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Fuel Consumption Investigation for Quran Disposal Incinerator System

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Abstract
In this study, the fuel consumption characteristic of a Quran incineration system was conducted. The experiment examines the relation between fuel usage and Quran loads as well as how the usage of blower affects the fuel utilization. The result proved that the blower unit shortens the combustion time and uses less fuel. Nevertheless, the electrical source to power the blower will increase the operating costs, especially during full loading operation. Therefore, this study will provide insight in determining the balance between the combustion duration over the operational costing of such a system.

Keywords: Quran Incinerator; Fuel Consumption; Disposal System; Environmental Effect.

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1.0 Introduction

In Islam, the Quran is regarded as a holy book that guides believers in living their lives in this transient world and contains their prayers. Due to its sacrednature, the Quran must always be respected when it is being read and when it cannot be used due to damage or poor state (Ab Gani & Ahmad, 2019). Therefore, Islamic scholars have debated this matter and concluded that burning unwanted Quran copies is one of the most revered methods. The Quran manuscript's traditional open-burning method is less efficient, and the ash that results from it is nearly hard to control and potentially harmful to the environment. Researchers have worked hard to develop specialised systems that can perform the Quran-burning process in a more efficient and controlled manner in order to overcome this issue. The system, which is based on the idea of an incinerator, has been developed to carry out a combustion process to burn Quran unused or damaged manuscripts at high temperatures, often between 700-1200 degrees Celsius.

Considering the recent rise in the number of sudden and unpredictable floods that have taken place in Malaysia, it is of the utmost importance that efforts be made to come up with an efficient way to manage the burning process of the Quran while adhering to the processes outlined in sharia law. Flash floods have been increasing in frequency because of many factors, including an inadequate drainage system, aside from inconsistent climate issues experienced globally. Among the objects that have been damaged, certain manuscripts of the Quran have been ruined, and these need to be handled in the most respected manner possible. The effort being made to oversee the disposal of the Quran will become more organised and methodical once this unique incineration technology is implemented. The recent rise in the number of sudden and unpredictable floods that have taken place in Malaysia, it is of the utmost importance that efforts be made to come up with an efficient way to manage the burning proses of the Quran while adhering to the processes outlined in sharia law. The occurrence of flash floods has been increasing in frequency because of a number of factors including an inadequate drainage system aside from inconsistence climates issue experienced globally. Among the objects that have been damaged, there have been certain manuscripts of the Quran that have been ruined, and these need to be handled with in the most respected manner possible. The effort that is being made to oversee the disposal of the Quran will become more organized and methodical once this unique incineration technology is put into place.

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Previously, incinerator technology was widely utilised for disposing of a wide range of materials such as medical, hazardous, municipal solid, and industrial waste (Baharun et al., 2005). Therefore, utilising incinerator technology to burn the Quran, which is based on material made from paper, is relatively not difficult. This is because the capability and performance of the incinerator are known to be affected by numerous elements and factors based on the configuration and kind of energy used to consume the waste rather than the material itself. Although the newly developed incinerator has successfully proven its function to burn the Quran, its operating performance has not been properly characterised, particularly in determining the relationship between fuel consumption and the system's combustion characteristics. In addition, limited studies examine the impact of using a blower unit as part of a similar incinerator combustion process, especially on the dedicated system to burn Quran manuscripts. Even though blower capability is generally regarded as a superior alternative because it increases the efficiency of the combustion process, it requires additional energy supply in the form of electricity to operate, which will incur additional operational costs.

Therefore, utilizing incenerator technology to burn Quran which its based material was made from paper is relatively not difficult. This is because the capability and performance of the incenerator is known to be affected by numerous elements and factors based on the configuration and kind of energy used to consume the waste rather than the based material iteself. Despite the newly developed incinerator has susccesfully proven its function to burn the Quran but the its operating performance has not been properly characterized, particularly in terms of determining the relationship between fuel consumption and the system's combustion characteristics.In addition, there are also limited studies that examine the impact of using blower unit as part of the similar incinerator combustion process especially on dedicated system to burn Quran manuscripts. Even though blower capability is generally regarded as a superior alternative because it increases the efficiency of the combustion process, it requires additional energy supply in the form of electricity to operate, which will incur additional operational costs.

