Environmental Management of Crematorium of Bhopal City Using Cow-Dung Wood (Logs) as Alternate Fuel

Central Pollution Control Board
Regional Directorate (Central)
Bhopal

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PROJECT TEAM

Regional Director	:	Sh. P. Jagan, Scientist 'E'
Project Coordinator	:	Dr.Yogendra Kumar Saxena, Scientist 'B'
Project Co-Coordinator	:	Dr.Ranu Chouksey Verma, Scientist 'B'
Report Compilation	:	Dr.Yogendra Kumar Saxena, Scientist 'B'
		Dr.Ranu Chouksey Verma, Scientist 'B'
Monitoring Team	:	Dr.Yogendra Kumar Saxena, Scientist 'B'
		Dr.Ranu Chouksey Verma, Scientist 'B'
		Sh. Rameshwar Bandewar, JSA
		Sh. Sunil Kolhatkar,SLA
Type Set By	:	Sh. Prahlad Baghel, LDC

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ABBREVIATIONS

APCD	Air Pollution Control Device
BDL	**Below Detection Limit**
CDR	**Crude Death Rate**
CO	**Carbon Monoxide**
CV	**Calorific Value**
GCV	**Gross Calorific Values**
HHV	**High Heating Value**
NCV	**Net Calorific Value**
NH_3	**Ammonia**
NO_X	**Nitrogen Oxides**
NT	**Not Traceable**
PM	Particulate Mater
SO_2	**Sulfur Dioxide**

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CHAPTER 1

Introduction

1.1 Background- Origin and Concepts

Cremation, the practice of reducing a corpse to its essential elements- Water, Soil, Fire, Air and Sky by burning is an inextricable part of Indian culture especially in Hinduism. Generally, Hindus believe that life and death are part of the concept of rebirth (samsara). The ultimate goal for many Hindus is to become free from desire, thereby escaping rebirth and attaining emancipation (moksha), the transcendent state of salvation. Once liberation is attained, the soul will be absorbed into Brahman, the divine force and ultimate reality.

These beliefs about the soul and the body form the basis for why Hindu funeral rites generally include cremation. Hindus typically not cremated are babies, children, and saints, who are believed to be pure and unattached to their bodies; therefore they may be buried instead of cremated.

The practice of cremation on open fires was introduced to the Western world by the Greeks as early as 1000 BCE. The Romans followed Greeks. Cremation in India is first attested in the formative stage of Vedic civilization around (1900 BCE). The Rig-Veda contains a reference to the emerging practice.

Burn him not up, nor quite consume him, Agni: let not his body or his skin be scattered, O all possessing Fire, when thou hast matured him, then send him on his way up to the Fathers. When thou hast made him ready, all possessing Fire, then do thou give him over to the Fathers, When he attains unto the life that waits him, he shall become subject to the will of gods. The Sun receive thine eye, the Wind thy Prana (life-principle, breathe); go, as thy merit is, to earth or

heaven.
Go, if it be thy lot, unto the waters; go, make thine home in plants with all thy members.

—***Rig-Veda 10.16***

In ancient literature of Hinduism, the death ritual called 'Anteyshti' is structured around the concept that the microcosm of all living beings is a reflection of a macrocosm of the universe. Historically, Hindu cremations take place in a cremation ground usually near a river or water body and after performing last rites the body is placed on a pyre of wood with feet facing south and burned in an open fire by close relative preferably, the eldest son. The cremated remains are then disposed of in a sacred river with rituals. Those who can afford it may prefer to go to special sacred places like Kashi (Varanasi), Haridwar, Prayagraj (Formerly known Allahabad), Sri-Rangam, Brahmaputra to complete this rite of immersion of ashes into water.

Varanasi: ***The sacred Burning Ghat in India***

Varanasi is among the oldest city of the world at the bank of holiest river the Ganges, is considered as the most sacred place in India to perform the last rites as people believes the holier the place, the better the chances one achieves *Moksha* and avoids reincarnation. In Varanasi, the demand of funeral is so high that pyre burns 24 hours and seven day a week because of its holiness.

Varanasi is having a total of 88 ghats (place near bank of river), out of which 2 ghats are exclusively used as cremation site. Across Varanasi, nearly 200 bodies are burned every day that averages to 73,000 cremations per year. According to the CNN report, United States a traditional Hindu funeral pyre takes six hours and burns 500–600 kilograms (1,102–1,323 pounds) of wood to burn a body completely that cost around 4000 to 5000 Rupees. In Varanasi alone, per year around 36,500 tonnes of wood is consumed in cremation. Every year fifty to sixty million trees are burned during cremations in India, which results in about eight million tonnes of carbon dioxide or greenhouse gas emissions.

Previously, families who cannot afford the wood for cremation sometimes throw unburned or partially burned corpses in the river leading to the severe water pollution. Now, the Government has become rigid in this regard.

Figure 1.1 *Manikarnika Ghat in Varanasi (Source: Wordpress.com)*

This concern at the waste of wood is understandable. At the annual death rate of 11 per thousand in India it is estimated that each year three lakh tonnes of dry wood worth over Rupees 300 Crore is sacrificed at the altar of moksha.

According to some environmentalist, the ceremony of burning human bodies using wood, with the belief that it releases the soul, is actually a threat to the environment. All the year round, million trees are burned during cremation India and while burning the wood, there is also emission of tones of carbon di-oxide gas. The two main drawbacks of the traditional cremation are air pollution and deforestation. Also cremation in open ground generates large amounts of ashes, which are later thrown into rivers and other water bodies, thereby polluting the water.

However, there has always been a controversy on the use of the electric crematoriums and Indians largely follow the traditional burning of the bodies. In metropolitan cities, the electric crematoriums are used, but not to a great extent and most of these have failed due to religious reasons.

1.2 Cremation Practices in India

The practice of cremation varies in different religions. All religions are having their own perceptions of life after death and the final deposition of themselves or a loved one. Religious acceptance of cremation is a determining factor for many. Some of the common practices followed in various religions include:

Hinduism

In Hinduism cremation takes place in a cremation ground usually near a river or water body and after performing last rites the body is placed on a pyre of wood burned in an

open fire by close relative. The cremated remains are then disposed of in a sacred river with rituals. For traditional Hindus, cremation fit into an overall scheme of destiny. The fire itself is the medium by which the body is offered to the gods as a kind of last sacrifice.

Buddhism

In Buddhism also cremation is the preferred funeral rite for Buddhists as well and is reinforced by the fact that the Buddha was himself cremated. Cremated remains may be collected by the family the following day, and may be kept by the family, enshrined in a columbarium or urn garden, or scattered at sea.

Christianity

In Christianity bodies are placed into a casket, or coffin, and buried typically 6 feet under in a local cemetery. Often, headstones are then placed above ground over the location of the body to state the name and date of birth and death. This gives loved ones a place to come and pay respects. Even though they aren't very eco-friendly, ground burials are the most common and traditional method of being buried.

Islam

Islam strictly forbids cremation. Islam has specific rites for the treatment of the body after death and prefers burial of the dead body in the ground as quickly as possible – preferably within a day of death. Embalming is also not permissible, except where required by law.

Judaism

Traditional Jewish law strictly forbids cremation, requiring burial instead. The Jewish belief is that a body and soul will be reunited after death; therefore, a body is considered

sacred and must be buried. Embalming of the deceased is not performed, as the body is to be returned to dust from where it came, as it was created. The deceased is buried in a plain wooden casket, usually pine, without any metal, to help facilitate natural decomposition.

Zoroastrianism (Parsis)

Parsis consider both earth and fire sacred, and dead bodies are said to be Nasu, i.e. unclean. They can therefore neither cremate nor bury their dead as this would pollute fire and earth. Hence, dead bodies are just placed in a Dakhma i.e. Tower of Silence and allowed to be decomposed by the sun and scavenging birds.

