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DEVELOPMENT MODEL OF PROTOTYPE BUDDHIST CREMATORIUM FOR URBAN COMMUNITY

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Abstract: The practice of temple cremation has long been an important aspect of Buddhist culture, but it has also been a source of environmental pollution and public health concerns. However, a recent study has developed a prototype crematorium and Vimutti sprayers that can reduce harmful pollutants generated during cremation. Using qualitative, fieldwork, and experimental research methods, the study found that incomplete combustion during the temple cremation released dangerous pollutants such as carbon monoxide, sulfur dioxide, dioxins, and furans into the environment, which causes harm to public health and the environment. The development of the prototype crematorium and Vimutti sprayers provides a solution to these problems. The research showed that these technologies effectively reduced the emission of dioxin and furans during cremation, thus minimizing the harmful impact on the environment and public health. The pollution control analysis found that the emissions were below the benchmark and lower than the standard value. The use of these technologies can benefit urban communities by improving public health and environmental quality. The study's findings present a valuable solution to the long-standing issue of environmental pollution caused by temple cremation, offering a practical and effective way to reduce pollution and benefit urban communities, and is a step towards creating a cleaner and healthier environment for future generations.

Keywords: Buddhist cremation, prototype crematorium, environmental pollution, public health, urban community.

Introduction

The cremation ritual has long been a part of Thai culture, and many other countries also believe in sending the souls of the deceased to heaven by choosing to burn their physical bodies. Many temples in Bangkok and throughout Thailand have crematoriums to perform these religious rituals. However, this practice produces toxic substances from the burning process that can be life-threatening. Dioxins and furans are formed by the combination of chlorine, oxygen, and benzene. Although stable to heat, they decompose quickly in light but stabilize in soil and water. They can also be found during the combustion of carbon-containing or chlorine-containing substances from factories, and they are harmful to the health of living organisms. Dioxins and furans are not new hazardous substances, they have been present for hundreds of years (Maher & Ford, 2017; Widén & Karlsson, 2018; Winzer *et al*., 2018; Chaibao, 2018; Birrell *et al*., 2020).

Dioxins and furans can enter the human body through ingested foods such as meat, milk, eggs, and animals that have been exposed to the substance by eating grass or drinking water that contains dioxins and furans from crematoriums. When people consume these animal products, these substances accumulate in their bodies, dissolve in fat and settle in the fat layers of the human body. During cremation, the fat layer must be burnt, which produces a large number of dioxins and furans from the corpses and releases them into the atmosphere (Becher & Flesch-Janys, 1998; Kanan & Samara, 2017; Tarekegn & Akele, 2018; Zubair & Adrees,

2019; Kirkok, *et al.*, 2020). Thai and foreign scholars have studied the effects of cremation, dioxins and furans, and small particulate matter on human health.

Investigating and monitoring the circumstances of dust particles that affect health due to their accumulation in the respiratory system is crucial, as they can reach the air sacs in the lungs. Particulate matter up to 2.5 microns (PM2.5) has a significant impact on health (Pollution Control Department, 2019), and the problem of air pollution from cremation, such as soot and odours, often occurs early (Department of Local Administration, 2000). Airborne impurities can last long enough to cause adverse effects on the health of people, animals, and plants and may take the form of Suspended Particulate Matter (SPM), lead (Pb), carbon monoxide (CO), sulphur oxide (SOx), and nitrogen oxide (NOx) (Borkham, 2013). Therefore, these toxins should be prevented and controlled to a level that is safe for humans and the environment (Cruz *et al*., 2017; Decker *et al*., 2018), and this must be carried out with caution (Kengchuwong, 2018).

Most of Thailand's crematoriums don't have a high enough burning heat to burn the dioxins and furans, which are considered to be one of the deadliest toxins invented by humans in modern times, according to a report by the U.S. Environmental Protection Agency. Dioxin is a colourless, odourless, and smokeless substance that is known to be highly toxic. The International Agency for Research on Cancer (IARC), which is a WHO agency, has classified dioxin as a Class 1 carcinogen (Hazardous and Waste Survey Management Division, Pollution Control Department, 1999).