Without a good understanding of the fuel consumption characteristic of the Quran incinerator system, the projection on the operational cost of the system is relative to the amount of Quran that needs to be disposed . This is a very important aspect, especially for the organisation or the system owner, to define how much budget they need to allocate to run the system in a specific timeframe. Therefore, the purpose of this study is to characterise the fuel consumption of the Quran incinerator system in order to determine the operation cost of the system. The specific objective is to investigate the rate of fuel needed to burn different weights of Quran and how the blower unit will affect this relationship, which eventually will directly impact the system's operational cost. Once the fuel consumption characteristic has been determined, the proper planning of incinerator usage can be established to support the overall management of the system, especially when the system needs to be operated at full capacity.

2.0 Literature Review

Incineration method referred as a waste treatment method that entails the combustion of natural substances found in waste products until it become ashes (Abushammala et al., 2022; Sun et al., 2023). Incineration has been broadly utilized for waste disposal method because it allows for significant waste mass reduction and recovery of energy (Ghasemi et al., 2023; Tuan Habib & Saad, 2009). Incineration entails producing ash, flue gas, and heat from the waste. The ash is mostly composed of inorganic waste components and can take the form of lumps or particulates that the flue gas carried. Before being released, flue gases are presumed to be cleaned from any contaminants. In simplest description, incinerator is a container designed to burn waste. This is accomplished by reducing the waste to bottom ash by extremely high temperature combustion (Li et al., 2022; Qin et al., 2022). In order to contain the combustion heat, the furnace must be constructed with well-insulated strong materials (Nabavi-Pelesaraei et al., 2017). There are a few factors that considered important to enhance performance of the incinerator, such as practical aspects, characterization of the waste, volume of moisture, and the lower heating value (Huang & Marefati, 2023).The incinerator must have operating systems that is optimal for the combustion process. Previous study suggests that incinerator's flawed design and ineffective system lead to unsuccessful usage of incinerator (He et al., 2023*)*. A poorly designed incinerator can hinder steady and ideal combustion process. The size of the combustion chamber is crucial in terms of temperature, turbulence, and time. If the amount of waste exceeds the size of the chamber, temperature will be higher which can lead to insufficient oxygen supply and increased number of unburnt contaminants. If the waste is too small, temperature will be lower resulting to incomplete combustion (Chen et al., 2022; Simanjuntak et al., 2022).The combustion chamber walls were built with materials that can withstand minimum temperature of 1300 ˚C (Manyele et al., 2011). Mostly, incineration method helps reduce the weight of the waste about 75% to 90% depending on the density and composition of the waste (Baharun et al., 2005; Manyele & Kagonji, 2012).

Fuel consumption is one of the main factors that can affect the incinerator performance. Fuel consumption of the system can be high for several reasons such as high moisture content of the waste, excess air from the wall's leakage, and no adequate control of 3T (temperature, time, turbulence) (Wu et al., 2022). The water from the wet waste needs to be evaporated first before volatilization can take place. If heat from the waste is not released, auxiliary burner must support by providing extra energy required, resulting in high fuel consumption (Manyele & Kagonji, 2012). Too much excess air can cause the temperature of the flame to drop (Li et al., 2022), means that less heat enters the system. Furthermore, excess air must be heated to temperature of the flue gas, which requires more energy, leading to higher fuel consumption. Reducing cycle time of the incineration and limiting the moisture content of the waste can help in minimizing fuel consumption. Low fuel consumption can lead to higher fuel effectiveness of the system (Matee & Manyele, 2015). While (Hassan et al., 2015) never claimed the effective level of their Quran incinerator system, they reported that for the maximum 2 Kg capacity, they require 60 minutes of burning time with the total fuel consumption of 1.1 Kg. All these finding suggest that the relation between fuel consumption to the burning parameters needs to be investigated to ensure the accuracy of fuel consumption calculation depends on different capacity of the incinerator design. Therefore, this research aimed to determine the characteristics of the rate of

fuel consumption involving various parameters by investigating the correlation between fuel consumption of the system and parameters involved from experiments and deliberate fuel consumption rate characteristics that relative to the incinerator's burning capacity.

