SESHATA

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SESHATA

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Seshata

The Official Research Journal of Holy Cross College of Calinan, Inc.

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About the Journal

Seshata: The official student research journal of Holy Cross College of Calinan, Inc. is an annual compendium of the research projects of the Senior High School and College udents in the field of science, mathematics, education, social science, business, marketing, and arts. This is published by the school's Research and Publication Office in cooperation with the Basic Education and College departments. This journal is basically committed to recognize the efforts of the students who painstakingly conducted their research works, to publicize research-based data that would be a good source of information for innovation and improvement, and to motivate other students to venture into a more challenging research which is a good opportunity for them to develop fully their scientific and technical skills.

About the Title

SESHATA is the Egyptian goddess of knowledge, writing, and wisdom. Her name was purposely chosen as the title of this journal to represent the qualities needed in doing a research. In order for the students to produce quality research outputs, they must be knowledgeable of the subject under study. Ergo, they have to read, read, and read. Then, they have to sensibly and rightfully put together all their ideas into writing. The last quality is wisdom, the resultant of the application of all the knowledge they learned.

About the Cover

Through the years, research endeavors have been evolving with much consideration on the utilization of different technologies to make research outputs more valid and reliable. The student in the cover represents

the researchers who long for knowledge and skills and who embrace the usefulness of technology in research. Therefore, with the technological resources we have, they will help us achieve a more accurate and time-efficient research work.

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PREFACE

The Seshata Student Research Journal, Volume 1 issue highlights different scholarly works in various fields conducted by the senior high school and college students of Holy Cross College of Calinan, Inc. This journal features six sections that present studies in the fields of natural science, mathematics, social science, education, business, and marketing.

Section 1 presents research outputs focused on natural science like determining the presence of salmonella in food, assessing water quality, and improving solid waste management.

Section 2 highlights studies that delve into using mathematical models. Such researches include forecasting the number of enrollees using ARIMA, assessing the effectiveness of Quickest Flow Model in lessening evacuation time and determining the optimal locations of CCTV cameras in HCCC.

Section 3 features research works that deal with issues happening in the society. Phenomena that were considered in the research are the lived experiences of street dwellers and the Pantawid Pamilyang Pilipino Program (4 P's).

Section 4 reveals studies that discuss issues in education. More specifically, they tackle the multiple intelligences of students, and mother-tongue and the efficiency of students in using English and Filipino.

Section 5 shows a study that focused on establishing a business like mobile food truck business.

Section 6 provides information through a research work on how to market a business. It is featured in this study the forms and styles of marketing strategies used by the school.

ASSESSING THE CAPACITY OF THE NEW CARMEN SANITARY LANDFILL TO HOLD THE SOLID WASTE GENERATED VIS-À-VIS THE POPULATION GROWTH FOR THE NEXT FIVE YEARS

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ABSTRACT

Solid waste generation and population growth are massive issues that cover worldwide. Population growth has demonstrated a direct relationship with an increase in waste generation, which affects the stability of the dumping sites and challenges the government in managing waste. This research aimed to assess the capacity of the New Carmen Sanitary Landfill to hold the solid waste generated vis-à-vis the population growth for the next five years. It was quantitative in nature and used the descriptive type of research design. Descriptive statistics such as Line Plot, Autoregressive Integrated Moving Average (ARIMA), and Ratio and Proportion were utilized to analyze the data. The data were obtained from the City Environment and Natural Resources Office (CENRO) and Philippine Statistics Authority (PSA). Findings showed that the solid waste generation and the population growth of Davao City in the past eleven years are increasing trends. Also, the forecasted solid waste generation and the population growth for the next five years will expand, with growth rates of 58.12% and 11.31%, respectively. Correspondingly, the total capacity of the existing and proposed landfills is not greater than or equal to the predicted solid waste generation. In conclusion, it suggested that the projected solid waste generation of Davao City will surpass the capacity of the New Carmen Sanitary Landfill for the next five years. With that, the researchers recommended that policymakers can further strengthen the enforcement and

application of the initiatives to mitigate the rise of population and trash production.

Keywords: *solid waste generation, population growth, landfill, New Carmen Sanitary. Landfill, Davao City, Line Plot, ARIMA, Ratio and Proportion*

INTRODUCTION

Background of the Study

Even before, inappropriate trash disposal, poor waste collection, and shortage of disposal sites stayed massive issues in the solid waste management (SWM) of the Philippines, particularly in metropolitan locations (Senate of the Philippines, 2017). Idaho Public Health (2022) stated that any discarded substance thrown off, burned, recycled, or regarded as "trash-like" is considered solid waste. Leblanc (2020) also added that solid waste is produced from industrial, residential, and commercial activities in a particular area. As a result, landfills are often divided into four categories: sanitary, municipal, construction and demolition, and industrial waste sites.

Gee (2018) asserted that population growth refers to the change in population size over time based on the balance of births and deaths. Many individuals are concerned that uncontrolled population growth may eventually result in a disaster for the environment (Australian Academy of Science, 2015). Meanwhile, there have been reports stating that as the population of the world increases, so does the amount of trash generated. Therefore, this poses a challenge for the authorities in managing waste, which might strain the condition of the environment and may eventually result in a significant effect on humankind and wildlife (Wowrzeczka, 2021).

