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WASTE TO ENERGY: ITS VIABILITY AND IMPACT ON HEALTH, ENVIRONMENT, AND ECONOMY

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By

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APPROVAL SHEET

In partial fulfillment of the requirements in Practical Research 2, this study entitled **WASTE TO ENERGY: ITS VIABILITY AND IMPACT ON HEALTH, ENVIRONMENT, AND ECONOMY** prepared and submitted by Jestha Hanna Rabang, Jannel Destrajo, Kimberly Marie Nisnea, Vincent Jay Manalili, and Ruzz Yuri Obenza is hereby recommended for oral examination, approval and acceptance.

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ABSTRACT

Waste-to-energy (WTE) is a critical component of a waste management system. WTE will contribute to the development of a low-carbon society from the standpoint of the energy system. It includes the pollution and particulates it produces, the destruction of useful materials, and the potential to deter more sustainable waste management solutions and renewable energy sources. This quantitative content analysis study aimed to know the viability of waste to energy predicating on its effect on environment, health and economy. Furthermore, with the use of a unit of analysis and sampling frame, the researchers were able to gather significant statements from different studies on the viability of establishing waste to energy facilities and the impact of incineration on health, environment, and economy. After organizing all the data, thematic analysis was done. There are four themes that emerged from the viability of establishing waste to energy facility which are: Cost, Efficient, Profitable, and Technological. The impact of incineration on health (IH) are health risks and health consequences. On environment (IE) are environmental consequence and pollutes. On economy returns (IE) are cost, profitable, efficient, and technological. In summation, the incineration process is found to be viable; however, it needs to be well-planned and well-designed in order to mitigate the resulting risks and impact considering the combustion process involved.

Keywords: Incineration, Impact on health, Environment, Economy, Viability

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INTRODUCTION

Background of the Study

Waste has become part of human lives. Everything that is consumed and created, waste is always the by-product. The Environmental Protection Energy reported that a person produces 2 kg of garbage a day, a total of 13 kg per week and 726 per year (Bocco, 2021). Thus, over 141 million metric tons of plastic packaging have been used and thrown since 2015 (Gooljar, 2018). Municipal solid waste such as household waste, non-hazardous waste, and construction waste are contained in landfill sites (UNISAN, 2020). As a matter of fact, ninety percent of the waste generated in Africa is disposed to land, either controlled or uncontrolled dumpsites (Godfrey et al., 2019).

Recently, overfilling landfills has become a burden for countries that are developed, underdeveloped (Khatib, 2011), and countries undergoing development (Ferronato, Torretta, 2019). In Australia, eighty four percent of the plastic waste in a year was sent to landfills (Paul's Rubbish, 2020). Serious cases of overfilling landfills have occurred in India which exceeded its landfill capacity since 2002 and the country still receives 2,000 tons of garbage each day. Further in China, the largest landfill which is designed to take 2,500 tons of waste per day receives 10,000 tons of waste per day (Jin, 2019), brimmed two decades ahead of schedule (Yan & Zhou, 2019). Furthermore, the capital city of Cambodia receives 800 to 1,475 tons of waste daily on its landfill and was said to be half full since 2014 (Denney, 2016). The same scenario also occurred in the Philippines, of which Zamboanga City had reached its landfill's full capacity (Go, 2018) along with Davao

City's landfill which reached its full capacity since 2016 as it reached 900,000 tons which are past its maximum capacity that is only 700,000-800,000 tons (Garay & Bernardo, 2020).

As a result, landfills drastically pose a danger to humans as well as to the environment and biodiversity as a whole. It makes people sick and contributes to climate change (UN Environment Program, 2020). It is similar to air pollution, as it expels methane during the decomposition of inorganic matter. In Thailand, four landfills emitted high spatial heterogeneity (Wangyao et al., 2010) and when mixed with carbon dioxide, it will deplete the amount of oxygen in the air or may cause global warming (Rossi, De-Giorgio, Grassi, Pascali, & Lancia, 2013). Toxic products coming from households and industries that are being landfilled cause groundwater pollution for it creates leaks and penetrates the soil until it reaches the waterways (Elbeshbishy & Okoye, 2019). It can start an outbreak of vector-borne diseases that can be transmitted by rodents and insects (Nathanson, 2020).

Thus, many countries are now practicing solid waste management to monitor and manage waste from collecting, recycling, and composting, particularly on establishing waste-to-energy facilities (Swamy, 2021). One of the important advantages of waste management is the resourcefulness to recycle and reuse the waste in a variety of ways (Netnews ledger, 2018). Waste incineration facilities are being built to produce electricity out of waste (Nicoll, 2017). Therefore, waste into energy is becoming a viable option in other countries (Jain, 2019) since it decreases solid waste on landfills by about eighty to eighty five percent (Marketing, 2020) and provides electricity to 1.2 million households (Kiger, 2018).

In order to adapt with the solid waste management, the Department of Environment and Natural Resources (DENR) in the Philippines, implemented RA 9003, or the Ecological Solid Waste Management Act that aims to establish and execute solid waste management and waste management programs in the most effective and environmentally friendly manner possible (DENR, 2019). Local Government Units (LGUs) are required by this legislation to develop their own local solid waste management plan as well as a system for reusing, recycling, and composting waste in their jurisdiction. Just 1,005 out of 1,634 LGUs have developed and practiced this law in the 20 years since it was established, with Davao City being one of them (Bagayas, 2020). The city planned and built greenhouses, sanitary landfill, environmental engagement, waste to energy plants, septage management program (Solid Waste Management, 2019), and mandating the Davao City ecological solid waste wherein the City Environment and Natural Resources Office (CENRO) collects both residual and special waste (CENRO's Environment & Waste Management, 2021).

Despite the fact that the city has adapted R.A. 9003, it is not yet well implemented and the volume of waste still continues to increase (Japan International Cooperation Agency, 2016) and "would lead to a further garbage disposal problem" (Cortez, 2019, para 7). Looking on the current situation of the City's landfill, there is a need to minimize the amount of waste being composted. The management of landfills costs a lot since garbage decomposition takes millions of years; effective strategies on maintaining it and facilities are required (Rinkesh, 2021). The city also includes WTE incineration from the 10- year solid waste management plan and is currently accepting incineration project proposal from both local and foreign investors (Banta, 2021).

However, the R.A. 8749 or the Philippine Clean Air Act, section 20 which was approved on June 23, 1999 bans incineration due to the concern of climate change thus, promoting the state-of-the-art, environmentally-sound and safe non-burn technologies for handling waste should be considered. Therefore, this study was conducted in order to assess whether waste to energy can be established predicating on its effect on the environment, health, and economy.

Statement of the Problem

The study aimed to know the viability of converting waste to energy as part of the waste management in Davao City. Particularly, it sought to answer the following questions:

1. To what extent is the viability of establishing waste to energy facility?
2. To what extent is the effect of incineration on:

    1.1 Health;

    1.2 Environment; and

    1.3 Economy

Review of Related Literature

This section contains the numerous studies and literature that are related to the current study that have been collected from various sources through a meticulous search. It also examines the views of other studies concerning the effects of waste, the impacts of incineration on the environment and economy, and the general concept of waste to energy.

Initiatives and Issues on Waste Management

The solid waste management issue is the biggest challenge to the authorities of both small and large cities in developing countries. This is mainly due to the increasing generation of such solid waste (Abdel-Shafy & Mansour, 2018). Solid wastes are garbage and by-products that are produced from the household, industrial, hospital, and agricultural operation. They may be solid, semi-solid, or contained gaseous material. Wastes that are discarded by being abandoned, inherently waste-like, recycled, or a military munition are identified as solid waste (Heritage, 2013). These wastes can produce a hazardous by-product that can ignite, corrode, leach groundwater and land (Admin, 2017). The rapid increase in urbanization, industrialization, population, and change of lifestyle has resulted in a greater amount of solid waste produced in developed countries that are disposed of either in an open dump or landfills (Singh, Singh, Araujo, Ibrahim, & Sulaiman, 2011) and needs proper waste management (Khan, Ahmed, Najmi, & Younus, 2019).

The waste generated is collected, treated, and disposed of (BYJU'S, 2021) in a variety of ways depending on their category. It can be through recycling, waste source reduction, composting, landfilling, and combustion or incineration (Leblanc, 2020). Thrown-away material, considered abandoned, is incinerated. Hazardous waste or categorized as inherently waste-like are incinerated as well (Hazardous Waste, 2021). Decomposable organic matter is separated and composed similar to sanitary landfills (Types of Solid Waste Disposal and Management, 2021). In recycling, wastes such as scraps are separated and are converted to new products (Solid Waste Recycling and Recovery, 2019). Waste management can save a business since there is a considerable amount of money and can prevent harmful effects on the environment (Solo Team, 2019).

Solid waste management requires an understanding of different factors upon handling the system and high financial costs (Abdel-Shafy & Mansour, 2018) because if it is mismanaged, waste can pollute in a variety of ways, (Better Meets Reality, 2018) and illegal dumping can cause environmental harm (Liu, Kong & Santibanez, 2017). When toxic waste ends up in the ground, in streams, or even in the air, it can endanger people, animals, and plants. Toxins like mercury and lead can stay in the environment for a long period and they build up over time. When humans or wildlife consume fish or other prey, they are often unknowingly exposed to toxic substances. (Wolters, 2019). Waste management approaches are practical and effective options to establish sustainability (Das et al., 2019). For effective waste management, providing waste collection bins to every household to ensure that residents do not dispose of their household waste indiscriminately is recommended (Odonkor, Frimpong, & Kurantin, 2020).