3.0 Methodology

3.1 Incinerator Concept Description

Figure 1 shows the photo of the incinerator that was used for this research. The main structure of the equipment was made of steel and weight about 50 kg. but the heavy-duty castor wheel been attached at the bottom of the body, this incinerator unit can be maneuver easily for ease of movement. The core component of this system, which is the combustion chamber, has a dimension of 1000mm × 500mm × 340mm. A hollow pipe with 355mm length and 68 mm diameter was installed at the side of the incinerator as the inlet for fuel source. In the early design of the chamber, the inner wall material was not focused that much which caused effective transfer issue. Due to this issue, an additional layer of cement has been plastered on the surface to effectively contain the heat within the chamber. A similar issue was observed on the top cover of the incinerator and by applying thicker cement material, the heat resistance capability is increased and becomes a better insulator layer to prevent the combustion heat from transfer to the environment.

Fig. 1: Image of Quran Incinerator System (*source: Politeknik Sultan Ahmad Shah*)

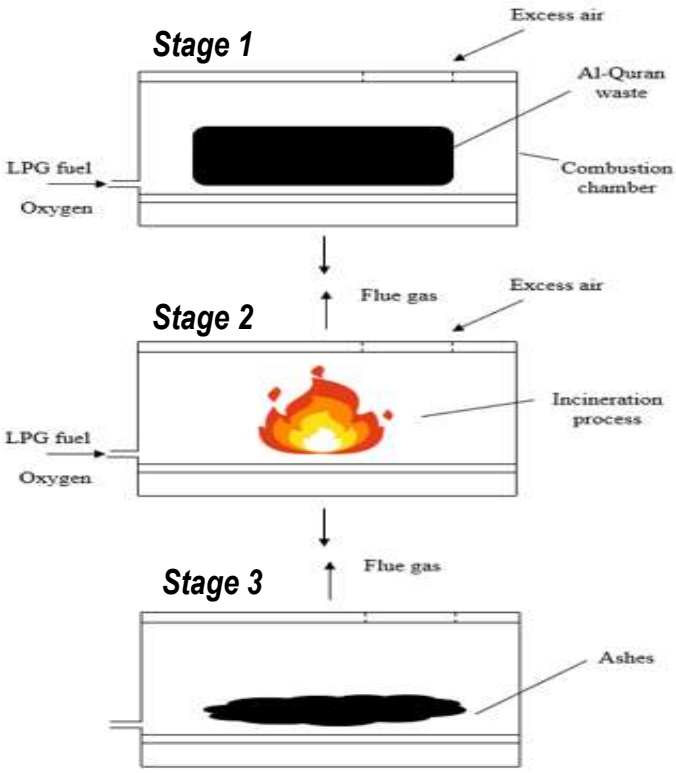

Fig. 2: simplified burning operation

The simplified burning operation of the disposed Quran incinerator is depicted in Figure 2. In the first stage, the disposed material was placed in the centre of the incinerator before the mix of liquid petroleum Gas (LPG) fuel and Oxygen was allowed to flow into the chamber. Once the fuel ignites, the Quran will be caught by fire, and the burning process of the documents will happen inside the chamber (stage 2) until it completely turns into ash in stage 3. This process has been repeated according to the prepared matric according to the variable under study until all the required data is collected for analysis.

3.2 Experiment Setup

Figure 3 shows the complete setup that was used for the experiment. The experiments have been divided into two (2) groups of setups, that is, without using a blower unit and with a blower unit usage. The responses recorded from the variation of parameters in terms of combustion time and fuel rate will be consistent for both groups of the experiment. The LPG fuel tank was weighed using a scale to determine the original weight before starting the experiment. For the combustion process, a dedicated nozzle that functions as the point for the LPG fuel mixed with Oxygen is directed inside the chamber. In stage 1, Quran waste was positioned inside the chamber before the fuel was ignited at the tip of the nozzle. The experiment started with incinerating the maximum load of waste of 25 kg.

During the experiment, the temperature was taken with an infrared thermometer. The average temperature was recorded on one complete combustion process by 5 minute time-interval until the combustion process was completed. This was determined by observing whether the Quran waste transformed into lightweight whitish ashes from its original nature and form. The time taken for the complete combustion process was taken with a stopwatch. After the experiment, the LPG tank was weighed again to determine the new weight to compute the usage. The experiment was repeated with different weights of the waste, 15kg and 5kg respectively. Once the first cycle of burning the waste with purely LPG fuel was completed, a similar experiment was repeated by adding a blower for the combustion process.