1.3 Modern Cremation Practices

1. Electrical Cremation

The concept of electric cremation is not new. It was commissioned in January 1989 as a part of the Ganga Action Plan. The basic idea was to serve the purpose of river friendly cremation. In electric cremation body is cremated in a closed chamber called cremator with the intense heat generated by electric power. Relative to traditional cremation, electric cremation is comparatively less expensive, requires less time, wood is not burned and therefore, no gas emissions. However, electric cremation has not been popularized in India due to some traditional beliefs of Hindus regarding ritual of 'Kapal Kriya' where a long bamboo stick is used to crack open the skull which is not possible in electric cremation.

2. LPG Cremation

The LPG gas automatic burners are built with fan, motor, pump, ignition transformer and electrode, flame sensor, sequence controller, gas solenoid valve, air pressure switch and gas pressure switch. The automatic LPG gas burners can be hooked with external control signal for

total automation like PLC system, burner trip signal for alarm and hooter can be given from the burner sequence controller and burner fan can be by passed with a separate switch without any modification.

3. Aqua Cremation

Aqua cremation also called aquamation, resomation or alkaline hydrolysis is a method now becoming popular in western countries. In aquamation, the body is placed in a pressure vessel filled with a mixture of water and potassium hydroxide, and heated to a temperature around 160 °C. The process takes around 5 to 6 hours. The method results into green-brown tinted liquid containing amino acids, peptides, sugars and salts and soft white bone ash. The ash is returned to the next of kin of deceased. The liquid is disposed of either through the sanitary sewer system or in a green space.

1.4 Environmental impacts of Cremation

All Hindus believe that the soul of a dead person must be completely detached from the body and the material world, so that it can be reincarnated again. For this, an open cremation is needed so that the soul can be easily released as soon as the body is burned atop a massive pile of wood. Open cremations are quite common in India having many associated environmental issues. Pollution from cremations occurs silently and continuously and it is considered as one of the traditional sources of environmental contamination.

1. The traditional funeral pyre requires around 400-500 kg of firewood per body that constitutes a major part of wood consumption and promotes cutting of millions of trees and deforestation.
2. The process of corpse cremation generates numerous harmful air pollutants, including particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOCs) and heavy metals into the environment.
3. The burning of natural gas for cremation releases of greenhouse gases, as well as the vaporization of other chemicals

that may be present in the cremated body, such as mercury used in amalgam dental fillings, and dioxins and furans. And also contributes to resource consumption.

4. As traditionally most of the open pyre cremations occur near water source like river contributes to water pollution.
5. Immersion of ashes into water bodies after cremation also pollutes them.
6. During cremation there are toxic emissions associated with if any mercury amalgam dental fillings, plutonium pacemakers, silicone implants, organo-halogens and other toxins accumulated in body due to any specific medical treatment.

1.5 Project Conceptualization

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 60 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. New Delhi alone has around 400 traditional cremation grounds, while Mumbai has around 300.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, adding to the toxicity of their waters. 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.

Another concern is, in India cow is considered as sacred animal worshipped throughout the nation for its maternal figure supporting many lives through its valuable products including cow dung. However, management of large volumes of cow dung generated is a serious issue to be handled with prime concern, as if left contributes to water pollution, methane generation, foul smelling, growth of micro-organisms etc. Previously most of the waste was used as energy resource or collected in pits or left to decompose in the open which pose a significant environmental hazard.

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 waste effectively. The revenue so generated by cow sheds (Go-Shala) will surely help to fulfill the perspective of improving condition of cows in the country.

So, the proposed Go-Kashth Bhopal model 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 waste, improving present condition of cow sheds, future scope of its use as alternate fuel in other areas like small industries, puja/ havan, hotel tandoors etc.

1.6 Project Objectives

The objective of the project is *"To develop an alternate model for environmental management of Crematoriums in Bhopal city using cow dung wood (Go-Kashth) as alternate fuel.*

The present study aims to achieve the following:

(i) To completely replace the use of wood in crematoriums of the city by cow dung wood 'Go-Kashth'.
(ii) Inform public about benefits of using 'Go-Kashth' and promotes it use over wood.
(iii) Aware citizens about associated air pollution with open cremation and switch to modern methods of cremation.
(iv) Generate experimental data and comparison for emission from 'Go-Kashth' and firewood combustion.

(v) Implementation of the 'Go-Kashth' model to other nearby cities.

1.7 Scope of the work

The scope of the work is summarized as below:

a) Data collection from all major Crematoriums and Cow-Sheds of Bhopal city for complete inventory based on questionnaire developed.
b) Development of a service model for the use of Cow dung wood 'Go-Kashth' for Cremation in the city.
c) Comparative analysis of firewood and Cow dung wood 'Go-Kashth' for important parameters under proximate and ultimate analysis.
d) Experimental study on combustion of cow dung wood 'Go-Kashth' to quantify release of various air pollutants in the environment and comparative study of the same with firewood.
e) Designing of Air Pollution Control Device (APCD) for Crematorium to control air emissions.
f) To explore and develop other ways for utilization of 'Go-Kashth' to substitute firewood as in Holika dahan, Havan, Hotel tandoors, Dhaba, Industrial boilers etc.
g) Mass awareness to encourage peoples to use 'Go-Kashth'.

CHAPTER 2

Cremation- A Review & Data Collection

2.1 Study Area- Bhopal

Bhopal, also called city of lakes selected as the area of study for this project. Bhopal is a city in central India, and the capital of the state of Madhya Pradesh. 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). Bhopal is a metropolis city ranked the17th largest city of the India and the 131st in the World with area 285.55 Km2 (110.38 sq. miles) presently having population of above 1.5 million with density 3, 887/ Km^2.

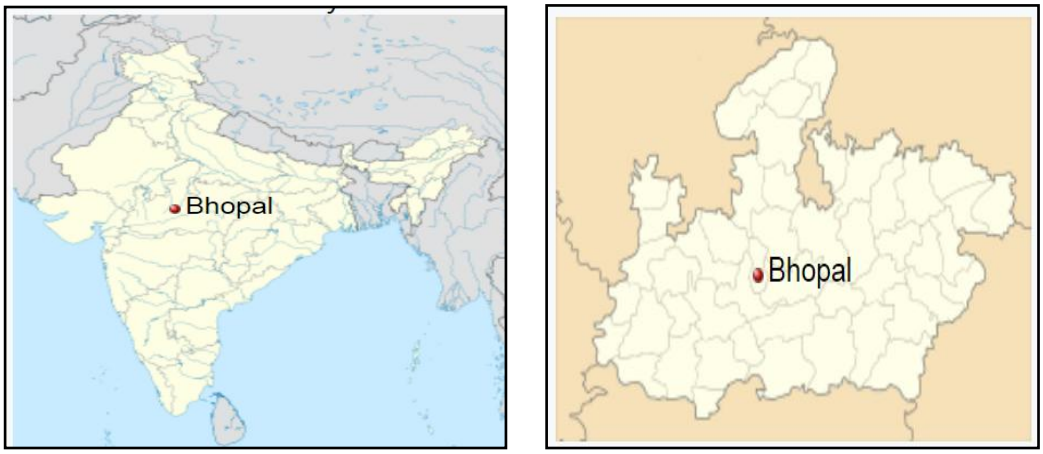


Figure 2.1*(a)Location of Bhopal in the Central Indian State- Madhya Pradesh*
(b) Location of Bhopal in the Country- India

The city Bhopal was originally founded by the Parmara dynasty King Bhoj in the 11th Century, so initially named as Bhojpal. The present city of Bhopal was founded by Dost Mohammed, an Afghan soldier, when the Mughal kingdom was nearing its

decline after the death of the Emperor Aurangzeb in 1707. So, Bhopal was a princely state ruled by Nawabs and Begums.