Dioxins and furans do not cause immediate death, but symptoms can gradually occur and increase in severity, eventually leading to death. They are long-lasting residual air pollutants that are toxic to human health and are released into the environment due to incomplete combustion of organic matter. However, it is possible to control or prevent this pollution at the source (Boonlong, 2004). According to a research report on dioxins and mercury released from crematoriums and furnaces, they can harm human life and the environment by stimulating cancer and affecting the reproductive and immune systems of the human body (Mari & Domingo, 2010). The assessment of the impact on the surrounding environment indicates that there is indeed an impact on the environment caused by the release of dioxins and furans from crematoriums.

In summary, the aim of this research is to develop a prototype Buddhist crematorium model that is safe and free from dioxin and furans for urban communities. This study focuses on developing and testing Vimutti sprayers as a preventive practice to gain useful knowledge and encourage awareness among the public and religious figures. The impact of this research is not only significant for the health of individuals living near crematoriums but also for the environment. The development of a prototype Buddhist crematorium model will lead to a model area for the development of cremations that are free from dioxin and furans, resulting in a good quality of life and a happy community for the monks and people in the community. This research has the potential to guide the development of a model community in Thai society, providing a safer and more sustainable approach to cremation practices.

Materials and Methods

Research design

The research design for this study utilized a combination of qualitative research methods, including the analysis of data from secondary sources through documentary research, as well as action research that focused on studying local wisdom from primary sources within the community. The purpose of this approach was to synthesize both parts of the data and create a comprehensive research and development process. The study aimed to address the pollution issues caused by cremation in urban and provincial communities by seeking solutions through the development and experimentation

of the GAIA (Vimutti) substance in cremation. By analysing the problems and obstacles, the study led to the development of GAIA (Vimutti) sprayers, which were then installed in a developed crematorium. The findings of this study are expected to have a significant impact on the health and well-being of the monks, people in the community, and the environment, leading to the development of a model community in Thai society with a good quality of life and reduced environmental pollution.

Population and samples

The population studied was a group of monks or religious leaders, local government administrators, and community representatives living in Bangkok (Study Area) and Wat Dan Samrong, Muang District, Samut Prakan Province. The sampling method used was purposive sampling, selecting knowledgeable individuals who could provide important information based on defined criteria, namely, those who had expertise in the issues studied and who were willing to provide insight into the phenomena that occur in the context of the area.

Research instruments

The implementation of the aforementioned research focused on the active participation of the study area in data collection through interviews and focus groups. Workshops, in-depth interviews, and focus group discussions were the instruments used to collect data in detail.

1. The workshop was created to gather important information from luminaries involved in the 'Development Model of Prototype Buddhist Crematorium for Urban Community' to develop a cremation model. These models were then distributed to various locations throughout the country to gather basic information and categorise it. It was easy for relevant authorities to manage and helped raise awareness of the silent dangers of cremation, including the spread of dioxin and furans. The aim was to further develop a crematorium model that could control pollution and push the government to adopt a policy regulating the construction of crematoriums in urban and provincial communities, linking them to identity with Buddhist traditions and rituals. There were 21 participants, including 2 Directors of the Pollution Control Department, 1 Deputy Permanent Secretary of Bangkok (Responsible for the environment), 1 Former Permanent Secretary of the Ministry of Resources and Environment, 3 dioxin measurement experts, 2 people from the Office of Buddhism, 2 crematorium design supervisors, and 12 community representatives from Pathum Thani Province. The 'Development Model of Prototype Buddhist Crematorium for Urban Community' promoted the drive towards the development of Crematorium 4.0, a crematorium with at least two burning chambers and capable of attaching a GAIA (Vimutti) sprayer. The first burning chamber was the cremation chamber, and the final burning chamber was for the gas and smoke generated by the first burning chamber before ventilating the waste into the atmosphere.
2. The in-depth interviews were conducted using a structured interview format, which involved using a prepared interview plan and providing interview administration in advance. This ensured that the interviews were conducted with formal operational characteristics. The participants, which included 9 Monks or religious leaders, 10 Academics/Directors, and 5 community leaders/Undertakers, were asked the same set of questions, in the same order. The interview form was divided into two parts: Part 1 consisted of personal information, such as name, alias/surname, address, position, affiliation, and telephone number. Part 2 included questions related to the 'Development Model of Prototype Buddhist Crematorium for Urban Community,' which covered topics such as pollution generated by temple cremation, development and experimentation of Vimutti substance in

cremation, analysis of pollution control results using Vimutti substances, and what form of cremation could control poisoning, among others.