Fig. 3: The Experimental Setup of Actual Burning Process

3.3 Calculation

The following formula can be used to determine the fuel effectiveness of the system:

$$\text{Fuel Effectiveness } \left(\frac{kg}{L}\right) = \frac{W}{x(W_1 - W_0)} \quad (1)$$

Where W_0 and W_1 are the weight of the fuel tank before experiment, and the weight of the fuel tank after experiment, respectively. W represent the load of the waste. The difference between both initial and final weight of the fuel tank must be converted into litre. Value of x can be determined by using the formula:

$$1 \text{ kg LPG fuel} = 1.96 \text{ L LPG fuel} \quad (2)$$

To determine electrical consumption that was used for the experiment (blower), the following formula was used:

$$\text{Electrical consumption (kWh)} = P \times T \quad (3)$$

The current experimental procedure was conducted with the assumption that the waste were identical for all sets of experiment but in actual, there is possibility that the waste condition may varies in terms of moisture level and types of paper which can have some effects to the incinerator burning performance.

4.0 Result and Discussion

The fuel consumption of the incineration was investigated by taking the weight of the LPG fuel before and after experiment. The duration of the incineration process from beginning until it reached complete combustion condition was recorded by stopwatch. The experiment

started without using a blower for the incineration process (full fuel gas consumption) then followed by incineration process with a blower (fuel gas with electrical consumption). Table 1 and Table 2 show the tabulation of the data for both experiments.

Table 1. Data Tabulation of the Incineration Process Without Blower Setup

Temperature: 445 ˚C		
Load of the waste (kg)	Time for complete combustion process (minutes)	Total fuel consumed (L)
5	35	2.783
15	115	8.977
25	180	15.896

Table 2. Data Tabulation of the Incineration Process with Blower Setup

Temperature: 610 ˚C		
Load of the waste (kg)	Time for complete combustion process (minutes)	Total fuel consumed (L)
5	10	0.843
15	25	1.803
25	40	2.685

The first comparison that can be made was on the combustion temperature between the two experimental setups. The usage of blower unit significantly increases the temperature from 445 ˚C to 610 ˚C. When the blower turned on, it forces air from surrounding into the combustion chamber at a higher velocity than natural air flow. This will increase the amount of oxygen availability for combustion which generate more heat hence increase the temperature inside the chamber. At the same time, the blower also create turbulence inside the chamber which allow the better mixture of oxygen and fuel thoroughly that contributes to more complete combustion and higher temperature.

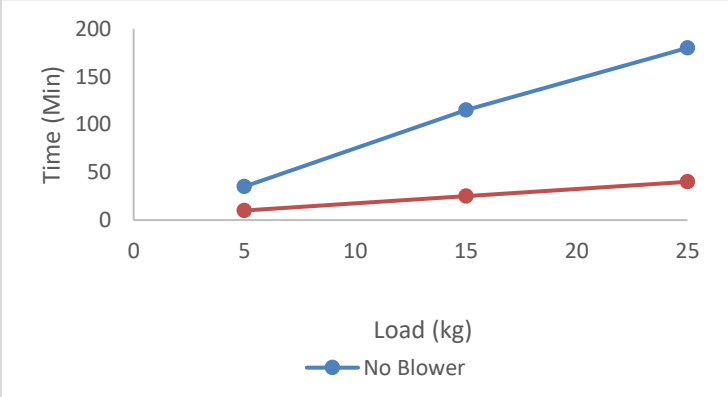

Fig. 4: Effect of Blower to Incinerator Combustion Time

This is in agreement with research by (Ketlogetswe et al., 2004) where they conclude the significant effect of blower on their incinerator system used for medical waste combustion. They found out that when the blower is not functioning, the incinerator experienced fluctuation of internal temperature during the ignition stage. They relate this phenomenon to the difficulty of achieving a uniform spread of flame because of the consistent flow of oxygen mixture was not supplied when the blower is off. Figure 4 represent the time taken to complete the burning of different loads. The incinerator took about 40 min to burn 25 kg loads when using blower compared to 180 min when blower was not use with the same load which is almost 4.5 times longer. This variation of burning completion between the two set-ups however is become less as the loads reduced to 15kg and 5 kg respectively.