Bhopal is the city of serine beauty having several natural and artificial lakes dominant the city giving it the title of "City of Lakes". Also, rich in culture, art and public work having numerous heritage structures its period include the Taj-ul-Masajid, Taj Mahal palace, Gohar Mahal, Rani Kamlapati Palace, Indira Gandhi Rashtriya Manav Sangrahalaya, Bhojpur Temple, Bheem Betka, Van Vihar National Forest, Bharat Bhawan, various Dams etc.

The city has also witnessed the India's worst industrial disaster, "Bhopal Gas Tragedy" in 1984 claimed 2,259 lives and left several thousand permanently or partially disabled.

Bhopal is a cosmopolitan city where majority of the population is dominated by the Hindus (occupying around 69% of the total), whereas Muslims form the second highest of the total population. The city also has people from other religions, like Christians and Jains. Since Bhopal is centrally located, people from other communities have also settled here for generations.

2.2 Crematoriums in the city

The current population of the city as per world population review is around 2,389,574. According to demographics, Hinduism is the major religion followed in the city which constitutes around 69.20 % of Bhopal population. As per Madhya Pradesh AHS document, the Crude Death Rate (CDR) per 1000 people is around 5.8 in the city. To develop a functional model and for complete environment management of the study area it is necessary to collect the complete information about the available Crematoriums and Cow-sheds (Go-Shala) of the city along with the current facilities provided by them. To perform the inventory of the same questionnaire were prepared for Crematoriums and Cow-sheds. A survey of all the crematoriums and Cow-sheds of Bhopal city was done by the project team to collect desired information.

As per the collected information, crematoriums have been classified into three categories depending on the numbers of bodies cremated in a month.

Table 2.2.1 Crematoriums in Bhopal, Madhya Pradesh

S. No.	Cremation/ Month	Category	No. of Crematorium in the city	Name of Crematoriums
1.	=> 100	Large	03	• Chhola Vishram Ghat Trust,Chhola Road Bhopal • Shubhash Nagar Crematorium • Bhadbhada Crematorium
2.	26- 100	Medium	04	• Kolar Crematorium • Govindpura Vishram Ghat • Bairagarh Crematorium • Shri Vishram Ghat Sewa Trust, Mandeep N.H-12, Vishram Ghat,Parisar, Satlapur Road, Mandeep, Jila-Raisen (M.P.)
3.	<= 25	Small	03	• Anth Vishram GhatNear T.T. Group of Institution Hatai Kheda, Anand Nagar Road • Kahna Saiya Vishram Ghat , Kahna Saiya Gram Panchayat Dist. Bhopal • Khajuri Vishram Ghat – Khurd Jivan Moksh Vishram Ghat Seva Samiti Ward-53, Misrod, Bhopal

During the survey of crematoriums of the city it was observed that in many of the crematoriums rather than traditional funeral pyre at ground, a man sized metal grate base is constructed beneath a roof are used and woods are placed on the metal base. It is found affordable, energy efficient, and promotes circulation of air, while all the religious needs of Hindus are taken into consideration.

Table 2.2.2 Solid Waste Management at Crematoriums

S. No.	Materials	Management
1.	Cremated bones	Shall be handed over to relatives, if not collected by relatives on time stored in tinned box with full details in a designate room by the management and on yearly basis disposed of in river.
2.	Ash	Shall be handed over to relatives, if not collected by them or in case of non-claimed bodies disposed in low lying areas of crematorium.
3.	Bamboo	Shall be used by crematorium management for making plant protective guard, taken by working people for their use making huts, fence etc.
4.	Flower/ Straw	Shall be collected separately from other non-degradable wastes, shall be treated as wet waste and send to Municipal Solid Waste facility for wet waste, shall install a bio—digester/ composter/ compost pit for large sized crematoriums
5.	Clothes	Shall be donated to needy ones
6.	Utensils	Shall be donated to needy people
7.	Mud pots	Shall be crushed and disposed in low lying areas
8.	Metals/ Ornaments	Shall be occupied by the poor people or shall be donated to the needy ones
9.	Plastic waste	Shall be collected separately and is to be collected by Nagar Nigam authority
10.	Glass materials	Shall be collected separately and is to be collected by Nagar Nigam authority
11.	Food materials	Shall be collected separately from other non-degradable wastes, shall be treated as wet waste and send to Municipal Solid Waste facility for wet waste, shall install a bio—digester/ composter/ compost pit for large sized crematoriums
12.	Rope (Kalawa)	Shall be used to prepare and tie up the plant protective guards at crematorium
13.	Hairs	Shall be collected separately and disposed off accordingly, shall be collected and can be used for amino acid preparation. More effective ways for utilizing human hairs shall be explored.

2.3 Cow Sheds (Go-Shala) in the city

In the similar way, all the cow sheds of the city have been visited and details of the cow sheds and installed Go-Kashth machines have been collected as mentioned in the **Table 2.3**.

Table 2.3 Details of Cow sheds and Installed Go-Kashth Machines in Bhopal, Madhya Pradesh

S. No.	Name of Cow shed	Number of Cows present (Approximate)	No. of Go-Kashth Machine
1.	Shri Mahamrutyunjays Go-Shala Gram-post- Mugaliya Chhap Teh. Huzur, Block-Phanda Dist. Bhopa	125	01
2.	Nandini Goshala, Sharda Vihar, Bhopal	600	01
3.	Mahamrityunjay Go Sewa Sadan, Transport Nagar, Bhopal	650	01
4.	Ram kali Goshala, Halali Dam, Vidisha Road	1700	02
5.	Go Seva Bharati, Berasia	350	01
6.	Sanjeevani Gaushala, Mugaliya Hat, Bhopal	48	01

7.	Bunty Patidar Go Shala, Misrod, Bhopal	20	01
8.	Brij Goshala, Mandideep	30	01
9.	Veer Center, Bhopal	100	01
10.	Cattle Farm, Mahua Kheda, Bhopal	62	01
11.	Shri Kishor Parihar, Go-Kashth Kendra, Bhopal	Buying of cow dung from other Cow sheds and production of Go-Kashth	01
12.	Chhola Vishram Ghat, Chhola, Bhopal	Production of Go-Kashth from the Cow dung provided by the Municipal Corporation, Bhopal	01

CHAPTER 3

Development and Implementation of Go-Kashth Model

3.1 About The Go-Kashth

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 (Werner et al. 1989; Brown 2003). 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 beneficial constituents that 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 (Pongrácz and Pohjola 2004).

Due to lack of effective means of cow dung management the associated pollution is a serious concern. The most common environment concern with the waste includes disagreeable odor, ammonia, release of methane and other gases contribute to green-house effect and acid rain. It could pollute water sources and be instrumental in spreading infectious diseases. If the disposal of water is not properly planned it might create social tension owing to the release of odors and contamination of water sources.

Proper disposal and returning of nutrients back in the soil without pollution and spreading of diseases/pathogens, is required for efficient utilization of wastes on large farms.

Another major concern that in India cow is considered sacred and worshipped throughout the nation for its maternal figure as goddess supporting human lives from millions of years as a source of valuable products like milk, cow dung, go-mutra having versatile utility. So, cow is considered highly auspicious in Hinduism and is a symbol of divine bounty in India. However, in present condition of cow is not at that par as one can find it roaming on the busy street anywhere in India, even if in Cow shed (Go- Shala) the condition is not satisfactory. The Indian government is providing financial support to such cow sheds to improve the situation at its best.

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. But, these measures were not found sufficient to handle the large amounts of waste generated and have related environmental concerns.