Promoter and Barriers of Waste to Energy (WTE) Scheme

Waste can be converted into something useful and valuable, through the waste to energy process. Solid waste from landfills will be burned to generate electricity. There are different ways to turn waste into energy and these are depolymerization, gasification, pyrolysis, plasma arc gasification, and incineration, which is the most common technology in WTE (Green energy, 2017). In any WTE technology wastes are burned in a special power plant, capturing methane also known as biogas, in which they emit to produce electricity or letting them rot in landfills (Mubeen & Buekens, 2019). Waste to energy can be thought of as both a waste management and an energy production process. Waste to energy's carbon neutrality is a big advantage, and from a sustainability standpoint, waste to energy is much more promising than landfilling (Hettiarachchi & Kshourad, 2019).

By implementing the WTE concept, the negative effects on the environment that can occur when waste is not treated before disposal can be reduced. In this regard, waste to energy can be a reliable process for producing renewable fuel, which helps to reduce the reliance on fossil fuels while also lowering greenhouse gas emissions. It also has the potential to benefit the government, productivity, and related emerging opportunities (Moharir, Gautam & Kumar, 2019). Waste to energy is a notion that is a key issue in the waste management system. On the part of the energy system, it would contribute to the development of a low-carbon society. Seven productive countries, including the United States of America and China, have made significant contributions to waste to energy research (Sun, 2020). Also, Mubeen et al. (2019) said there is a growing concern about the availability of affordable, renewable, and clean energy sources that cause less social and environmental harm, and solid waste is the suitable source of renewable energy in this demand.

However, there are economic barriers to WTE in developed, developing, and underdeveloped countries. The lack of enough funding is one of the most major challenges facing economically by developing and underdeveloped countries. This is caused by insufficient resources from local tax income, insufficient user fees, and inefficient fund management practices (Vujic, Batinic, Ubavin, Stanisavljevic, & Jurakic, 2015) resulting in inefficient practices in garbage segregation, collection, storage, treatment, and disposal. (Agaton, Guno, Villanueva, 2020). These economic barriers affect the implementation of WTE technologies as it depends on the income of the country, as well as a description of the value chain, its creation, and the value chain's possible outcomes.

It can be argued that economic value considerations for WTE are not uniform for the chosen WTE technology and country at any given time, taking into account market trends and public perception of the technology (Lakshmikanthan, 2019). Chand et al (2020) unveiled the waste to energy technology value chain and economic considerations that can be taken into account of its effective implementation. Government laws, policies, and subsidies all play a significant role in the adoption of WTE technologies. Due to the constant growth of industrialization, urbanization, and population in developed countries like India, waste generation is constantly increasing. Nonetheless, waste management procedures and acts are flexible enough to incorporate modern technology without disrupting their intended purpose. (Hettiarachchi et al., 2019).

The Evolution of Incineration Process

Incineration is the destruction of waste materials or products by combustion. It is the thermal oxidation of any unwanted or unused material. It is one of the critical processes that are involved in the disposal of municipal solid wastes (MSW) and other such wastes, like hazardous wastes (Tillman, 2014). It is also the means of getting rid of the waste while keeping emission levels below the extant emission standards and, when feasible, reclaiming back energy that was lost, as well as residues that have resulted from the incineration process. The characteristics of incinerating furnaces are as outlined: reducing the amount of waste as much as possible; acquiring sterile and packed residue, but also treating a considerable flow of flue gas while disposing of a wide array of pollutants (Beukens, 2013). Modern waste incineration technology aims to treat waste to reduce the sheer amount of volume and hazard that it causes, to capture and destroy potentially harmful substances in the waste and in and of itself, and to recover energy from combustion.

The advance of technology has made waste incinerators run more cleanly and with less impact on the environment. Pollutants are still produced nonetheless, with facilities needing regular service and maintenance to maintain minimum emission levels. In Australia, alternatives like waste incineration to traditional methods like landfilling are increasingly being employed in order to reduce the pressure on the aforementioned. Modern incinerators are also designed with the ability to generate electricity (waste-to-energy) as it combusts waste, which increases their appeal to policymakers (Tait et al., 2019). Thus, regulations are heavily enforced in most countries in order to regulate greenhouse gas emissions, technical requirements, and operating conditions (Campo, Bechtold, Borsari, & Fustinoni, 2019).

In the study of Assamoi and Lawryshyn (2012), results showed that incineration performed better in terms of the environment and had a lesser impact on greenhouse emissions compared to landfills that were getting ever fuller. Landfilling was found to be the superior financial option; however, it was only for the short term; incineration for the long term, yet is at a higher cost. In China, incineration has taken the place of landfilling as the most important option for the disposal of MSW (Wang, Hu, & Cheng, 2019).

Impacts of Incineration on the Environment

Incineration plants are required to follow legal restrictions, regardless of the composition of the incinerated waste, and shall consider incineration model and include the installation of suitable pollution control devices to lower emission to air (Patil, Kulkarni & Patil, 2014). Since incineration involves the combustion of waste and produces steam, it generates residues such as slag and ash (Team Sepro, 2019). There are two kinds of ash produced by the incineration process: the bottom ash from the oven that contains slags and metal objects with high melting points; the second kind is fly ash, which is a pulverized waste from the cleaning system of the oven (Sloot, 1997; Tang, 2017).

Incineration emits volatile organic compounds (VOCs), dioxins, furans, sulfur dioxide, carbon dioxide, mercury, and carbon monoxide into the air, causing air pollution, with the latter affecting human health (Manisalidis, Stavropoulou, Stravropoulos, & Beritzoglou, 2020). Since 2012, solid waste incineration facilities in China have emitted 8,500 tons of sulfur dioxide, 11,200 tons of dust, 14,100 tons of nitrogen oxide, and 610.47 grams I-TEQ of dioxins (China National Implementation Plan, 2007; Ministry of Environmental Protection of China, 2010; Li, Huang, Lu, Wu, Li, & Yan, 2015). The study conducted by Li et al. (2015), indicates that incineration contributes the most to human toxicity, followed by global warming. Therefore, it could bring more harm than good effects to the environment and health of the people (Colina, 2017).

On contrary, in a 15-year study conducted in Italy by Venturini and Passarini (2014), it has been found that incineration's contribution to pollution appears to be minor when compared to the concentrations generated in urban areas. Also, municipal waste incineration (MWI) in Great Britain operating from 2003 till 2010 emitted a very low concentration of incinerator-related PM_{10} which are small particles found in dust and smoke causing cough, runny nose, and stingy eyes (EPA Victoria State Government Victoria, 2021) within 10 kms of the plant, ranging from a mean of $1.00\ x\ 10^{-5}$ to $5.53\ x\ 10^{-2} \mu g m^{-3}$ (Douglas et al., 2017).

Integrated Waste Management Facilities (2021) argued that adapting advanced-control technologies in incineration reduces pollutant emissions effectively. Gas cleaning systems in modern incinerator models can be further developed to lessen pollution depending on the requirements of the legislation (Quina, Bordado, & Ferreira, 2011). If an energy recovery system is installed, the environmental impact will be reduced. Also, toxins can be trapped and filtered in this way but it requires a special landfill for disposal because when stacked, they become hazardous waste (Zafar, 2020). Further, residues produced by the incinerator can be recycled. Slags can replace coarse aggregate up to 20% rate substitution and fly ash can replace slags up to 30% rate substitution to make concrete and it does not affect the concrete's strength (Zeng et al., 2020). If municipal incineration is implemented, nearly 90% of waste will be eliminated (Ovy, 2019).

Impacts of Incineration on Health

Despite technological advances, the effects of waste incinerators on local and global health remain a problem for communities where they are being installed. In the primary research, adverse health effects have been demonstrated in communities near waste incinerators, including cancers and reproductive dysfunction. Unfortunately, the precise assessment of the health effects of waste incinerators will vary in detail. The higher prevalence of cancer and respiratory symptoms is the main health effect; congenital anomalies, hormonal defects, and elevated sex ratios are the other effects of incineration (Sharma, R., Sharma, M., Sharma, R., & Sharma, V., 2013).

Fine airborne particulates (2.5 μm diameter and smaller), heavy metals, and organic chemicals are the main air pollutants. The specific emission content varies with the substance incinerated: persistent organic contaminants, hormone disrupters, and carcinogens are among the chemicals released. Chemical risks have been underestimated in the past: chemicals such as dichlorodiphenyltrichloroethane (DDT) and chlorofluorocarbons (CFCs) were deemed safe to be implemented but were banned due to widespread ill-effects several years later. The health risks of another major incinerator pollution, fine particulates, have become generally known in the last 10 years. These are associated with an increased incidence of lung cancer, but also with a linear rise in mortality, particularly from cardiovascular causes with the rise in mortality with no safe level. Moreover, increased adult lung cancer and all cancers in the vicinity of incinerators have been found: the peak tends to occur at least 14 years after the start-up of the incinerator. No direct studies of the incidence of heart disease around incinerators have been performed, but because incinerators are a major source of fine particles, and ischemic heart disease is a reasonably common cause of death, there is expectation that cardiac mortality and morbidity would be in excess (Thompson & Anthony, 2009; Shamshiry, 2014).

Impacts of Incineration on Economy

Waste generation is an arising problem generated by the increase of the global population and the development of economic and industrial activities. As the population increases, the amount of municipal solid waste (MSW) generated increases. This aspect has become a major concern for many under-developed nations as local governments have generally assumed the collection, transfer, and disposal of waste (Escamilla-García et al., 2020).