3. Focus group discussion 'Development Model of Prototype Buddhist Crematorium for Urban Community' in research operations, group discussions were another tool used to gather information from group conversations with a group of informants on a specific issue by a moderator to point out the discussion, to persuade the panellists to come up with ideas and comment on issues or approaches to the discussion in a broad and detailed manner. Participants included 10 monks or religious leaders, scholars, crematorium management (undertakers) and 10 community representatives selected from a given target population, or as a group discussion suitable for a variety of purposeful studies, such as finding issues of a particular subject that had no prior knowledge (Exploratory), finding explanations for certain phenomena (Explanatory), and situation assessment (Assessment), etc.

Results and Discussion

The results of the study on the pollution generated by the cremation at the temple's bodies such as coffins with Thepphanom pattern, clothing, personal belongings, etc. And during a period of about 20 to 30 minutes, it was time during various types of pollution.

The air especially in Bangkok and the metropolitan area, was contaminated with fine particulate matter (PM 2.5), dioxins and furans, which is dangerous to humans, pets, plants, and food chain systems. This is consistent with research reports by Wang and others (Wang *et al*., 2003), who studied the characteristics of dioxin and polychlorinated dibenzo-p-dioxins and furans (PCDD/F) emissions from crematoriums by conducting experiments on two crematoriums. The first furnace was not equipped with an air filter, and the second furnace was equipped with an air filter. The results showed that the PCDD/F emitted from the first and second furnaces were 2.36 and 0.322 ng I-TEQ Nm^{-3}, respectively. This indicates that the removal efficiency of PCDD/F filters was 55.1%. Additionally, Passornsiri (2003) found that pollution caused by incomplete combustion would cause soot to be released through the crater due to the decomposition of fat from the corpse and elements contained in the crematorium, such as coffins with Thepphanom pattern, clothing, personal belongings, etc. During a period of about 20 to 30 minutes, various types of pollution were released.

The problem of pollution from the crematorium of the temple was that it was caused by faith and rituals, which occurred due to incomplete combustion, according to the research report by Pattarapremcharoen (Pattarapremcharoen, 2019). This was caused by incomplete combustion, which is a limitation of crematoriums that cannot provide a sufficiently high temperature to complete combustion, leading to impurities being present in the air for a long period of time and causing damage to people's health, animals, plants, and the environment. Dust, carbon monoxide, sulfur oxides, and nitrogen oxides are formed, and dioxins are ranked as a class 1 carcinogen by the World Health Organization (Maher & Ford, 2017; Bull *et al*., 2020).

Developed crematoriums and Vimutti sprayers in cremation.

The development and trial of Vimutti substances to control dioxins, furans, and odours from organic decomposition in corpses involves the following procedures: Step 1 involves studying the pollution caused by crematoriums, Step 2 involves exploring the area around crematoriums, Step 3 involves exploring and cleaning the crematoriums' crater, Step 4 involves obtaining permission and cooperation from the deceased relatives, Step 5 involves placing the Vimutti boxes before cremation by the planning team, and Step 6 involves showing a simulated image of the placement of Vimutti substances, the cremation

costs, and a Vimutti sprayer. The sprayer has six nozzles, a 15.8 mm pipe size, an air density of 1,200 g/m^3, a minimum wind speed of 7,620 mm/s, an airflow rate of 1,493,271.588 mm^3/sec, and uses a 2-bar air pump. The air delivery rate is 54 mm/hr., the pressure loss is 144.4752, the roughness ratio to pipe diameter is 0.00633, and the friction factor (Moody's chart) (f) is 0.035. The development and trial of Vimutti substances are shown in Figure 1 and Figure 2.

