. The study of combustion parameters for Go-Kashth reinforced its effective use as an energy resource while the comparative study of Go-Kashth & Wood for emission characteristics shows reduced air pollutants. The developed Go-Kashth model for the city has easy acceptance among the city people and showed manifold advantages including reduced fuel consumption, reduced cost of cremation, effective management of large volumes of cow dung, effectively contributing to control related air, water and land pollution, improving present condition of cow sheds, employment to local people and beneficial for stray cows. The research study has future scope of developing better applications of Go-Kashth that can be recognized at global level and in designing of Air Pollution Control Device for Crematoriums.

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