Incineration dominates the waste-to-energy market all over the world, particularly in developed countries. After thermal processes, anaerobic digestion is the growing technology in clean energy production. Incineration is a thermal process with low environmental impact and reduces the waste volume to be dumped in landfills (Mubeen et al., 2019).

A waste-incineration facility may create jobs both directly and indirectly by attracting industry to the area as a result of the facility's services. Furthermore, such a facility may contribute to electricity cogeneration and district heating. The number of jobs created will be determined by the incinerator's size and type. The number and types of jobs available to residents whether abundant and well-paid or scarce, low-skilled, and low-paid will be determined by the type of facility and its hiring policies, local union policies and willingness to accept new members, and the demographics of the local population. However, if businesses leave or decide not to settle in the affected area, a waste facility may harm local economic prospects. Public perceptions of the risk may exaggerate it, resulting in stigmatization of affected communities (Waste Incineration and Public Health, 2021). It might also hurt finances since investors would impose a 20-to-30-year lock-in period which will burden with fees (Colina, 2017).

Furthermore, for most communities, an incinerator is merely a costly investment that increases the costs of waste management, introduces financial risks, and puts community and environmental health at risk (Ecocycle, 2011). Volume reduction and disease control are the primary advantages of MSW incineration, and it is a practical way to treat MSW in large or populated cities because it can be localized in an urbanized zone. WTE incineration also has the advantage of using waste as a source of energy. If used instead of landfilling, this method of incineration reduces carbon emissions by offsetting the need for energy from fossil fuel sources and reduces methane produced by landfills. The introduction of MSW incineration, on the other hand, comes with its own set of challenges: high construction and operating costs, insufficient revenue from waste disposal and energy sales to cover all costs, the minimum amount of feedstock needed for operations, which could potentially divert waste away from the 3Rs (Reduce, Reuse, Recycle), and risks to human health are just a few of the issues (Karim & Corazzini, 2019; GAIA, 2019; Chen, Toru, Katsuya & So, 2020).

In summary, incineration has become a viable option for decreasing solid waste on landfill. Since it disposes both municipal and industrial/hospital hazardous waste (Campo et al., 2019). Although it helps dispose waste, some research findings found out that it is associated with negative impacts on the environment, health and economy. Other studies also concluded that it has lesser impacts on the environment, health and economy. For example, a study conducted by Li et al. (2015) incineration contributes the most to human toxicity followed by global warming. In contrary, Venturini et al. (2014) found out that incineration has minor contribution to pollution and PM_{10} which causes cough, runny nose and stingy eyes (EPA Victoria State Government Victoria, 2021) compared to the concentration generated in urban areas (Venturini et al.) however, when the facility stops to operate, there will be a negative impact on local economic prospect and may result in stigmatization of the affected community (Waste Incineration and Public Health, 2021). These studies, therefore, provide possible impacts of incineration both negative and positive and for future incineration sustainability.

Theoretical Framework

This study is anchored with the theory of waste management by Pongracz, Phillips, Keiski (2004). According to this theory, waste management is the manipulation of discarded things and encompasses more than just merely the treatment of waste. Waste management aims to prevent waste from causing harm to human health and the environment by conserving resources, avoiding waste creation by creating useful objects, and encompassing the goal of turning waste into non-waste (Pongracz, 2002). Towards the theory of waste management, practical values are needed to be followed, such as providing a guide for choosing waste management options, providing a foundation when integrating waste management options, predicting outcomes of the use of waste management actions, and aiding legislation upon prescribing activity on waste (Pongracz, Phillips, & Keiski, 2004).

In this study, the waste management option is through waste to energy, particularly on incineration. Incineration, therefore, is the method of manipulating waste, hence, the study aimed to know whether incineration is viable predicating on its effect on health, environment, and economy.

Significance of the Study

This study is beneficial to the people living near landfills since it would lessen the impacts caused by landfilling, especially on health. It can serve as a reference for environmental advocates to further support their advocacies. It can also improve the technology in the city. It can provide a solution to the community by lessening the waste, providing electricity, and providing possible income if facilities will be established. This study also can be an endeavor on considering waste to energy, particularly incineration, as part of the plan of the city with regard to waste management. It can also serve as an eye-opener for legislators to revise existing laws about waste management. The vital results of this study are not only beneficial to the city, but also to other cities in the Philippines as a basis of implementing waste to energy facilities.

Scope and Limitations

This study is limited only to the viability, benefits, and effects of using waste to energy as part of waste management in Davao City. Effects of using WTE focus only on health, environment, and economy. Other considerations that may result from the use of incineration were not considered; other methods of converting waste to energy, such as depolymerization, gasification, pyrolysis, and plasma arc gasification, which can convert waste to electricity, were not included in the study. Only literature on the efficacy and impacts of establishing a waste-to-energy facility were used in the study. Furthermore, the study did not take into account the amount of waste that would be reduced or the amount of electricity that would be generated if a waste-to-energy facility is built in the city.

Definition of Terms

This section contains the terms used in the study.

Waste management - refers to the activities from the collecting to the disposal of waste.

Incineration - refers to the method used to burn waste in order to produce energy.

Environment - refers to the surroundings (air, water, land) that will be affected by incineration.

Economy - refers to the profit gained using the energy generated during incineration.

Health - refers to the physical condition of the people near the incineration plant.

Wastes - refers to the discarded or unused materials coming from households, different industries, and hospitals

Chapter 2

METHODS

This chapter contains the discussion of all the methods used in this study, including the research design, ethical consideration, and data analysis which is also associated with sampling frame, unit of analysis, and coding and procedure scheme.

Research Design

This study used quantitative content analysis research design to determine the impact and viability of incineration. In a quantitative content analysis research method, the data, either textual, visual or aural, are systematically categorized and recorded in order to be analyzed (Coe & Scacco, 2017). Interviews, open-ended questions, field study notes, interactions, or any instance of communicative language may be used as data sources such as books, essays, results and discussion, newspaper headlines, speeches, media, and historical documents (Columbia University, 2019). Furthermore, the process of coding, which includes following a collection of instructions on what features to look for in a text and then creating the appropriate notation when that feature appears, is central to quantitative content analysis (Scacco, 2017).

Therefore, the researchers answered the research questions through coding and analyzing text from the gathered researches and articles about the viability and impacts of incineration. This research design used contents from different data sources in order to assess the impact of incineration to health, environment, and economy and viability of establishing incinerator in managing solid wastes.

Ethical Consideration

It is important to follow research ethics since these are the moral standards that direct researchers in conducting and reporting research without deceit or the intent to hurt study participants or society as a whole, whether intentionally or unintentionally. In content analysis, it is important to follow ethical standards when conducting and reporting research in order to ensure the validity of a researcher's findings (Singh, 2019). Intellectual property rights such as patents, copyright, and other intellectual property must be respected. All contributions to science must be properly and accordingly credited (Resnik, 2020). Intercoder reliability should also be followed, wherein two or more independent coders hold the same opinion on the coding of relevant contents using the same coding scheme (IGI Global, 2021). This enables the researchers to defend their findings' consistency, and therefore their validity (Allen, 2017).

In order to hide the identity of the authors and the title of the studies that were used, the researchers used code names in respect to confidentiality and anonymity. Moreover, organizations mentioned in the sample data were covered in black in order not to be exposed. With regard to the intercoder reliability, the researchers analyzed each data repeatedly and similar themes and significant statements were obtained. This ensured the precision and accuracy of the coded data by establishing a consistent understanding among the coders regarding the contexts of the data analyzed.

Sampling Frame

During the conduct of the study, the researchers utilized ten research journals and/or articles randomly picked online. These research journals and articles discussed the impact and efficacy of incineration. Moreover, the data were collected from search engines, news articles, online articles, and online journals in PDF files. The timestamp of the said data is from 2016-2021. This year range was chosen since the six-year time period would be enough to assess the impact and efficacy of incineration.

Unit of Analysis

The unit of analysis is one of the most critical concepts in a research project. A unit of analysis in a study could be individuals, groups, books, photos, geographical units, and social interactions (Trochim, 2020). As part of the process of deciding on a research method and how one will operationalize that method, one will need to pick their units of study once they have defined a research issue (Cole, 2018). Being specific about the units of study becomes increasingly important in this highly complex environment. The unit of study is made clear both concerning empirical cases and consequences for learning research and practice in this special issue, which brings together contributions from diverse theoretical and methodological traditions within learning research (Damsa & Jornet, 2020).

In this study, the data gathered from websites and engines (Google Scholar, Academia, Research Gate, and Science Direct) are the unit of analysis. The body of the news articles, results and discussion, and the conclusion of the research studies would be the particular area where the researchers would gather data. In order to answer the research questions, the data gathered were analyzed with codes as to the ideas each conveys. Furthermore, coding sheets with respective themes was used in quantifying the thought of each data. A word frequency table was also used on the data to assess the impact and efficacy of incineration that would further help the researchers analyze the main thought of the data.

Coding and Procedure Scheme

Each datum gathered was coded and analyzed based on the coding sheet, which was made by the researchers. The coding sheet is described as: Sample #, code, significant phrases, and theme. Sample #, impact, significant phrases, and theme are based on the sample # data that were used. The impact gathered was denoted with codes. Code IE, represents the impact of incineration on the environment, code IH, on health, and code IC, on the economy.