The Ministry of Natural Resources and Environment (MNRE) designated the crematorium as a source of pollution, and it was necessary to control the discharge of polluted air into the environment. In line with the development of crematoriums and appropriate practices, whenever problems are encountered, they should modify or develop innovative crematoriums and agree to reduce the number of materials put in coffins before cremation. The innovation of dual combustion chamber crematoriums, which can ensure complete combustion (Jaroenpanich, 2001), should also be accepted to eliminate dioxins and furans. It is important to clarify these issues to the public and promote awareness campaigns to raise awareness of the dangers of these toxins (Soonthonwaritthichod, 2013).

The development of crematoriums and Vimutti sprayers for cremation is a new type of cremation innovation that can reduce the release of dioxins and furans, which is consistent with research reports (Hua & Wang, 2015). Dioxin release is a global concern due to its residue and persistence in the environment and its carcinogenic effects, including mutations. It

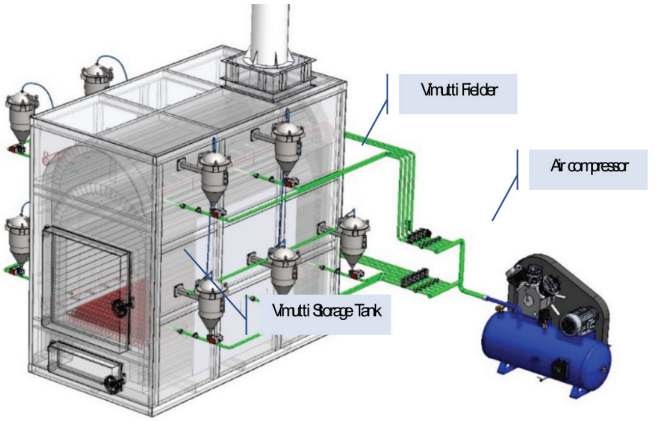

Figure 1: A model of the operation system of Vimutti sprayers and a prototype crematorium to experiment with Vimutti substances in cremation

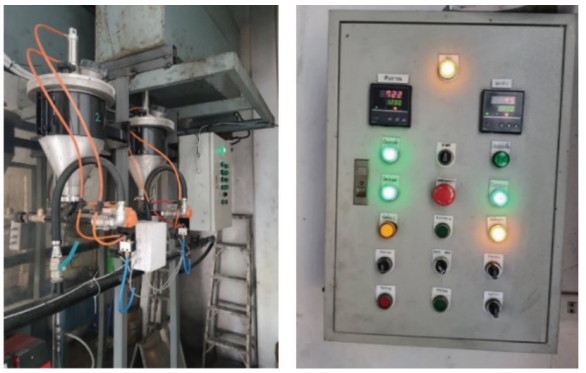

Figure 2: The operation system of Vimutti sprayers and prototype crematoriums to experiment with Vimutti substances in cremation

is a hazardous substance that is considered a Class 1 hazardous substance, with the highest level of toxicity and carcinogenicity. It affects human health and genetics and is a substance that is difficult to decompose (Larson *et al*., 2013). The focus of this research is on pollution and its relationship with the attitudes of people toward natural habitats and the importance we place on the environment (Choo-in, 2010). The problem of air pollution is that it is a challenge that requires the participation of all parties (Charoenpokaraj, 2011) in order to solve it.

The application of scientific knowledge has brought practical benefits by managing toxins such as dioxins and furans. Stakeholders in temple funerals, including monks, crematorium workers, relatives of deceased persons, and people living in communities near the temple, have become aware of the problem of pollution caused by cremation and the approach to solving the working mechanisms of traditional crematoriums, which are highly prone to pollution (Viboon-uthai, 2011). This was achieved by developing a two-chamber crematorium, consisting of the structure outside the 2-chamber crematorium and the main and secondary cremation chambers (Sumsiriphet, 2012). The problem of air pollution caused by the funeral furnace was a matter for the temple to find a solution to (Yenjai, 2008).