Cow dung wood (Go-Kashth) has emerged as an effective solution to this problem. Go-Kashth is cow dung logs prepared exclusively from cow dung. 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.

"Go-Kashth" the long dried cow dung logs can be prepared by a simple machine with minimum human intervention. For production of Go-Kashth cow dung is fed into the hopper of the machine having Screw mechanism, which helps in mixing thoroughly, compress them and extrude them out. By using different size of die, logs of different shapes and sizes can be made easily. Produced logs are then put under the sunlight to dry out the moisture inside them, making them hard and sturdy.

The machine used in manufacturing cow dung logs is a simple electricity based machine weighs 208 Kg approx. having average dimensions as Length (2.6 ft.), Width (3 ft.) and Height (4 ft.) with Hooper of dimensions Length 16 inch, Width 16 inch and Height 14 inch and fitted with a motor of about 5 HP that requires 440 V of AC power having frequency of 50 to 60 Hz. Machine with above specification in 8 hours working every day it can consume around 1500 Kg of cow dung with the production speed of 50 logs/ hour (4*4 inch square die and 4 inch round die logs).

Machine Specifications

Weight- 208 Kg approx
Machine Dimensions- Length (2.6 ft),
Width (3 ft) & Height (4 ft)
Hooper Dimensions- Length 16 inch,
Width 16 inch &Height 14 inch
Size of Die- 4*4 inch square die & 4 inch round die logs
Motor- 5 HP requires 440 V of AC power
Frequency- 50 -60 Hz
Efficiency- Consume around 1500 Kg of cow-dung
in 8 hours working
Production Rate- 50 logs/ hour

The machine made of stainless steel of Grade 304 is having cost between Rupees 60, 000 and 80, 000 Rupees. But, presently is being installed at various Go-Shala of Bhopal city free of cost by donation from public and Government. Production of 1000 Kg of "Go-Kashth" has cost price of approx. Rupees 1000 including the labour and maintenance. This machine can be of iron also, it costs less but the stainless steel machine is more durable. In future, to deal with the problem of drying cow dung logs during rainy season, the machine can be fitted with a dryer to resolve this problem. Presently, for rainy season "Go-Kashth" is being stored in advance in Crematorium for the use.

"Go-Kashth" is having many advantages like it helps in managing cow dung in Go-Shala and dairy farms by making value added products and increase in income. Easy to operate and maintain, even women labour can also operate it. Size of logs can be increased or decreased as per requirement for various applications. Logs can also be cut into small pieces for its usage in "Chula" and "Havan" purpose. Eco friendly application saves the forest cover and better utilizes the cow dung.

3.2 The Go-Kashth Bhopal Model

The concept of using cow dung wood, Go-Kashth as an alternative of wood in Indian crematoriums was developed in July, 2018. The study area selected to develop a model was Bhopal city. For the development of a basic system it is very important to accumulate knowledge and distribute it to the crematorium management people to persuade 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 five macrophases, each having a particular purpose.

1. Knowledge accumulation and sharing of the knowledge to crematorium management and cow shed 'Go-Shala' people to involve them in the system.
2. Survey of Cow shed in the city to check for easy availability of cow dung to make cow dung logs.
3. Search for the technology to convert cow dung waste into compressed dry cow dung logs, 'Go-Kashth'.
4. Service model development with cost estimation to transport 'Go-Kashth' to Crematorium for use.
5. The most challenging phase was to make citizens ready for the change from traditional wood to 'Go-Kashth', promote the use of 'Go-Kashth' and mass awareness.

At the initial stage to make the system work, a 'Go-Kashth' making machine was installed at one of the large sized cow-shed 'Go-Shala' in the city named *Ramkali Go-Shala, Halali Dam*, Bhopal (MP) for production of Go-Kashth. A proper system was developed where dried

‘Go-Kashth’ was collected and transported to crematorium of use. Later, for making the system effective and to ensure the timely availability of ‘Go-Kashth’ at crematorium small sized cow sheds having less numbers of cows also get involved in the system. Cow dung produced there is collected and buys by interested people having their own ‘Go-Kashth’ making machine for the production.

The designated amount for ‘Go-Kashth’ is being directly paid by the crematorium committee to the concern ‘Go-Shala’ or others related either in account or through account payee cheque. This Bhopal model has proved a boon to the ‘Go-Shala’ in the city to generate money from waste. Previously, managing such a large volumes of cow dung was a serious concern to them. They have developed small mountains of cow dung in many years and used to dispose it in open land or discharged in drains or other nearby water bodies and were found very difficult to manage. Most of the cow sheds run as non-profits voluntary groups and are completely dependent on Government funds and subsidies for their work. Because of the lack of proper funds and money the conditions of many cow shed were found very poor. Even, at sometimes it was found difficult to arrange the fodder for the herds.

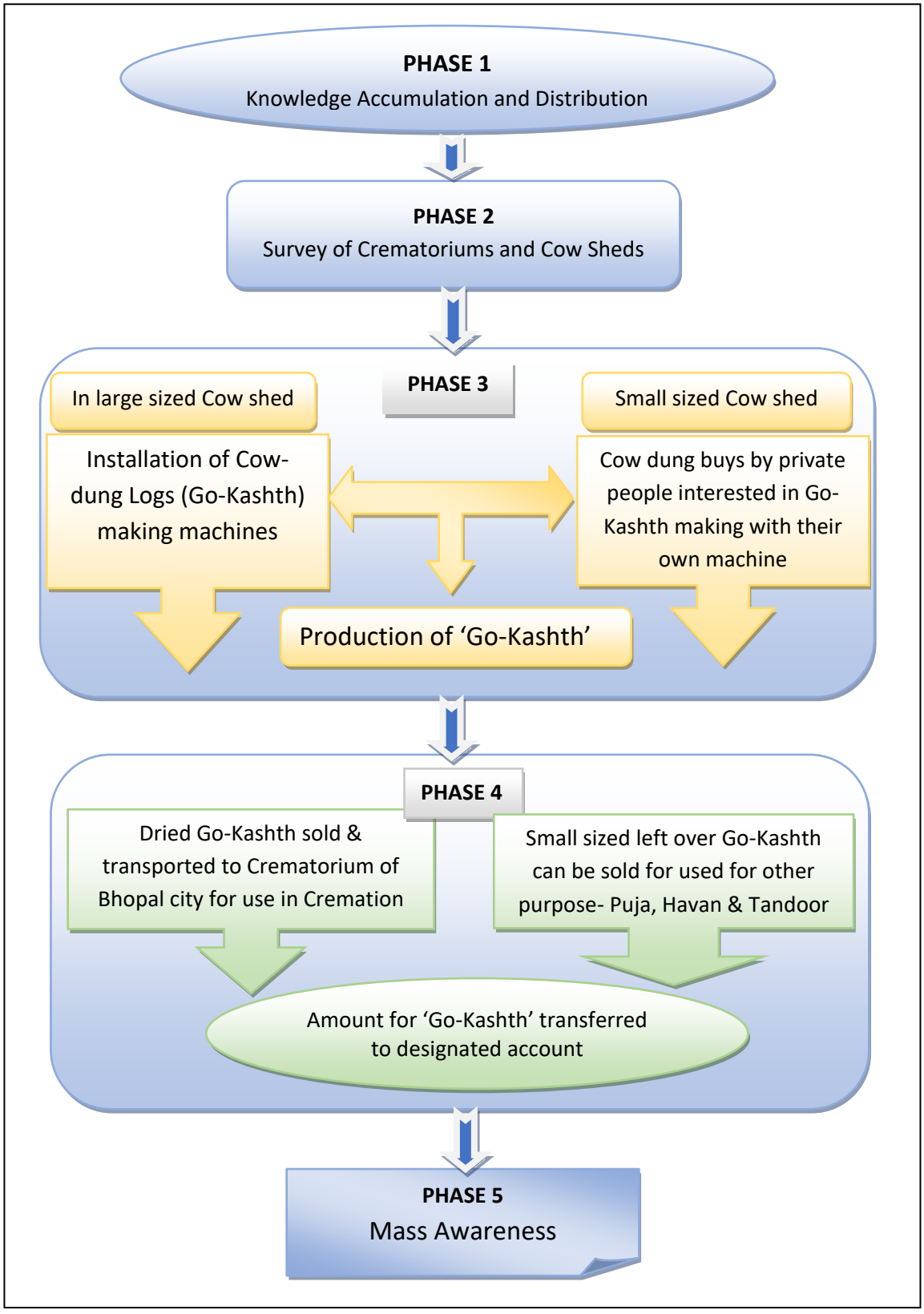


Figure 3.2 *The 'Go-Kashth' Bhopal model, Bhopal (MP), India*

But, after installation of 'Go-Kashth' machine and production of 'Go-Kashth' many benefits were observed like:

1) Small cow sheds are blooming and generating revenues to stand on their own legs and now, becoming self-sufficient.
2) Also, after introduction of the 'Go-Kashth' model managing cow dung has become very easy for cow sheds.
3) As no cow dung is now being discharged in drains and nearby water bodies, disposed off on open lands, it is effectively contributing to control air, water and land pollution.
4) Stray cows which were earlier observed roaming on streets and become victims of accidents. Now, because of the benefits of cow dung they are treated in good way.
5) It has also contributing to provide daily wages to 3 to 4 local women at one machine to earn for their families.

3.3 Current Status in the City

The 'Go-Kashth; model has proved to be success story for Bhopal city. Since, its commencement in July, 2018 till date more than six thousand cremations had been done in the city by cow dung wood. 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 vishram ghats have now become almost 100 percent free from use of wood in cremations.

With the experience of crematorium working people use of cow dung wood in cremation has many advantages over the use of fire wood. Initially, when wood was used it takes around 400-600 kg of wood depending on the size of the dead body. The time it takes extend from 7 to 8 hours to completely cremate the body. Also, to ignite the fire in wood it requires use of other additives like ghee, oil, cow dung cakes and laar. As the nature of wood is dense in between the process of cremation the crematorium workers need to make use of bamboo to reach the fire to all areas and cremate the body to all parts efficiently.

But after switching to use of 'Go-Kashth' the cow dung logs it was observed as it is less dense only 250-300 kg of 'Go-Kashth' is required for a body i.e. just half of the wood volume. The designing of the 'Go-Kashth' logs has been done in a way that each of the logs are having an air cavity in the center which adds to proper flow of air and thus, it is found easy to ignite the fire without using additives or very less amount of additives needed. Also, it takes almost half time as compared to wood i.e. around 4-5 hours for the complete cremation of the body to ashes. No additional efforts of cremation working people are needed in between the process as due to proper flow of air in all parts and less dense nature of cow dung wood the entire body catches the fire simultaneously and burns efficiently.

If we compare economically, cremation of a body with wood costs around 5000-6000 rupees while the use of 'Go-Kashth' in cremation costs around 3000-4000 rupees.

Another success story of ‘Go-Kashth’ in Bhopal has become the use of cow dung logs ‘Go-Kashth’ in festival of Holi. The Holi festival celebrating triumph of good over evil millions of trees will be cut and tons of wood will be burnt for the Holika bonfire and generating so much amount of air pollution. In order to provide solution to this cow dung logs ‘Go-Kashth’ has come up as an eco-friendly alternate of wooden logs. For the two consecutive years in 2019 and 2020, Bhopal city has witnessed the success of using ‘Go-Kashth’ in Holika bonfire and cuts off around 90 % use of wooden during this festival. In order to reduce pollution caused by burning of woo den logs during ‘holika dahan’ and to save trees from being cut for this, use of ‘Go-Kashth’ initiative has proved to be a saving card for the city.

To fulfill the increasing demands for ‘Go-Kashth’ more than 15 ‘Go-Kashth’ making machines have already being installed in different cow sheds and by private people of the city.

Inspired by Bhopal ‘Go-Kashth’ model many other cities have opted for using

cow dung logs in Holika bonfire. One of such initiatives is by IIT-Delhi students who visited Bhopal 'Go-Kashth' Model, got guidance and training and provided with cow dung logs which were distributed in residential colonies in Delhi, Ghaziabad, Noida and Faridabad for eco-friendly 'Holika Dahan'. Similarly, to prevent cutting of trees for rendering wood for Holika Dahan in 2020, the Indore and Dewas district administration has tied up with Go-Shala (cowsheds) for cow dung logs to make eco-friendly Holi.

In success of 'Go-Kashth' model in the city the citizens of Bhopal has played an accountable role. They helped it to make a mass movement and now people themselves demand for cow dung wood to be use in cremations rather the wood logs. To promote the 'Go-Kashth' Bhopal model in the city and also to other cities; to prevent cutting of trees for their use in cremation, to ensure 90-100 percent use of 'Go-Kashth' in all the crematoriums of the Bhopal city, to make people aware about its use; and to make evolve the model in a more effective way Bhopal city has also came up with a committee including persons from crematorium management, cow-shed management, mass media and environmentalist and named as "*Go-Kashth Samvardhan v Paryavaran Sanrakshan Samiti*".

Bhopal city is looking forward to set an example as a model for the other cities of the India by eradicating cent percent use

of wood in cremation and developing better applications of "Go-Kashth" that can be recognized on the global level.

3.4 Mass Awareness

Mass awareness and involvement of public serve as the most important element in success of any project. Public participation and education approach are the ways to move citizens and others in the efforts to shape a sustainable view.

A vision in mind if can be turned into a mass movement will be able to set mild stones. But, as cremation rituals are years going and have religious sentiments associated with them, it is closely related to basic societal function and its interpretation varies accordingly in different societies. It is therefore, a challenge to let public accept the change. So, mass awareness to let public understand their responsibility towards society and environment and accept the change was very important part of this project.

Many awareness programs have been performed by the team at various cremation grounds of Bhopal city to aware them about 'Go-Kashth' the cow dung wood/ logs prepared exclusively from cow dung. These awareness programs played very crucial part to let the public except this change and further promote the concept to others. Go-Kashth workshop at Nagar Nigam, Sagar (MP); Workshop at MPPCB, RO-Bhopal (MP); Holly Navduniya Samvad, awareness program at Central Jail, Bhopal (MP) are some of the awareness programs done in this regard. A

meeting with Municipal Corporation, Delhi (MCD) was also done to adopt the concept for management of cow dung at Delhi and to discuss other valuable utilities of cow dung wood.

Promotion with education approach has an effective role in creating healthy awareness and preparing suitable environment for the development of sustainable view in future. With this view more than 20 schools and colleges of the city were visited by the project team to make the students aware about 'Go-Kashth' and its various applications like Raja Bhoj school, Bhopal; Saint Joseph Co-ed school, Piplani- Bhopal; Shashkiy Hamidia Kala AVN Vanijya Vidyalaya, Hamidia- Bhopal; BHEL Govt. School, BHEL-Bhopal; Sadhu Vaswani College, Bairagarh- Bhopal; Career College, BHEL- Bhopal etc.

CHAPTER 4

Experimental Studies

4.1 Solid Fuel Analysis

Proximate & Ultimate Analysis of 'Go-Kashth'

Biomass cow dung, due to its energetic properties, is an alternative source of energy that can be successfully exploited. Solid biomass waste of animal origin is a biodegradable fraction of products, waste and residues of the agricultural industry (including herbal and animal substances), forestry, and related industries, as well as biodegradable industrial and urban waste fractions.