Further, the researchers used thematic analysis wherein the deductive method was performed. This helped assess the analysis of the data with predetermined themes and categories. The themes were decided after the data were gathered since the factors determining the theme were not yet determined. After coding and filling up the coding sheets, conclusions were be made based on the result of the findings.

Chapter 3

RESULTS AND DISCUSSION

This chapter contains the presentation of the data gathered and the results of this study. This part also shows the various studies from the review of related literature and tables for easy comprehension.

Research Problem #1 To what extent is the viability of establishing waste to energy facility?

Table 1: Viability of establishing waste to energy facility

Significant Statement	Themes	Frequency
Increase treatment cost	Cost	4
Low energy recovery		
High initial investment		
Low evaluation of waste value		
Effective fuel replacement	Efficient	4
Zero-waste approach due to production of inert materials		
Saves non-renewable resources		
Produces materials that may be reused as filler		
High profit	Profitable	3
Opens new perspective markets and business models		
Fly ash as a potential source of critical metals (Lutetium, Magnesium, Scandium, Thulium, Zinc)		
Technology advancement to improve environmental impacts	Technological	1

Table 1 shows the viability of establishing waste to energy facility, wherein the results were based on the significant statements of the gathered data and were categorized by theme and the frequency shows how many times the significant phrases appeared to the sample data.

Based on the results of the data gathered, establishing incineration is efficient because it is an effective fuel replacement, and saves non-renewable resources. The results corroborate to the study conducted by Moharir (2019) which revealed that it is a reliable process for producing renewable energy since it reduces the reliance on fossil fuels and lowers greenhouse gas emissions. It also has a zero-waste approach due to the production of inert materials and produces materials that may be reused as a filler. The results also corroborate the study conducted by Zeng et al. (2020) that shows that slags can replace the coarse aggregate up to 20% rate substitution, and fly ash can be a substitute to make concrete up to 30% rate without affecting the concrete's strength.

It is profitable since the fly ash produced is a potential source of critical metals such as Lutetium, Magnesium, Scandium, Thulium, and Zinc, has high profit, and opens new perspective markets and business models. This supports the findings of the Waste Incineration and Public Health (2021) that incineration facilities attract industry to the area as a result of the facilities' services.

Apart from these, establishing incineration needs to have advanced technology to improve environmental impacts. This is because the advanced technology installed in the incinerator runs more cleanly, with less environmental impacts (Tait et al., 2019), and reduces pollutant emissions effectively (Integrated Waste Management Facilities, 2021).

Establishing an incinerator requires high cost because of the increased treatment cost, low energy recovery, low evaluation of waste value, and high initial investment. This can be supported by the study conducted by Chen et al. (2020) that it has high construction and operating costs, insufficient revenue from waste disposal and energy recovery to cover all costs, and the minimum amount of feedstock needed for the operation would potentially divert it away from the 3Rs (Reduce, reuse, recycle).

Research Problem #2: To what extent is the impact of incineration on health, environment and economy?

Table 2. Portrayed Impacts of Incineration

Category	Significant Statement	Impacts	Frequency
Health (IH)	Asthma related admissions within 2 km and between 2 km and 5 km of the incineration facilities	Health risks	8
	Proximity to incinerators and respiratory symptoms was inconclusive		
	Disease may vary depending on the characteristics of different incinerators		
	Exposure to dioxins and heavy metals		
	Tumors, and respiratory diseases		
	Reproductive disorders		
	Food contamination and ingestion of pollutants of both nearby and distant residents.		
	Older incineration was linked with neoplasia and reproductive issues		
	Associated with preterm birth and miscarriage	Health consequence	1
Environment (IE)	Global warming	Environmental consequence	6
	Acidification		
	Dioxin emission		
	Soil and aquatic environment suffer from the effects of combustion products.		
	Rainfall causes blurred toxic substances entering the soil, exerting further polluting effect which allows these substances to become incorporated into the food chain.		
	Air pollution		
	Mixed waste produces other toxic compounds	Pollutes	3
	Inadequate combustion result in large amount of flue gas deposits		
	Absence of built-in filtering facility may allow pollutants enter the environment		
Economy(IC)	Increase treatment cost	Cost	4
	Low energy recovery		

	High initial investment		
	Low evaluation of the waste value		
	High profit	Profitable	3
	Opens new perspective markets and business models		
	Fly ash as a potential source of critical metals (Lutetium, Magnesium, Scandium, Thulium, Zinc)		
	Effective fuel replacement	Efficient	4
	Zero-waste approach due to production of inert materials		
	Saves non-renewable resources		
	Produces materials that may be reused as filler		
	Technology advancement to improve environmental impacts	Technological	1

Table 2 shows the impact of incineration on health, environment, and economy. The identified impact of incineration was analyzed based on the themes determined from the significant words and phrases and the frequency that shows how many times the significant phrases appeared to the sample data.

Based on the results, incineration is associated with health risks and health consequences such as tumors, reproductive disorders, respiratory diseases, exposure to dioxins, heavy metals, associated with preterm birth, and miscarriage. But Sharma et al (2013) found out that despite the technological advancement, incinerators still demonstrated health effects in communities near the facility including cancer and reproductive dysfunction, and may vary on the type of incinerator.

Incineration is also associated with environmental risks, like contributing to global warming, acidification, and the emission of dioxins. The toxic substances that are also produced pollute the environment. Incinerators can bring harm and good to the environment and health of the people, may cause water and air pollution, and may affect finances (Colina, 2017), yet it is the key issue in the waste management system (Sun, 2020).

It can reduce negative effects on the environment when waste is not treated prior to disposal, can be reliable process for producing renewable energy and can be beneficial to the government, productivity, and emerging opportunities (Moharir et al., 2019) and nearly ninety percent of waste will be eliminated (Ovy, 2019).

Lastly, incinerators require hefty amounts of investment in order to construct and maintain them because pollution is still produced and health problem remains (Sharma et al., 2013). Nonetheless, the facility needs regular service and maintenance to maintain minimum emission levels (Tait et al., 2019) depending on the requirement of the legislation and the type of incineration. Further, incinerators incorporated with advanced technology reduced pollutant emission effectively (Quina et al., 2011).

The technology, however, is still profitable because of the potential source of critical metals such as Lutetium, Magnesium, Scandium, Thulium, and Zinc, has high profit, and opens new perspective markets and business models. Efficient because it is an effective fuel replacement, saves non-renewable resources, has a zero-waste approach due to the production of inert materials, and produces materials that may be reused as a filler.

Chapter 4

CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion drawn and the recommendations made as a result of the content-analysis study. The conclusion interprets and analyzes the results of the data gathered in the previous chapter while the recommendation proposes suggestions for reference of future researchers, thus resulting in the further improvement of related studies.

Conclusion

Based on the data gathered, the researchers conclude that establishing incineration facility is viable since it is efficient as it can be a potent replacement for fuel, has a zero-waste approach due to the production of inert materials, saves non-renewable resources, and produces materials that may be reused as filler. It is profitable since it would open new perspective markets and business models, high profit, and the fly ash can be a potential source of critical metals. It is technological because of the technology advancement to improve environmental impacts. But it is costly as it requires a high initial investment, low evaluation of waste, low energy recovery, and high treatment cost.

On the other hand, with regard to the portrayed impacts of incineration, the data that were gathered focused on three categories which include health impact, environmental impact, and economic impact. In terms of health impact, establishing incinerators can lead to illnesses such as tumors, reproductive disorder, and respiratory ailments. Moreover, in terms of environmental impact, incineration contributes to the worsening effects of global warming, and causes further pollution that will be incorporated into the food chain, acidification and dioxin emissions. Lastly, in terms of economic impact, it is deeply engraved in investing in advanced technologies as well as its regular maintenance. Therefore, the researchers conclude that incineration is viable but it must be well-planned and well-designed in order to lessen the negative impact on health, environment, and economy.

Recommendations

Based on the conclusion drawn from the research study, the researchers recommend to conduct a further research investigation about the different models and technology used in incineration as it has varied impact on the environment, health, and economy. For the future researchers in the same field of study, the current researchers recommend that they further expand their scope of study while using the current study as their primary or secondary reference. They can increase the current number of categories or they can include respondents that are familiar with incinerators to obtain reliable data and information. Furthermore, the researchers also recommend not to focus solely on online references but also on the organizations working for community sustainability because they have plenty of researches and case studies on the different problems and approaches in the community. The researchers also recommend for the national and local government to have more inclusive legislation on solid waste management and the Philippine Clean Air Act that in the long-term will be beneficial not just for the country but also for the whole world.

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APPENDICES

Appendix 1: Samples

Sample # 1

Conclusion

The main focus of waste incineration in the past was on the diminishment of the overall waste volume and hygienic treatment. Now, incineration plays a major role in waste energy production through heat energy recovery. Even though negative views in the past have led to a continual decrease in waste incineration rate, its recycling rate for use in RPF, fuel for cement furnace, and fuel for paper manufacturing furnaces is gradually increasing. However, both academia and the industry have argued that the overall feedstock recycle of RPF manufacture, cement, and paper production lacks preponderance compared with regular incineration, from both economic and environmental points of view. Further, there are increased treatment costs rising from the waste undergoing both shredding and reuse processes. It has also been asserted that the waste energy production that includes waste shredding as well as its treatment at recycle facilities will incur inevitable cost increases in waste treatment, and lead to a certain decline in the recycle rate.