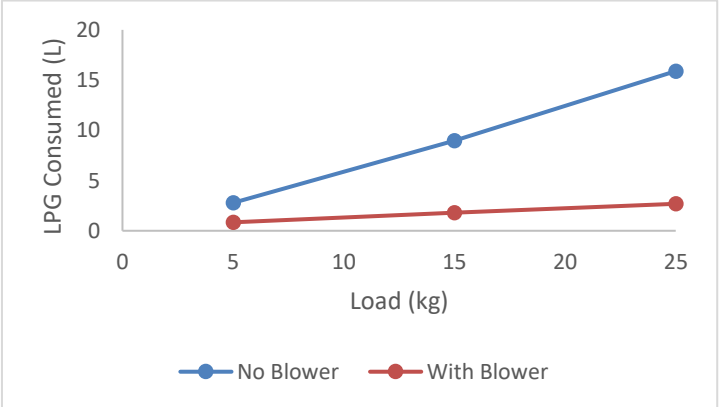

Fig. 5: Effect of Blower to Incinerator Fuel Consumption

The blower also significantly creates high impact the to the fuel consumption as shown in Figure 5. When burning 25 kg of load, only 2.6 L of LPG used to complete the burning but without blower unit, the LPG consumption recorded was at almost 16 L or about 6 times more. This is because when the burning is only depended on LPG, it requires more times to get the documents completely burn as the operational temperature is only 445 ˚C as compared to 610 ˚C when the blower is used. It was also observed that even though the fuel consumption and the load positively correlated for both setup as shown in Figure 5, the stiffness of without blower trend line is more compares to trend line with blower data. This suggest a very strong correlation between fuel composition and loading amount if the blower was not included in the operation. Meanwhile when the incinerator operates with the blower, the loading amount have less impact to the fuel consumption. For example, the rate to combust 5 kg of loading without using the blower is about 2.7 L/kg and for 25 kg loading, the rate recorded at ~ 16 L/kg. With blower, the rate at 5 kg is at just about 1 L/kg less but at 25 kg load, the different is very significant with not more than 3 L/kg rate or bout five (5) times lower consumption if compared to without blower. This huge different of fuel consumption rate is evident that the blower unit significantly reduced the usage of fuel due to fact that the blower unit improve streaming of oxygen drives hence improve the combustion efficiency. This condition helps to maintain a high temperature to ensure complete combustion resulting in more heat generated per unit of fuel.

5.0 Conclusion and Recommendation

In this research, a system specification for Quran disposal incinerator was analysed to develop the system's capability and performance baseline. During running this investigation, a system specification for a Quran disposal incinerator was dissected in order to establish a baseline for the system's capability and performance. The efficiency of the fuel and the burning rate were evaluated using experimental data acquired from tests that were tried with various kinds of loads and conditions of fuel consumption. When the blower is utilised, the results indicate that the incinerator can finish the combustion process much more quickly while consuming a significantly lesser amount of fuel. However, given that the blower itself utilised the electrical source, it is necessary to consider the overall cost of operation. This is due to the fact that the additional electrical power utilised might necessitate an increased cost for the electricity bills, particularly given the extended use of the incinerator. As a result, additional cost verification with the utilisation of the blower needs to be investigated to guarantee that the practicability and cost of operating the incinerator for Quran waste is set at its optimum level.

A similar flow of experiments also can be replicated with a focus on the effect of waste moisture level conditions on fuel consumption. In the current work, the moisture level on the waste was not measured; hence, no correlation between moisture levels can be established. Theoretically, if the water content of the waste is high, it requires extra combustion duration to evaporate the water compared to low water content material, which means the fuel usage also will be increased . Research on incinerators should also continue so that more functions may be added that make it possible to operate and maintain them, which will further contribute to the reduction of air pollution and improvement of environmental protection. For example, a wet scrubber system can be installed at the gas outlet area. The scrubber should remove unwanted particulate matter by capturing them in liquid droplets and, at the same time, absorbing the pollutant gases. In addition to this, it was recommended that the system be improved by the creation of an energy recovery system that could function as a closed loop to provide power to the blower unit on its own. This will eventually contribute to the construction of a Quran disposal incineration system that is exceedingly efficient, cost-effective, and sustainable.

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References

Abushammala, M. F., Qazi, W. A., Frrag, S., Alazaiza, M. Y., & Younes, M. K. (2022). Site selection of municipal solid waste incineration plant using GIS and multicriteria decision analysis. Journal of the Air & Waste Management Association, 72(9), 1027–1039.