As cow dung waste derived from biomass its use as biofuel provides substantial benefits as far as the environment is concerned. Biomass absorbs carbon dioxide during growth, and emits it during combustion. Therefore, biomass helps the atmospheric carbon dioxide recycling and contributes less to the greenhouse effect. Biomass consumes the same amount of CO_2 from the atmosphere during growth as is released during combustion.

This part of experimental studies predominately focused on proximate and ultimate analysis of 'Go-Kashth' and fire wood used in cremation. Proximate analysis, ultimate analysis and calorific value are commonly used to characterize solid biomass fuels. The proximate analysis serves as a simple means for determining the behaviour of a solid biomass fuel when it is heated. It determines the contents of moisture,

volatile matter, ash and fixed carbon of the fuel. The amount of fixed carbon and volatile matter directly contribute to the heating value of the fuel. Fixed carbon acts as main heat generator during burning while high volatile matter leads to smoky flame and easy ignition of the fuel.

On the other hand, the main purpose of an ultimate analysis is to determine the elemental composition of the solid fuel substance. It deals basically with determination of Carbon, Hydrogen, Nitrogen, Oxygen and Sulfur percentage in the fuel. It is useful in determining the quantity of air required for combustion, the volume and composition of combustion gases. This information also helps in flue duct designing. The calorific value of a fuel is a direct measure of the chemical energy stored in the fuel. The calorific value of fuel has dependence on carbon and hydrogen content of the fuel.

For this investigation about 1-3 kilograms samples of 'Go-Kashth' and mixed wood were collected from various Cremation grounds of the city. The samples were pulverized till of 30 mm size and representative samples marked as GS 01 and WS 02 were prepared from the collected 'Go-Kashth' and wood respectively to get the results. The prepared samples were analyzed by an NABL accredited laboratory. Comparative results of the two are mentioned in detail in **Table 4.1**.

The basic energetic parameter characterizing biomass is its calorific value. The Gross Calorific Values (GCV) of the two show that 'go-Kashth' is having lower GCV (2890 Kcal/Kg) than that of wood

sample (3533 Kcal/Kg). The high values for carbon and volatile matter of wood support its high GCV.

Moisture is another an important parameter of any biomass fuel. When utilizing biomass as fuel, the high moisture content of the biomass affects strongly the combustion process as well as the heating value such as lowering the flame temperature and/or the boiler efficiency. The low flame temperature could result incomplete combustion and/or other operational problems. Therefore it is a very important parameter, which strongly influences the economies of the utilization of biofuel. Results for moisture content shows that 'Go-Kashth' has much lower moisture content (8.29 g/100g) than that of wood (22.74 g/ 100g).

Ash content is the fraction in biomass that is composed of incombustible components remained after a fuel is completely burned. However, the volatile content in fuel is a lesser-known property that depicts the fraction of the fuel that can readily volatilize (turn to gas) when heated to a high temperature. 'Go-Kashth' contains much higher percentage of ash (32.20 g/100g) as compared to wood that contains only 1.69 %. While volatile matter fractions in 'Go-Kashth' and wood samples were found 50.82 and 62.64 respectively. Fixed carbon percent has direct relation with High Heating Value (HHV). Wood sample was found to have higher fixed carbon than cow dung wood.

Table 4.1 Comparative Analysis Report for Proximate and Ultimate Analysis of Cow dung wood (Go-Kashth) and Wood

(Date: 16, 17/01/2020)

S. No.	Parameters Analyzed	Unit	Test Method	Results	
				Go-Kashth GC-01	Fire wood WS- 02
Proximate Analysis					
1	Moisture	g/100 g	IS 1350 (Part I) 1984	8.29	22.74
2	Ash	g/100 g	IS 1350 (Part I) 1984	32.20	1.69
3	Volatile matter	g/100 g	IS 1350 (Part I) 1984	50.82	62.64
4	Fixed Carbon	g/100 g	IS 1350 (Part I) 1984	8.69	12.93
Ultimate Analysis					
5	Carbon (C)	g/100 g	ASTM Method D-3176	25.63	35.25
6	Hydrogen (H)	g/100 g	ASTM Method D-3176	3.53	4.45
7	Nitrogen (N)	g/100 g	ASTM Method D-3176	1.38	1.34
8	Sulfur (S)	g/100 g	ASTM Method D-3176	0.80	0.93
9	Oxygen (O)	g/100 g	ASTM Method D-3176	28.17	33.60
Calorific Value					
10	Gross Calorific Value (GCV)	Kcal/ Kg	IS 1350 (Part 2) 2017	2890	3533
11	Net Calorific Value (NCV)	Kcal/ Kg	IS 1350 (Part 2) 2017	2703	3297

Results of ultimate analysis shows that elemental composition of all elements except for Nitrogen is higher for wood than that of 'Go-Kashth'.

4.2 Ash Analysis

Ash content is the fraction in biomass that is composed of incombustible mineral material. Ash is present in the biomass in the form of certain inorganic compounds like sodium, potassium, calcium, Magnesium, Phosphorous, Iron, Zinc and Lead. The in-organics especially, potassium and calcium, catalyze biomass decomposition and char-forming reactions.

The samples for ash of both the 'Go-Kashth' and wood were collected from the boiler after complete combustion of both separately under controlled conditions. The samples marked as GAS-03 for 'Go-Kashth' ash and WAS-04 for wood ash. The representative samples of ash were prepared and was analyzed by NABL accredited laboratory. The detailed result of organic matter and other elemental parameters analyzed in ash samples is shown in **Table 4.2**.

The result shows that except for the elements- Sodium, Iron and Manganese, concentration of organic matter and all other determined elements were found higher in wood ash (WAS-04) as compared 'Go-Kashth' ash (GAS-03). Nickel and Arsenic were found absent in both the samples.

Large ash content makes it challenging for combustion machinery, because of the potential release of the ash and alkali metals during combustion. Melting of ash during combustion causes the problem of fouling (forming deposits on combustor surfaces) and slagging (hard chunks of glassy material left in the bottom of the combustion chamber). Agricultural residues contain minerals and therefore, typically have higher ash content than wood biomass. However, the volatile content in fuel is a lesser-

known property that depicts the fraction of the fuel that can readily volatilize (turn to gas) when heated to a high temperature. The presence of oxygenated volatile matter in biomass indicates a potential for creating large amounts of inorganic vapors during combustion. Feedstock with "high volatiles" tends to vaporize even before combustion ("flaming combustion"), whereas one with low volatile contents burn primarily as glowing "char." This accounts for the performance of the combustion chamber and should be taken into consideration when designing a combustor.

Table 4.2 Comparative Analysis Report of Ash Analysis of Cow dung wood (Go-Kashth) & Wood (Date: 16, 17/01/2020)

S. No.	Parameters Analysed	Unit	Test Method	Results	
				Go-Kashth GAS-03	Fire wood WAS- 04
1	Organic Matter	g/100 g	IS 2770 : Part- 22	0.28	4.23
Elemental Ash Analysis (On Ash Weight Basis)					
2	Sodium (Na)	g/100 g	ANqr/LabSOP/Inorg/General/01	3.81	0.36
3	Magnesium (Mg)	g/100 g	ANqr/LabSOP/Inorg/General/01	0.74	3.08
4	Calcium (Ca)	g/100 g	ANqr/LabSOP/Inorg/General/01	3.85	12.88
5	Phosphorus (P)	g/100 g	ANqr/LabSOP/Inorg/General/01	2.01	4.37
6	Iron (Fe)	g/100 g	ANqr/LabSOP/Inorg/General/01	0.62	0.12
7	Manganese (Mn)	g/100 g	ANqr/LabSOP/Inorg/General/01	0.07	0.02
8	Lead (Pb)	mg/Kg	ANqr/LabSOP/Inorg/General/01	3.022	6.26
9	Nickel (Ni)	mg/Kg	ANqr/LabSOP/Inorg/General/01	Absent	Absent
10	Copper (Cu)	mg/Kg	ANqr/LabSOP/Inorg/General/01	22.41	78.64
11	Arsenic (As)	mg/Kg	ANqr/LabSOP/Inorg/General/01	Absent	Absent
12	Zinc (Zn)	mg/Kg	ANqr/LabSOP/Inorg/General/01	37.17	140.33
13	Potassium (K)	g/ 100g	ANqr/LabSOP/Inorg/General/01	8.43	12.55

4.3 Emission Analysis

The burning of any biomass fuel in open fire of cremation releases oxides of Nitrogen, Sulphur and Carbon in atmosphere along with particulate matters that may contribute to air borne pollution and has impacts on people having continuous exposure to these pollutants. To evaluate the level of emission from combustion of 'Go-Kashth' and its comparison with that of wood combustion an experimental study was performed.