To resolve such argument, this research will take an in-depth look at waste treatment in Korea. An objective and quantitative analysis of the economic and environmental benefits will include combustible industrial waste collection, transportation, and final heat energy treatment, as well as the use of waste-generated fuel for cement and paper manufacturing. Comprehensive implications for each type of waste treatment are as follows. Incineration as the simplest treatment shows the highest economic benefit; high profit and effective fuel replacement prove its overall economic value. However, it has a low energy recovery rate of 50%, and displays relatively low evaluation of waste value and environmental benefits in comparison with paper incinerators with shredding. To improve the environmental benefits, expanded investment in energy recovery equipment is required. The use of cement furnaces with shredding displays economic advantages, with low treatment costs due to its utilization of existing equipment. Nevertheless, long transportation and a greater emission of air pollutants incurs high environmental costs, and with a low fossil fuel replacement effect, the estimation of relative effectiveness is low. Additional installation of post-treatment facilities will ameliorate environmental damage. RPF manufacturing induces high transportation and operation costs. It requires the use of RPF-dedicated boilers and a simplification of treatment path.

The major contribution of this research is that it presents a model with numeric indices that can be used to compare different waste treatment methods. This enables a shift from qualitative-to-qualitative analysis evaluation, with consideration to both economic and environmental benefits. With the acquisition of detailed information on waste flow quantity and the operation costs for each waste treatment path, and the inclusion of additional facilities that reflect possible changes in both regional and governmental policy, more precise and objective results will be made possible. Such outcomes will serve as scientific base data that can be utilized to draft future environment and energy-related policies.

Sample #2

Conclusion

The present study analyzed the environmental impact of municipal solid waste incineration in African countries. According to the findings of the study, the following are concluded: First, the global warming potential of Seychelles is expected to decline from 200.10 kton CO2eq in 2012 to 196.18 kton CO2eq in 2025, while in Saint Helena it will remain unchanged at 7.85 kton CO2eq. Except for Seychelles and Saint Helena, the global warming potential of incineration projects in all countries is expected to increase in 2025 compared to 2012. The global warming potential of incineration facilities in various countries was 7.85 kton CO2eq to 45,540.92 kton CO2eq and 7.85 kton CO2eq to 100,125.68 kton CO2eq in 2012 and 2025, respectively. In 2012, the country with the highest global warming potential was South Africa, and it is expected to be Egypt by 2025. Saint Helena recorded the lowest global warming potential emissions in both years.

Second, the acidification potential of the incineration project in 2012 was 740.56 kg SO2eq to 4,297,839.96 kg SO2eq, and the acidification potential in 2025 is expected to be 740.56 kg SO2eq to 9,449,175.32 kg SO2eq. In Seychelles, the acidification potential decreased from 18,884.28 kg SO2eq in 2012 to 18,514.00 kg SO2eq in 2025, while that of Saint Helena remained at 740.56 kg SO2eq in 2012 and 2025. Among all countries, the acidification potential of the project is the highest in South Africa, with 4,297,839.96 kg SO2eq in 2012. In 2025, the countries that will have the highest acidification potential are Egypt and Nigeria, at 9,449,175.32 kg SO2eq and 8,984,103.64 kg SO2eq, in that order. Similarly, the acidification potential of Saint Helena is the lowest in 2012 and 2025.

Third, compared with other countries covered in this study, South Africa, Egypt, Algeria, Morocco, and Nigeria have higher dioxin emission potential in 2012 and 2025. The dioxin emission potential in 2012 was 0.0000662 kg TCDD to 0.3841917 kg TCDD, and in 2025 is expected to be 0.0000662 kg TCDD to 0.8446789 kg TCDD. The highest dioxin emission potential of the facility in 2012 was in South Africa, while in 2025 will be in Egypt. Compared to other countries, the dioxin emission potential in Saint Helena is the lowest.

Sample #3

Conclusion

The life cycle assessment study presented in this paper demonstrated that the environmental situation in Hangzhou could be improved by changing the MSW management system that is currently employed in the area. The highest improvement potential arises from producing RDF that is of a higher quality than the original MSW for energy recovery. However, the benefits gained may be easily diminished if the organic reject from RDF production is landfilled. To prevent this, the organic reject from RDF production should, instead, be used in energy recovery; e.g., by anaerobic digestion. In addition, the environmental situation in Hangzhou could be improved even further if the waste incineration plants combined heat and power production to produce heat for industry. Still, the main problem in Hangzhou is linked to inefficient source separation, especially in relation to food waste, which deteriorates the quality of any MSW that is directed to incineration. Reducing the share of food waste would mean that the heating value of MSW would be higher, more electricity from the incineration could be produced, the auxiliary coal in waste incineration could be reduced, less reject from the RDF would be produced, and RDF production energy demand would be lower.

In conclusion, technologically advanced systems could partly improve the environmental situation, while officials from Hangzhou's MSW management should treat educating the general public about the benefits of source separation as a top priority (Havukainen, Zhan, Dong, Liikanen, Deciatkin, et al., 2017).

Sample #4

Conclusion

Although the public is concerned about the negative impact of incinerator emissions on human respiratory conditions, little research has addressed the relationship between closeness to incineration facilities and the risk of asthma in Korea. This study was designed to identify the spatial relationship between incineration facilities and their health effects in Seoul from 2009–2011. We observed the spatial distribution of asthma-related admissions and disease clusters, which were hotspots with an increased asthma-related admission risk, and investigated these trends. Using the RIF, the specific asthma-related admission risks of those residing within 2 km and between 2 km and 5 km of the incineration facilities were analyzed.

Across the entire study population, there was no significant difference in terms of IRRS values among all age groups or the senior and children's groups. However, when the data were disaggregated into sub-districts, disease maps of age-specific asthma admissions revealed significant spatial differences in the relative risks of different sub-districts. This indicated that the hotspots of asthma-related hospital admission were highly related to the location of incinerators. These results also mean that spatial distribution analysis can produce more meaningful results than showing the entire area in a single quantitative value. To find spatial clusters with a high risk of asthma-related admissions, this study employed SaTScan. Researchers in other countries have been conducting disease monitoring using SaTScan, while only limited studies have been performed in Korea. We found hotspots with relatively high risks of asthma admissions by age group in Seoul, and the results showed that spatial analysis using SaTScan is also useful in a Korean context.

To achieve the main research objectives, this study analyzed the risk of asthma-related admission based on the separation distance from incineration facilities using the RIF. In the risk analysis using the RIF, the most interesting finding was that the risk of asthma-related admissions in areas adjacent to the incineration facilities (0–2 km) across the whole group, children group, and senior group were significantly higher than the reference values of the entire study population of Seoul (ISRR = 0.99). The relative risks of asthma-related hospitalization were 1.13 (95% confidence interval (CI): 1.10–1.17), 1.12 (95% CI: 1.08–1.17), and 1.18 (95% CI: 1.10–1.27) for all ages, those aged below 15 years, and those aged 65 years and older, respectively. Interestingly, the risk ratio of the senior group increased compared to that of the whole group and children group. The reason the elderly has a higher asthma risk than the children group seems to reflect the general trend. According to [redacted], the prevalence of asthma in children was around 5–9%, but decreased to 3% in young adults, but asthma increased after 50 years, indicating a high prevalence rate of 6.8–12% among those 65 years or older.

This study makes some important theoretical contributions to the literature regarding the possible health effects of those residing close to incinerators. Existing studies have suggested the presence of three broad health concerns in association with residing close to an incinerator: cancer (all cancers, including that of larynx, lungs, esophagus, stomach, intestine, liver, kidney, bladder, and breast, as well as non-Hodgkin's lymphoma and soft-tissue sarcoma), reproductive outcomes (infant deaths, congenital malformations, birth defects, and gestational age), and respiratory symptoms. While previous studies investigating the health effects of incinerators have focused predominantly on dioxins and cancer incidence, there have been difficulties in establishing causal relationships because of the characteristics of some types of cancer, such as low incidence rates and latent periods greater than 20 years. Therefore, identifying short-term health effects by utilizing health endpoints with high morbidities and excessive incidence rates or aggravations is required. In comparison, asthma is an appropriate surrogate marker for the health impact of incinerators, since it has high morbidity and requires continuous medical treatment. However, only a few studies have focused on the related respiratory effects.

Among studies focusing on respiratory effects in association with residing close to an incinerator, [redacted] observed no difference in either the respiratory symptoms or pulmonary function between the populations living close to and far away from the incinerators. [redacted] also examined the frequency of occurrence of respiratory symptoms in children living near two sludge-burning incinerators, finding no differences in lung function, asthma prevalence, or atopy prevalence between the study and control populations. [redacted] evaluated the health impact of emissions from two incinerators in a pilot cohort study. They found that the mortality and morbidity experience due to respiratory diseases of the whole cohort did not differ from the regional population. [redacted], meanwhile, concluded that the association between incinerators and respiratory symptoms was inconclusive considering the uncertainty and residual confounding. Unlike the authors of other studies, [redacted] suggested that the proximity of schools to municipal waste incinerators may be associated with an increased prevalence of wheezing, with an adjusted odds ratio of 1.08 (95% CI: 1.01–1.15). From the literature review, the association between the proximity to incinerators and respiratory symptoms was inconclusive.

In the midst of the discrepancies in previous studies, this study is meaningful in that it adds to the literature focused on the spatially significant relationship between proximity to incinerators and asthma-related risk. This study is the first to observe an increased risk of asthma-related hospitalization in relation to a person's distance from an incinerator in Korea. Although there are uncertainties surrounding the estimated excess risk, mainly due to the less-sophisticated exposure assessment approach used in the analysis, it is clear that asthma should be considered an adverse health outcome during health impact assessments of incineration plants, which were not seriously considered in current assessments. The qualitative evaluation methodology and the results pertaining to this relationship may serve as a basis for environmental policymaking and the identification of vulnerable areas in the future.