Baharun, S., Adnan, R., Mohamad, I., Arshad, K. A., Ahmad, T., & Rashid, M. (2005). Variables affecting the combustion efficiency of a clinical waste incineration process. Jurnal Teknologi, 42, 11–24.

Chen, H., Li, J., Li, T., Xu, G., Jin, X., Wang, M., & Liu, T. (2022). Performance assessment of a novel medical-waste-to-energy design based on plasma gasification and integrated with a municipal solid waste incineration plant. Energy, 245, 123156.

Ghasemi, M., Rajabi, M., & Aghakhani, S. (2023). Towards sustainability: The effect of industries on CO2 emissions. Journal of Future Sustainability, 3(2), 107–118.

Hassan, R., Azmi, H., Bakri, I. M. I., & Abd Wahab, M. N. (2015). DESIGN AND DEVELOPMENT OF USED AL-QURAN PAPER DISPOSAL SYSTEM. Jurnal Teknologi, 76(6).

He, X., Xu, M., Cui, C., Xia, B., Ke, Y., Skitmore, M., & Liu, Y. (2023). Evaluating the social license to operate of waste-to-energy incineration projects: A case study from the Yangtze River Delta of China. Journal of Cleaner Production, 135966.

Huang, W., & Marefati, M. (2023). Development, exergoeconomic assessment and optimization of a novel municipal solid waste-incineration and solar thermal energy based integrated power plant: An effort to improve the performance of the power plant. Process Safety and Environmental Protection.

Ketlogetswe, C., Oladiran, M. T., & Foster, J. (2004). Improved combustion processes in medical wastes incinerators for rural applications. African Journal of Science and Technology, 5(1).

Li, Y., Feng, D., Bai, C., Sun, S., Zhang, Y., Zhao, Y., Li, Y., Zhang, F., Chang, G., & Qin, Y. (2022). Thermal synergistic treatment of municipal solid waste incineration (MSWI) fly ash and fluxing agent in specific situation: Melting characteristics, leaching characteristics of heavy metals. Fuel Processing Technology, 233, 107311.

Liu, H., Qiao, H., Liu, S., Wei, G., Zhao, H., Li, K., & Weng, F. (2023). Energy, environment and economy assessment of sewage sludge incineration technologies in China. Energy, 264, 126294.

Manyele, S. V., & Kagonji, I. S. (2012). Analysis of Medical Waste Incinerator Performance Based on Fuel Consumption and Incineration Cycle Times. Engineering, 4, 625-635.

Manyele, S. V., Kagonji, I. S., & Mrisho, J. (2011). Assessment of medical waste incinerator performance based on physical characteristics of ashes. Engineering, 3(10), 1045.

Matee, V. E., & Manyele, S. V. (2015). Performance of a large-scale medical waste incinerator in a referral hospital. Engineering, 7(10), 676.

Nabavi-Pelesaraei, A., Bayat, R., Hosseinzadeh-Bandbafha, H., Afrasyabi, H., & Chau, K. (2017). Modeling of energy consumption and environmental life cycle assessment for incineration and landfill systems of municipal solid waste management-A case study in Tehran Metropolis of Iran. Journal of Cleaner Production, 148, 427–440.

Qin, J., Zhang, Y., Heberlein, S., Lisak, G., & Yi, Y. (2022). Characterization and comparison of gasification and incineration fly ashes generated from municipal solid waste in Singapore. Waste Management, 146, 44–52.

Simanjuntak, J. P., Daryanto, E., & Tambunan, B. H. (2022). An operating parameter study of the biomass solid feedstock incinerator of fixed-bed type with two stage air supply. Journal of Physics: Conference Series, 2193(1), 012077.

Sun, C., Wang, Z., Yang, Y., Wang, M., Jing, X., Li, G., Yan, J., Zhao, L., Nie, L., & Wang, Y. (2023). Characteristics, secondary transformation and odor activity evaluation of VOCs emitted from municipal solid waste incineration power plant. Journal of Environmental Management, 326, 116703.

Sharifah, A. S., Abidin, H. Z., Sulaiman, M. R., Khoo, K. H., & Ali, H. (2008). Combustion characteristics of Malaysian municipal solid waste and predictions of air flow in a rotary kiln incinerator. Journal of Material Cycles and Waste Management, 10, 116–123.