To perform the study an experimental setup was designed at M/s Anik Milk Product located at Govindpura Industrial Area, Bhopal (Madhya Pradesh), India. The study

was performed in a closed controlled experimental setup dated 16 and 17/ 01/ 2020. The experimental setup designed for emission analysis is described in **Figure 4.3.1.**

The combustion chamber of the boiler was used for burning of 'Go-Kashth' and wood as fuel to assess the emissions in both the cases. The port hole for sampling was made in the duct before installed flue gas treatment system, scrubber and usual monitoring chimney. In the study monitoring was performed for the parameters- particulate matter (PM), gaseous pollutant (NO_x, SO_2, CO) and heavy metals.

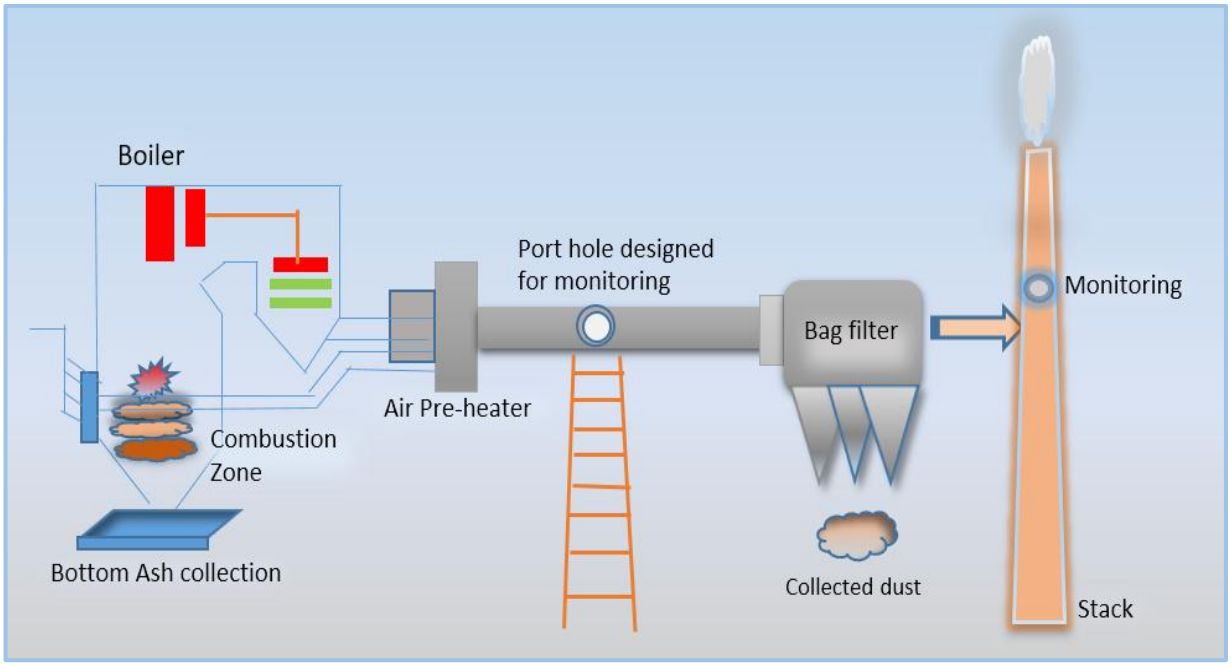


Figure 4.3.1*Experimental setup for 'Go-Kashth' experiment*

Material and Method

The experiment was performed in the month of 16-17 January, 2020 for which 'Go-Kashth' and wood required for combustion was purchased from a Crematorium that is commonly used in cremation. The equal quantity of both the fuels i.e. 500 kg weighed for combustion. The methodology involves three steps. At the start, combustion chamber of the boiler was emptied completely and then blank readings were taken for the designated parameters for background corrections to get the exact value of emissions. The combustion chamber was charged with wood first and then with 'Go-Kashth 'and emissions were monitored for the calculated period of time respectively. A constant air to fuel ratio was maintained in both the cases to ensure complete combustion of fuels.

The emissions from combustion are not constant throughout the burning process and may vary with time. Therefore, to obtain data that cover the entire burning cycle integrated sampling was done. For both the fuels, sampling was done twice during the

combustion- at the start of the combustion when desired steam pressure was reached and near the end of the burning cycle.

A typical sampling configuration was used including a sampling probe, a filter holder, a pump and impingers with absorbing media for SO_2, NO_x. A pre-weighed desiccated cellulose thimble was used for PM. The emission for CO was measured with a battery operated Testo 350 'XL' instrument.

Results

As in all the crematoriums of the city body is burned kept on iron pyre or ground with wood or 'Go-Kashth' it was found difficult to quantify exact emission level of pollutants that occur during cremation in the natural draft as there is always dilution of air. So, the study was performed in a controlled experiment where combustion was done inside a boiler and sampling was done. The emissions from combustion of 'Go-Kashth' and wood were determined and compared for the studied parameters are presented in **Table 4.3.**

Table 4.3 Comparative study report on emission study of combustion of 'Go-Kashth' & Wood (Date: 16,17/01/2020)

S. No.	Parameter	Unit	Test Method	Results				
				Blank	Go-Kashth		Fire wood	
				B-1	GC-01	GC-02	WS- 03	WS- 04
1	PM	mg/NM^3	USEPA-17, 3rd ed., 1998 (Gravimetric method)	134	224	252	334	351
2	SO_2	mg/NM^3	USEPA-6, 3rd ed., 1998 (Titrimetric method)	0.05	2.94	3.56	5.77	6.02
3	NO_x	mg/NM^3	USEPA-7, 3rd ed., 1998 (PDS method)	5.0	7.30	7.01	8.04	8.40
4	CO	ppm	Testo 350 XL	NT	2617	1970	3280	2445
5	NH_3	mg/NM^3	USEPA-29, 3rd ed., 1998 (AAS/Graphite generation)	NT	NT	NT	NT	NT

***NT- Not Traceable**

In this study, monitoring was conducted for PM, SO_2, NO_x, and CO along with related parameters including flue gas oxygen content, temperature and flow rate. The emission concentration of PM when 'Go-Kashth' was used as fuel ranged between 224 to 252 mg/NM^3 with an average concentration of 238 mg/NM^3. While, in case wood combustion it was calculated as ranged between 334 and 351 mg/NM^3 having an average concentration of 342.5 mg/NM^3. Emission of PM on combustion of wood was exceeded by 43.90% than that in 'Go-Kashth'.