In addition, this study confirmed that the RIF can be used to rapidly conduct ecological, environmental, and epidemiological analyses, including risk assessments and disease mapping. This approach builds on a method previously used by [redacted]., who applied epidemiological, statistical, and geoinformatical methods in spatial epidemiology.

Likewise, [redacted]. used the RIF in the performance of spatial analyses for the determination of geographical changes in cancer incidences at [redacted], Ontario, Canada. The standardized incidence ratio of cancer showed various spatial distribution forms. Similarly [redacted] set the RIF in the application of statistical packages linked to it, such as SaTScan.

For elaborate risk analysis, the composition deprivation index (CDI) was taken into account as a potentially confounding factor in this study. [redacted] found that the rate of lifetime asthma-related hospitalization was higher in the lowest income group, using individual and small area indicators of socioeconomic status (odd ratio 6.84 (95% CI: 2.1–22.5)). The approach corroborates the methods used by [redacted] who developed the CDI (Composite Deprivation Index) based on socioeconomic exclusion including the following five dimensions: unemployment, poverty, housing, labor, and social network.

Although this study provides a greater understanding of the health impact of incineration facilities, it also has some limitations that need to be considered. First, the relative risk was calculated based only on the separation distance from incineration facilities and not on the relationship between air pollution emissions and health effects. Having reviewed 41 studies on incinerators, [redacted] suggested an optimal utilization of pollution dispersion models in future studies. Of the reviewed 41 studies, 19 used linear distance as a measure of exposure to incinerators. Second, due to the limitations of data, the study did not adjust for traffic pollution, although traffic is among the major causes of air pollution in Seoul, as well as other air pollution sources such as factories and other land uses relating to air pollution. Thus, further research is needed to consider other covariates that were not included in this research to produce more precise statistical results. Although the buffer zone distance from incinerators was decided based on a previous study that performed the air diffusion modelling of a waste incinerator, the zone did not fit the real emission area. Due to this, the risk may have some potential error. Finally, while the disease risk may vary depending on the characteristics of different incineration facilities such as quantity and type of waste, this study did not consider these issues. Further research needs to focus on each facility and calculate the individual risks of each facility

Sample #5

Results and Discussion

When compared to older incinerators, newer incinerators established after 2000 are considered relatively safe in terms of health effects. Nevertheless, there have been some studies that have linked them to various diseases, such as malignant tumors including soft tissue cancer and non-Hodgkin's lymphoma, reproductive disorders, respiratory diseases, and more. In addition, incinerator workers and local residents are considered to be exposed to dioxins and some heavy metals from the incinerator. Since most studies included subjects exposed to older incinerators, it is difficult to apply these results to the health impact assessment of new incinerators. However, it is not appropriate to conclude that new incinerators made with state-of-the-art technology are safe, as chronic environmental diseases caused by hazardous substances tend to appear only after prolonged exposure. In terms of environmental health, it is necessary to continuously monitor the health effects of incinerators. Also, there is a need to develop a research methodology that can minimize various confounders in incineration-related epidemiological study.

Sample #6

Conclusion

In the present study a new urban mining strategy is proposed for MSWI FA stabilization, based on the reuse of MSWI BA due to its content of amorphous phases. CFA and FGD residues were also used. The stabilization mechanism can be explained based on the ashes and final products characterization results. The pH evaluation, XRD and TEM analysis concluded that carbonation and pozzolanic reactions occurred, promoting stabilization of heavy metals (Pb and Zn). The simplicity of the proposed technology, which requires only the mixing of ashes from the same origin, makes it truly suitable to be applied directly to thermal treatment plants. Consequently, the new proposed strategy for MSWI waste management can be actually considered a zero-waste approach due to production of inert materials. Energy and materials recovery from waste-to-energy plants provides environmental advantages as it saves virgin materials, returns waste materials to the economic cycle and avoids the landfilling of incineration residues. It allows a saving of approximately 2630 t CO2-eq/day. The versatility of the process, which occurs at room temperature and requires the use of wastes produced at the same location, has the following benefits: (1) avoids landfilling of MSWI FA (and some BA residues); (2) avoids the transport of waste to another area for stabilization; (3) saves non-renewable resources and, consequently, safeguards them; (4) saves CO2 emission and sequestrates carbon dioxide due to carbonation reactions with good actions on climate change; (5) produces materials that may be reused as a filler and (6) opens new perspectives markets and business models.

Sample #7

Conclusion

This is the first systematic review that links the literature on exposure assessments (internal and external toxin measurements) to health outcomes. While we recognize that all studies discovered had limitations (only five reached NHMRC criterion C), this review permits assessment of incinerator safety. This review shows contamination of food and ingestion of pollutants is a significant risk pathway for both nearby and distant residents. While occupationally exposed groups have been shown in primary studies to most likely suffer adverse effects, they are a relatively smaller population than all residents in the vicinity of incinerators. Workers may be considered a sentinel population for adverse effects. Incinerator workers are probably also local residents so also subject to exposures outside the workplace. Both local residents ingesting food grown in close proximity to incinerators, as well as more distant populations consuming food transported from areas near an incinerator, are open to exposure. Because most studies in this review examined only a small subset of potential exposure and disease pathways, together with the low quality, it is likely that our review has ‘under-discovered’ the full health-effects picture. This systematic review highlights significant risks associated with waste incineration as a form of waste management. Many older incinerators were linked with neoplasia, reproductive issues and other diseases. While the results were not consistent across the literature, based on a precautionary

principle there is insufficient evidence to conclude that any incinerator is safe. There is some suggestion that newer incinerator technologies with robust maintenance schedules may be less harmful, but diseases from exposures tend to manifest only after many years of cumulative exposure, so it is premature to conclude that these newer technologies improve safety. Incineration for waste management, including waste-to-energy options, is likely to remain an alternative that governments will consider. However, the financial and ecological costs of waste to energy are comparably high. Building reliance on a waste stream for energy counters the need to reduce waste overall. This review suggests that incineration is not without problems and so it is an option that needs to be pursued carefully with close monitoring. Local community groups have a basis for legitimate concern and so siting of incineration facilities needs to take these concerns into account. Early transparent consultation with communities about these facilities is essential.

Sample #8

Results and Discussion

The adverse health effects of carbon monoxide gas *(CO)* and carbon dioxide *(CO2)* generated during the combustion process are well known. In terms of quantities, we can say that every five grams of burned PVC derivatives pollute a cubic meter of air to such an extent that it will surely damage our health. The burning process of mixed waste also produces other toxic compounds, which are fastened to one another and exert their harmful environmental impact. A further problem is that fuel used in household appliances are not designed for burning plastics and other waste, therefore the burning of waste in plants and in flue gas can cause damage. One of the main conditions of the combustion process is the presence of oxygen. The oxygen required for combustion is included. To burn one kg of firewood depending on the variety, 12–16 m^3 of air is needed and to burn waste a much larger quantity is necessary. Since the right amount of air cannot be provided, the lack of air results in an inadequate combustion and the flue may result in large amounts of flue gas deposits. The right amount of air cannot be provided, the resulting lack of air causes inadequate combustion which redounds the flue gas to sediment in flue gas deposits. Evacuation of the fumes during combustion is the task of the flue outlets, commonly called chimneys. In order to achieve sufficient heating efficiency, chimneys should be scaled for the heating system. It is also important to assure air supply for combustion. The combustion equipment and chimney system are designed to burn defined fuels. The deviation from the prescribed is always a risk because they may not develop the flue gas exhaust, and drafts of fresh air needed. The burning of domestic waste involves large amounts of flue gas formation, part of which is deposited in the chimney wall and because of the absence of built-in filtering equipment, the other parts enter the environment. The soot formation in the chimney occurs during strenuous plastic waste, burning rubber derivatives. The incineration of mixed waste causes a significant amount of smoke. The smoke flowing through the chimney cools down continuously. Due to the decrease in temperature, water vapour condenses on the chimney wall from the smoke. The plastic compound for smoke derivatives found in the precipitating liquid is acidic. This acidic fluid, on one hand, damages the chimneys internal plaster – this primarily can be said in the case of masonry chimneys – secondly, it is also a good adhesive surface for the solid particles in the exhaust smoke, including black carbon and also a tar inner layer is formed. Due to the constantly sticking flue combustion products the inside of the chimney narrows, therefore the temperature of the exhaust fumes increases. Due to this temperature increase, the internal temperature of the chimney also rises. After reaching the ignition temperature of the flue combustion products deposited in the chimney they ignite and a chimney fire occurs. The internal temperature can reach 1,000 ºC while burning. We have already mentioned the adverse effects of toxic gases arising from the combustion of plastics above, it should also be mentioned that the soil and the aquatic environment suffer from the effects of combustion products. While the combustion of solid combustion products of plastics, ashes, soot and various powders are formed, which settle on the ground objects such as plants or soil, they may appear in the aquatic environment. Rainfall causes blurred toxic substances entering the soil, exerting further polluting effects which allows these substances to become incorporated into the food chain. Some of the contaminants chemically react with water and resulting compounds alter the pH and thereby change the functioning of aquatic ecosystems. Non-soluble compounds added to the food chain exert their harmful effects.