Analysis of experiments and pollution control using Vimutti substances

According to pollution control experiments, the use of Vimutti substances in cremation showed that dioxins and furans were not detected, provided that the heat controls were above 850°C, for more than 2 seconds, while the air was circulating. Experiments were conducted using Vimutti substances in cremation to measure the amount of soot, air pollution, and dioxin and furans, which are carcinogens caused by incomplete combustion. These experiments were conducted at Wat Dan Samrong, Muang District, Samut Prakan Province. The experiment was conducted as follows:

Phase 1 involved experimenting with and controlling pollution using Vimutti substances. It was necessary to analyze the results to inhibit the occurrence of toxins such as dioxins and furans and, and reduce their emissions, as shown in Table 1. Figure 3 demonstrates how to apply the Vimutti substance in a blanket pattern.

Phase 2 involved the trial of smart crematoriums and Vimutti sprayers. After the development and installation of Vimutti sprayers in a smart crematorium, the experiment was conducted twice. The results of the dioxin and furans analysis of air samples discharged from the crater of Wat Phirunsart crematorium were as follows:

Example 1 collected data from the first 30 minutes of cremation, which began at the start of the cremation and continued until the coffin containing the corpse was fully cremated. The total concentration of PCDDs + PCDFs was 0.00474 ng/I - TEQ/m^3, measured at 1 atmospheric pressure, 25°C and a dry basis, with 50% excess air or 7% oxygen volume.

Example 2 collected data from the last 30 minutes of the cremation process. Once the first

Table 1: Experimental results

Items	Vimutti Substances	Experimental Results	Legally Required Values (0.5 ng I-TEQ/Nm3)
Corpse 1: Male	No substance was added.	1.07	Exceed the standard
Corpse 2: Female	Put a gold box of Vimutti.	0.301	Lower than standard
Corpse 3: Male	Put the Vimutti substance in a blanket pattern.	0.07445	Lower than standard
Corpse 4: Male	Put the Vimutti substance in a blanket pattern.	0.0582	Lower than standard

Figure 3: The Vimutti substance pattern simulates the placement of the substance within a blanket covering the corpse, containing the Vimutti substance inside

Figure 4: Collecting the air samples from the crater of Wat Phirunsart cremation

sample was collected, the GFF Filter and XAD-2 Trap were replaced, and the second sample was collected after the coffin was broken until the burning was complete. The total concentration of PCDDs + PCDFs was less than 0.00501 ng/I - TEQ/m3, measured at 1 atmospheric pressure, 25°C and a dry basis, with 50% excess air or 7% oxygen volume.

The results of Phase 1 trial showed that pollution control by Vimutti substances effectively inhibited the occurrence of toxins such as dioxins and furans and reduced their emission. In Phase 2, trials of smart crematoriums and Vimutti sprayers were conducted. After developing and installing Vimutti sprayers in smart crematoriums, two trials were conducted on air samples discharged from the crater of Wat Phirunsart crematoriums in Pathum Thani Province (Badge *et al*., 2016). The findings were consistent with research reports on dioxin contamination conditions (Sun *et al.*, 2014), such as those observed in Vietnam during the 1960s and 1970s due to the use of fiberboard-made coffins (Fiedler, 1996). Dioxins, formed as a result of incomplete combustion, are toxic and carcinogenic, and their release into the atmosphere poses a risk to human health, affecting the reproductive and immune systems of the human body. Bethea (1978) studied the causes of dioxins from the use of fiberboard-made coffins, which were found to be only slightly more likely to cause dioxin emissions than hardwood coffins.

The results of the study suggest that the temple should also have a policy or a process of communicating with the deceased relatives or society to raise awareness of the reasons and pollution caused by each cremation. These rituals are essential elements of the funeral and cannot be neglected as they are an integral part of Buddhist belief and faith, and the funeral arrangements indicate the status of the deceased.

Recommendations

Policy proposals

1. Agencies involved in cremation development should undertake research and development of crematoriums that can help reduce air pollution, which will have a positive impact on society.
2. Relevant agencies should allocate budgets to promote the construction of pollution-free crematoriums and address air pollution in the community.

Recommendations for further research

1. The environment affecting the success of the research project should be studied in order to reflect the results of the research study in the preparation of appropriate policy proposals that are worthwhile for the people in a sustainable manner.
2. Innovations in cremation should be developed to help reassure villagers living near the temple that they are free from the smell of cremation smoke and that the new method is environmentally friendly. Vimutti controlled substances or Vimutti sprayers do not endanger public health or pollute the environment.