SO_2 principally originates from the combustion of Sulphur in the fuel source. The emission concentration of SO_2 with 'Go-Kashth' and wood used as fuel ranged between 2.94 to 3.56 mg/NM^3 with an average of 3.25 mg/$NM^3$and 5.77 to 6.02 mg/$NM^3$with an average 5.89 mg/$NM^3$of respectively. Emission of SO_2on combustion of wood was exceeded by 55.18 % than that in 'Go-Kashth'.

NOx emissions depend primarily on fuel type and thermal conditions. The emission concentration of NOx with 'Go-Kashth' and wood used as fuel ranged between 7.30 to 7.01 mg/NM^3 with an average of 7.15 mg/$NM^3$and 8.04 to 8.40 mg/$NM^3$with an average 8.22 mg/$NM^3$of respectively. Emission of NOx on combustion of wood was exceeded by 14.96 % than that in 'Go-Kashth'.

CO is a product of incomplete combustion. At the start of fire as the temperature is low CO emission is high due to incomplete combustion but as the combustion continued with increase in temperature emission concentration of CO decreases. The emission concentration of CO with 'Go-Kashth' ranged between 2617 and 1970 ppm with an average value of 2293.5 ppm. While the emission concentration of CO when wood used as fuel ranged between 3280 and 2445 ppm with an average of 2862.5 ppm. The emission of CO on combustion of wood was exceeded by 24.80 % than that in 'Go-Kashth'.

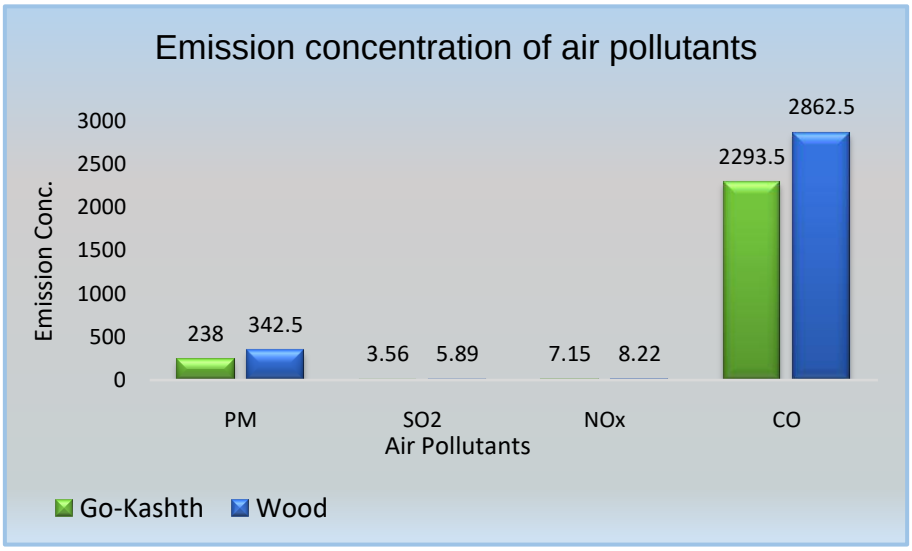
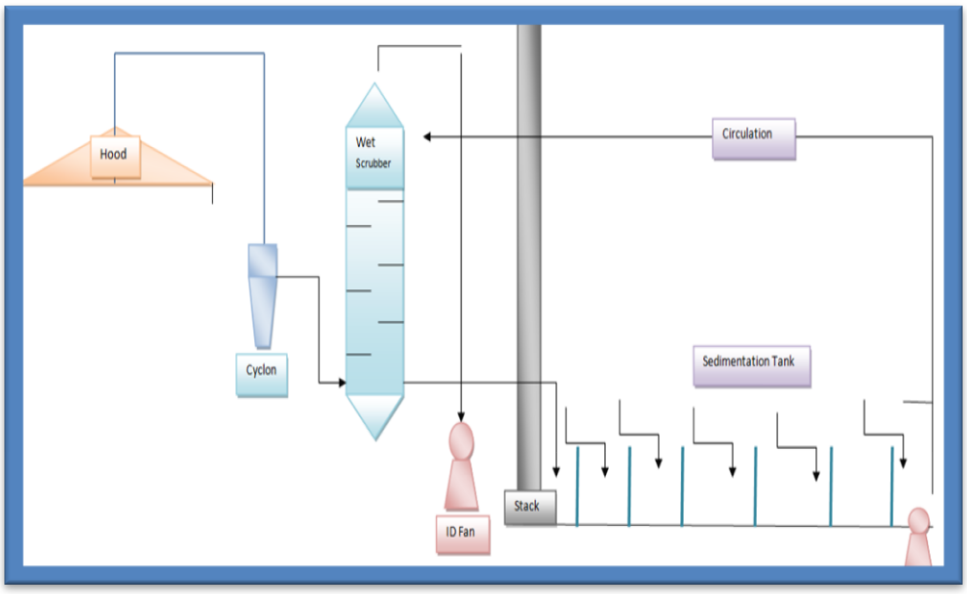


Figure4.3.2*Comparative emission concentration of air pollutants on combustion of 'Go-Kashth'& Wood*

4.4 Installation of APCD at Cremation Pyre

Air contaminants emitted during cremation include oxides of nitrogen, carbon monoxide, volatile organic compounds, and oxides of sulfur, particulate matter and toxic air contaminants. These emissions from cremation can be controlled by installation of some air Pollution control Devices at cremation pyre.

With this view a simple APCD design has been proposed to be installed at the crematoriums of the city. This system includes a Movable Suction hood, cyclone, wet scrubber, stack and sedimentation tank. The details of the same are as shown in the figure:



Installation of APCD at Cremation Pyre


गौ-काष्ठ

4.5 Conclusion

Corpse cremation is a common practice followed in Hinduism since historic period represents cycle of life where after death the body is burned on a stack of wood in an open area and ashes are finally disposed of to a water body that consumes million tons of wood every year in India adding to deforestation and contributes to air and water pollution. Electric cremation has come up with a solution to this but, has not been accepted due to traditional and ritual values. In this project, Cow dung wood termed 'Go-Kashth' prepared exclusively with cow dung using a simple machine has raised as a successful option for replacing wood in cremation in Bhopal city and has also accepted by people of city as of having sentimental values with cow and cow dung. More than 6000 cremations in the city have done with 'Go-Kashth' and three major Crematoriums of the city- Chholla vishram ghat, Subhash vishram ghat and Bhadbhada vishram ghat have swap the wood completely with 'Go-Kashth 'due to its manifold advantages like prevents deforestation, reduced fuel consumption, reduced cost of cremation, effective management of cow dung waste, effectively contributing to control related air, water and land pollution, improving present condition of cow sheds, employment to local people, beneficial for stray cows and also its future scope of use as alternate fuel in other areas like industrial boilers, puja/ havan, hotel tandoors etc. For the last two years, more than 80% *Holika Dahan*in the city was achieved with 'Go-Kashth'.

The results of comparative fuel analysis study of 'Go-Kashth' and wood shows although wood is having higher calorific value than that of 'Go-Kashth' instead the emission concentration of air pollutants- PM, SO_2 and NO_x was found lower on combustion of 'Go-Kashth'. So, use of cow dung wood logs in cremation was found to have manifold advantages viz. depreciate cutting of trees for cremation, lesser emissions of air pollutants, management of large volumes of cow dung produced in cow sheds, earning of money for cow sheds, cost effective etc. The

'Go-Kashth' Bhopal model has proved a success story in the city and is looking forward for the designing and installation of APCDs at crematoriums to control emissions and to regularize its proper monitoring.

Dr. Ranu Chouksey Verma
Scientist 'B'
Project Co-Coordinator
Central Pollution Control Board
Regional Directorate (Central)
Bhopal

(Dr. Yogendra Kumar Saxena)
Scientist 'B'
Project Coordinator
Government Analyst
Central Pollution Control Board
Regional Directorate (Central)
Bhopal