Sample #9

Results and Discussion

Economic potential of Zn and critical elements locked in Swedish fly ash

Estimations based on the annual amount of Swedish waste fly ash give the potential value of Zn is about 7 million Euro, assuming a Zn metal price of 1.2 Euro/kg^2. Consequently, there are large values that are not utilized. The amount of critical metals in fly ash from waste to Energy plants in Sweden 2012 is given in Figure 1.

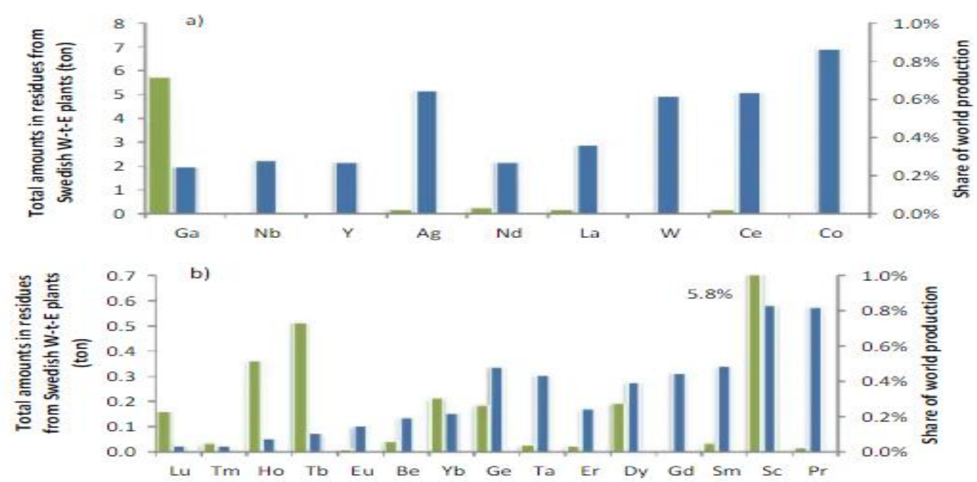


Figure 1: The amount of critical metals in residues from Swedish waste-to-energy plants in 2012. a) The total amount is above 1 ton/year and b) below 1 ton/year. Green bars indicate how large part of the world production the different amounts constitute. The results indicate the potential of fly ash from Sweden as a relevant source for some of the critical metals identified by the [redacted] (Figure 1). The amounts constitute up to 5.8% of the world production (Figure 1). Although the respectively amounts in totals are high (Figure 1) the contents in the ash are generally lower than the contents in the average earth crust (results not shown). Exceptions are antimony, cobalt, silver, tantalum and wolfram with higher content in the fly ash than in the average earth crust. The value of the analyzed critical metals in their pure form is about 140 Meuro/year (Figure 1; pricing MetalPrices.com; 2012). Lutetium, magnesium, scandium and thulium contribute to a large part of that potential. Magnesium is present in large amounts (11900 ton/year) while the others have a very high market price (in pure metallic form). Combined with Zn the value

locked in fly ash is approximately 200 Meuro/year in Sweden only. Sampling and analysis of Zn and critical metals from 8 and 10 waste to energy plants respectively has been reported in technical reports.

The feasibility of recovering all these metals remains to be assessed. Magnesium recovery from fly ash is explored by Latrobe Magnesium (Australia) aiming at production of 5000 tons/day in 2016 with a 95% recovery rate at laboratory scale4. Zn recovery from fly ash has been demonstrated at commercial scale in Zuchwill, Switzerland with the capacity of producing 1-ton high-grade Zn/day with the so called FLUREC method5. Pilot scale tests treating 100 kg/h fly ash have also been performed in Sweden. 70% of the Zn could be leached using a one-step leaching procedure with a leaching. The recovered Zn was in the form of a filter cake containing 50-80% zinc hydroxide. The economic feasibility for this zinc hydroxide process depends on the Zn prices, the classification of the ashes and the landfilling costs. Preliminary results also show the technical feasibility of re-circulation of the ash residue to the incineration process with more than 90% of the re-circulated fly ash residue ending up in the bottom ash. Landfilling the residue is an alternative since it fulfilled the requirements for non-hazardous waste for all elements except for Sb. Further research on stabilization of the ash residue is needed. The pilot scale tests have been reported in technical report by [redacted]. 2016.

Environmental potential of mining Zn and Mg from fly ash

The process costs of metal recovery from fly ashes are high due to the relatively low contents and the fact that the metals are often present in complex chemical compounds, which makes the economics challenging. However, the benefits on the environment can be higher and there are therefore potential savings on the society cost. To illustrate this potential, a literature review on carbon and water footprint of primary mining of Zn and Mg were performed (Figure 2.)

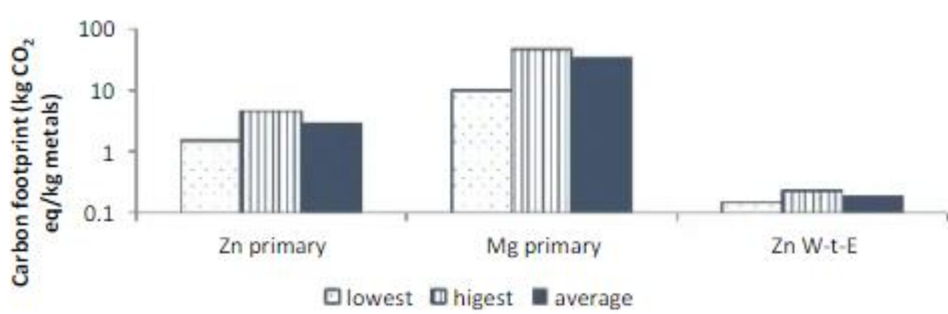


Figure 2: Carbon footprint of Zn7 and Mg8 from primary sources based on literature and of Zn production from fly ash from Waste-to-Energy plants in Sweden (0.23 kg CO2 eq/kg Zn; estimated values) and with the FLUREC process in [redacted] The data shows that primary mining has significant negative impact on the greenhouse gas emissions and water although the data can vary a lot between plants (Figure 2). If the metals life span in the economy can be prolonged with recycling in Waste-to-Energy plants, the greenhouse gas

emissions can be reduced 7-20 folds (Figure 2). Water footprint can also be significantly reduced from primary mining, which reach 370 L water/kg Zn10 and 10-47 L water/kg Mg8 for primary mining. the proposed Swedish process is closed. Inlet water is waste water from incineration and can technically be upgraded to high standard after the process and recirculated to a large extent. Obvious benefits are also to be found in waste reduction and reduced land use change and acidification but these are not quantified in this report.

Sample #10

Conclusion

The aim of this study was to estimate the association between exposure to a MSWI and adverse reproductive outcomes. One of the key features of the study was the use of dispersion models for assigning exposure to the MSWI and to other sources of pollution located in the area. In addition, the study design enabled the exposure to be attributed to the different sources at an individual level. Finally, individual maternal characteristics were also considered. The adopted methodology is consistent with the recent suggestions about the epidemiological investigation on health effects associated to MSWI exposure, including the use of atmospheric dispersion modelling for a more accurate exposure assessment, the adequate control for confounding related to other pollution sources and individual characteristics**.** In our model, mother's educational level and a census tract-based deprivation index were included, which allowed us to partially adjust for unavailable individual variables such as occupational exposure and smoking, and reasonably reduce a possible bias. Single-site studies, as the one here presented, are commonly characterized by a small population size often leading to models endowed of a low statistical power. Considering that the adverse reproductive outcomes are quite rare events, the risks estimated in our study can be affected by low precision. The study area presents an overall complex environmental framework and the overlap of the different sources of air pollution could lead to a misclassification of the individual exposure. Modeled PM10 concentrations from the MSWI of San Zeno were quantitatively low and have been considered as a tracer for evaluating the level of environmental exposure in relative terms, consistently with other recent epidemiological studies on MSWIs. The simulation models used in our study for the exposure assessment were based on data available only for the year 2007. The assumption of lack of temporal variability of exposure is likely supportable by the fact that major changes of operating conditions of the MSWI plant in 2001-2010 are not documented by its monitoring systems. In our study we observed a risk of preterm birth with an increased exposure to the MSWI. The strength of the association increases if births to primiparous mothers are selected. The association between preterm birth and exposure to waste incinerators is investigated by the scientific community in a limited way. In the systematic review by [redacted] only one study about this birth outcome was reported. The study was conducted in Taiwan in 2006 by [redacted] and detected a slight increase of preterm birth. A more recent [redacted] study by [redacted]. detected strong evidence of an association between exposure to MSWIs and preterm birth. Furthermore, an association between exposure with incinerator emissions and the occurrence of miscarriages has recently been reported by the same Authors, who suggested interpreting this finding together with previous results on the risks of preterm birth. Although we detected slight evidence of risk of preterm birth, the result is consistent with results previously found in the multisite study by [redacted]. characterized by an analogous study design. Preterm birth is an outcome poorly investigated on specific association with exposure to MSWIs but some suggestive associations with sources of air pollution are also reported in recent studies. Premature birth is an important public health issue. The [redacted] includes complications related to preterm birth among the main indirect causes of neonatal mortality, mortality in children under 5 years old, and long-term disability. Spontaneous preterm delivery is recognized as a multi-factorial process, caused by the interaction of several factors. This includes the role of environmental causes, and the potential role of genetic- environment interactions in increasing the risk of preterm birth is considered as a research priority in this field. It is our belief that the results of this present study reinforce the recommendation to consider age of gestation as an end-point in epidemiological studies as well as surveillance activities in areas with waste incinerators and other sources of air pollution. Even if the scientific evidence is considered limited, public health policies should reinforce reproductive health promotion and surveillance, especially in area.