Conclusion

After conducting this research on the development model of a prototype Buddhist crematorium for urban communities and incorporating the reviewer's recommendations, it can be concluded that the prototype Buddhist crematorium can bring about various benefits for the urban community. The study showed that the prototype crematorium can help preserve Buddhist culture, meet the growing demand for cremation services, and reduce the environmental impact of traditional crematoriums.

The main findings of the study indicated that the prototype crematorium should have modern and eco-friendly facilities, adhere to Buddhist beliefs and customs, and incorporate appropriate architectural designs. Additionally, it was found that the prototype crematorium should be accessible and easily reachable for the urban community.

The benefits and impacts of the prototype crematorium include facilitating the grieving process, providing an alternative to traditional burial methods, and promoting sustainable practices. The prototype crematorium can also create job opportunities, promote community involvement and support, and contribute to the local economy.

The implications for the future of the development model of prototype Buddhist crematorium for urban communities are significant. The study highlights the need for further research and development to refine the prototype model and make it suitable for other communities with different cultural and religious backgrounds. Moreover, the development of such models can set an example for other communities to adopt eco-friendly and sustainable practices in various areas of their lives.

In conclusion, the development model of a prototype Buddhist crematorium for urban communities has the potential to meet the growing demand for cremation services, promote sustainable practices, and preserve cultural and religious values. The findings of this study can be used as a framework for further research and development and can serve as a guide for communities seeking to implement eco-friendly and sustainable practices. The summary is the knowledge gained from the research which is shown in Figure 5.

Dioxins and furans decompose with heat, at a temperature 850°C. They enter the human body through inhalation of air or impurities present in food.

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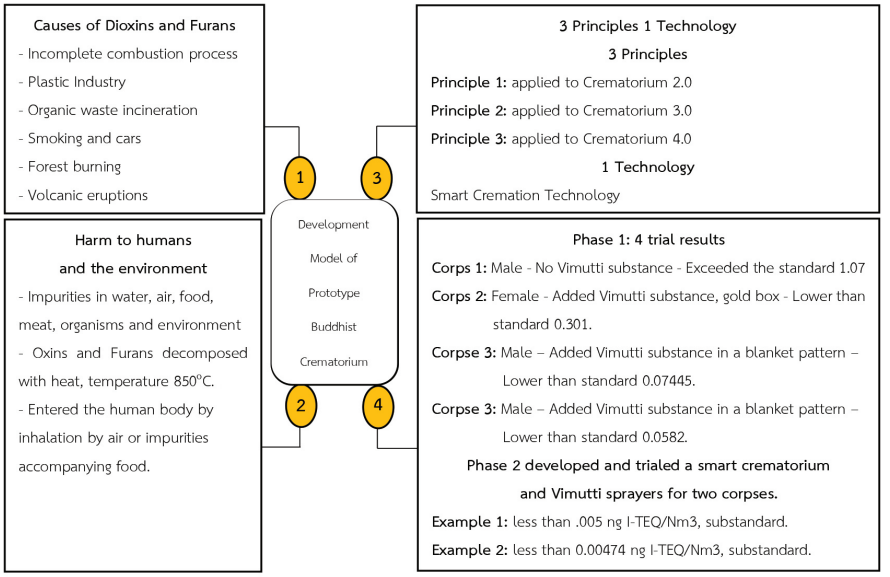

Figure 5: Knowledge from the research

Crematorium to Reduce Carcinogenic Content.' This was accomplished with the support and courtesy of government agencies, including the Pollution Control Department and the Office of the Permanent Secretary in Bangkok, as well as the National Office of Buddhism. We would like to express our gratitude to all the luminaries who attended the seminar on January 18, 2022, and the Director of the Buddhist Research Institute at Mahachulalongkornrajavidyalaya University for their collaboration. We would also like to thank the Science, Research and Innovation Promotion Fund for approving the research budget grant, as well as for providing knowledge, advice, and academic contributions to use the research results for the development of the national society.

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