Appendix 2: Coding Draft

Sample #	Code	Significant Words or Phrases (Codes)	Themes
Sample #1	IC	*Increased treatment costs *Low energy recovery *Low evaluation of waste value	**Cost**
		*Effective fuel replacement	**Efficient**
		*High profit	**Profitable**
Sample #2	IE	*Global warming *Acidification *Dioxin emission	**Environmental consequence**
Sample #3	IE	*Technology advancement to improve environmental impacts.	**Technological**
Sample #4	IH	*Asthma-related admissions within 2 km and between 2km and 5 km of the incineration facilities. *Proximity to incinerators and respiratory symptoms was inconclusive. *Diseases may vary depending on the characteristics of different incinerators.	**Health risk**
Sample #5	IH	*Exposure to dioxins and heavy metals. *Tumors, reproductive disorders and respiratory diseases	**Health risk**
Sample #6	IC	*Zero-waste approach due to production of inert materials. *Saves non-renewable resources *Produces materials that may be reused as a filler.	**Efficient**
		*Opens new perspective markets and business models.	**Profitable**
		*Higher initial investment	**Cost**
Sample #7	IH	*Food contamination and ingestion of pollutants of both nearby and distant residents.	**Health risk**

		*Older incineration was linked with neoplasia and reproductive issues.	**Health risk**
Sample #8	IE	*Mixed waste produces other toxic compounds.	**Pollutes**
		*Inadequate combustion result in large amounts of flue gas deposits.	
		*Absence of built-in filtering equipment may allow pollutants enter the environment.	**Pollutes**
		*Soil and aquatic environment suffer from the effects of combustion products.	**Environmental consequence**
		*Rainfall causes blurred toxic substances entering the soil, exerting further polluting effect which allows these substances to become incorporated into the food chain.	**Environmental consequence**
Sample #9	IC	*Fly ash as a potential source of critical metals (Lutetium, Magnesium, Scandium, Thulium, Zinc)	**Profitable**
Sample #10	IH	*Associated with preterm birth and miscarriage.	**Health consequence**
		*Air pollution	**Environmental consequence**

Appendix 3: Coding with frequency

Sample #	Significant Words or Phrases (Codes)	Themes	Frequency
Sample #1	*Increased treatment costs *Low energy recovery *Low evaluation of waste value	**Cost**	3
	*Effective fuel replacement	**Efficient**	1
	*High profit	**Profitable**	1
Sample #2	*Global warming *Acidification *Dioxin emission	**Environmental consequence**	3
Sample #3	*Technology advancement to improve environmental impacts.	**Technological**	1
Sample #4	*Asthma-related admissions within 2 km and between 2km and 5 km of the incineration facilities. *Proximity to incinerators and respiratory symptoms was inconclusive. *Diseases may vary depending on the characteristics of different incinerators.	**Health risk**	3
Sample #5	*Exposure to dioxins and heavy metals *Tumors, reproductive disorders and respiratory diseases.	**Health risk**	2
Sample #6	*Zero-waste approach due to production of inert materials. *Saves non-renewable resources *Produces materials that may be reused as a filler	**Efficient**	3
	*Opens new perspective markets and business models.	**Profitable**	1
	*Higher initial investment	**Cost**	1

Sample #7	*Food contamination and ingestion of pollutants of both nearby and distant residents.	**Health risk**	2
	*Older incineration was linked with neoplasia and reproductive issues.		
Sample #8	*Mixed waste produces other toxic compounds. *Inadequate combustion result in large amounts of flue gas deposits. *Absence of built-in filtering equipment may allow pollutants enter the environment.	**Pollutes**	3
	*Soil and aquatic environment suffer from the effects of combustion products. *Rainfall causes blurred toxic substances entering the soil, exerting further polluting effect which allows these substances to become incorporated into the food chain.	**Environmental consequence**	2
Sample #9	*Fly ash as a potential source of critical metals (Lutetium, Magnesium, Scandium, Thulium, Zinc).	**Profitable**	1
Sample #10	*Associated with preterm birth and miscarriage.	**Health consequence**	1
	*Air pollution	**Environmental consequence**	1

Appendix 4: Letter of Permission

HOLY CROSS COLLEGE OF CALINAN, INC
Davao—Bukidnon Highway, Calinan Poblacion, Davao City

November 22, 2021

Ma. Corazon Suñga, PhD
B.E.D. Principal
This Institution

Dear Ma'am:

Greetings of peace and solidarity!

We are writing this letter to inform you that we will be conducting a research study entitled: **Waste to Energy: Impacts on Health, Environment, and Economy** as the major requirement in our Practical Research 1 and 2. This study aims to consider waste incineration as part of better waste management, thus, providing a solution on lessening the waste that is overfilling landfills. The researchers will use content analysis as the method on gathering data.

In line with this, we would like to ask permission to conduct our research and our gathering of data using researches found on the internet.

During the gathering of data, the researchers will abide by the ethical considerations, the autonomy, and transparency of the authors and their researches.

Should you wish to know more about the study, please feel free to contact:
Jestha Hanna O. Rabang - 09120014406

Thank you very much.

Very truly yours,

Jestha Hanna O. Rabang
Researcher

Ruzz Yuri T. Obenza
Researcher

Jannel D. Destrajo
Researcher

Kimberly Marie T. Nisnea
Researcher

Vincent Jay S. Manalili
Researcher

Noted by:

Mrs. Jessica O. Rabang
Research Adviser

Approved by:

Ma. Corazon C. Suñga, PhD.
B.E.D. Principal

Appendix 5: Editor's Certificate

Holy Cross College of Calinan
Davao- Bukidnon Highway, Calinan Poblacion, Davao City
RESEARCH AND PUBLICATION OFFICE

CERTIFICATION

This is to certify that the research paper of **Jestha Hanna Rabang, Jannel Destrajo, Ruzz Yuri Obenza, Kimberley Marie Nisnea, and Vincent Jay Manalili**, entitled **WASTE TO ENERGY: ITS VIABILITY AND IMPACT ON HEALTH, ENVIRONMENT, AND ECONOMY** has undergone the editing process and been approved by the undersigned.

This certification is issued upon the request by the researchers on July 22, 2022.

RIZALITO H. PAGA, PhD.
Editor

CURRICULUM VITAE

Name: Jestha Hanna O. Rabang

Age: 17 years old

Date of Birth: May 12, 2004

Place of Birth: Davao City

Civil Status: Single

Citizenship: Filipino

Religion: Roman Catholic

Sex: Female

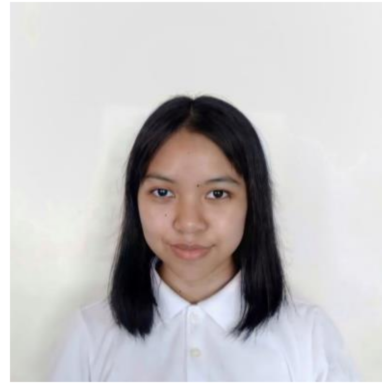
Father's Name: Joseph Thaddeus R. Rabang **Occupation:** Self-employed

Mother's Name: Jessica O. Rabang **Occupation:** Teaching

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Holy Cross College of Calinan	2016

CURRICULUM VITAE



Name:	Jannel D. Destrajo		
Age:	18 years old		
Date of Birth:	June 08, 2003		
Place of Birth:	Purok 6- Tamayong Calinan, Davao City		
Civil Status:	Single		
Citizenship:	Filipino		
Religion:	Roman Catholic		
Sex:	Female		
Father's Name:	Leopoldo M. Destrajo	**Occupation:**	Laborer
Mother's Name:	Ma. Teresita D. Destrajo	**Occupation:**	Housewife

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	St. Francis College of Davao, Inc.	2020
Elementary	St. Francis College of Davao, Inc.	2016

CURRICULUM VITAE

Name: Ruzz Yuri T. Obenza

Age: 19 years old

Date of Birth: January 04, 2003

Place of Birth: Davao City

Civil Status: Single

Citizenship: Filipino

Religion: Roman Catholic

Sex: Male

Father's Name: Jeoffrey A. Chua **Occupation:** Businessman

Mother's Name: Heidi T. Obenza-Chua **Occupation:** Baker

EDUCATIONAL ATTAINMENT

	School	**Year Graduated**
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Philippine Nikkei Jin Kai School of Calinan	2019
Elementary	Philippine Nikkei Jin Kai School of Calinan	2016

CURRICULUM VITAE

Name: Kimberly Marie T. Nisnea

Age: 17 years old

Date of Birth: September 07, 2004

Place of Birth: Calinan, Davao City

Civil Status: Single

Citizenship: Filipino

Religion: Roman Catholic

Sex: Female

Father's Name: Ruben P. Nisnea **Occupation:** Mechanic

Mother's Name: Maria Fe T. Nisnea **Occupation:** Teaching

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	General Roxas Central Elementary School	2016

CURRICULUM VITAE

Name: Vincent Jay S. Manalili

Age: 17 years old

Date of Birth: March 21, 2004

Place of Birth: Calinan, Davao City

Civil Status: Single

Citizenship: Filipino

Religion: Roman Catholic

Sex: Male

Father's Name: Cesar II S. Manalili **Occupation:** Farmer

Mother's Name: Rowena S. Manalili **Occupation:**Office Warehouse Staff

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Holy Cross College of Calinan	2016