Waste generation rates are increasing all around the world. In 2016, cities worldwide created 2.01 billion tons of solid waste, or 0.74 kilograms per person daily. Annual waste generation is anticipated to increase by 70% from 2016 to 3.4 billion tons in 2050 due to the growing population and urbanization (World Bank, 2022). Further, Ellis (2018) stated that rich countries like the United States, Canada, and the European Union members accounted for only 16% of the global population yet created 34% of global trash. Additionally, the United States produces the most garbage per capita globally, generating an average of 808 kilograms per year with each individual and more than twice that of Japanese citizens (Sensoneo, 2022).

Like many rapidly developing countries, the Philippines grapples with unsustainable plastic generation and insufficient SWM infrastructure. Every year, the country produces 2.7 million tons of plastic waste, an estimated 20% in the ocean (World Bank, 2021). Moreover, the National Solid Waste Management Commission (NSWMC) estimated that the country would generate 23 million tons of trash in 2020 (Sarmiento, 2018). Relative to this, Kangasmäki (2022) explained that Metro Manila had the highest population density, with over 13 million people as of 2019. More than 10,000 tons of trash are produced daily in the region, and is anticipated to double by 2030. A substantial percentage of this waste is either openly burnt or disposed of in rivers, creeks, and Manila Bay, aggravating the pollution in the city.

Davao City is not excused from these kinds of problems as it also contributes to waste generation annually. The Interface Development Interventions (IDIS) reported that the city generated 1,012 tons of waste daily, based on the 2018 statistics from the City Environment and Natural Resources Office (CENRO). Moreover, the city landfill in Carmen, Tugbok District, only has a capacity of 700,000 to 800,000 tons. Still, it has already surpassed almost 900,000 tons, according to an IDIS policy advocate ("Editorial: Davao", 2019). Additionally, Llemit (2021) reported that the average volume of collected waste in the city had been approximately 600 to 650 tons per day since the COVID-19 pandemic reached its location in March 2020 until the present.

Consequently, since factors such as population growth have demonstrated a direct relationship with an increase in waste generation, this could affect the stability and capacity of the dumping sites and challenge the government in managing waste. Moreover, according to recent reports from CENRO, a new dumping site will be opened at the exact location. These aspects encouraged the researchers to conduct a study on this matter. Hence, this research aimed to assess the capacity of the New Carmen Sanitary Landfill to hold the solid waste generated vis-à-vis the population growth for the next five years.

Statement of the Problem

This study generally aimed to assess the capacity of the New Carmen Sanitary Landfill to hold the solid waste generated vis-à-vis the population

growth for the next five years. Specifically, this sought to answer the following questions:

1. What are the annual solid waste generation and the population growth of Davao City in the past eleven years, from 2011 to 2021?

2. What are the forecasted solid waste generation and the population growth of Davao City for the next five years, from 2022 to 2026?

3. What is the capacity of the New Carmen Sanitary Landfill?

4. Can the New Carmen Sanitary Landfill still hold the forecasted solid waste generation of Davao City for the next five years?

METHODS

This chapter discussed the research design and procedure the researchers utilized to carry out this study. Further, it covered the sources of data, the locale of the study, the process of gathering the data, the ethics that need to be considered, and the research data analysis.

Research Design

This study was quantitative in nature and used the descriptive type of research design. Watson (2015) defined quantitative research as a type of study that includes a variety of techniques that uses statistical or numerical data to investigate social phenomena systematically. It also aims to analyze data for trends and relationships and validate the measurements. Meanwhile, Sahin and Mete (2021) explained that descriptive research is a form of non-experimental research that describes the characteristics of the population or phenomenon under study. With this methodology, the "what" is given more attention than the "why" of the research topic.

Therefore, the descriptive research design was applicable in this study since it aimed to assess the capacity of the New Carmen Sanitary Landfill to hold the solid waste generated vis-à-vis the population growth for the next five years. It also used scientific methods to make detailed observations and document the variables under study. Moreover, researchers could use quantitative data to perform simple to highly complex quantification and analysis of variables to arrive at conclusions about the issue.

Data Source

Research data are facts that researchers must gather to achieve the research goals. These are collected using various scientific techniques and tools. There are different methods for collecting data: the researcher might use observation, interview, survey questionnaire, documentary, and other approaches depending on the study goal and its limitations. Further, raw data are information from numerous sources and methods (Baral, 2017).

In this study, the researchers acquired the needed data from government offices. Specifically, the researchers obtained the data for the population growth of Davao City from 2011 to 2021 from the Philippine Statistics Authority (PSA). Then, the researchers acquired the data for the solid waste generation of Davao City from 2011 to 2021 and the capacity of the New Carmen Sanitary Landfill from the City Environment and Natural Resources Office (CENRO).

Research Locale

This study was conducted within the vicinity of Davao City, the third-largest city in the Philippines and the most populated city in Mindanao. It is the home of the first Mindanaoan president, Rodrigo Roa Duterte. Known for its thriving economic activities, urban development, and contemporary facilities, Davao City is also one of the largest producers and exporters of exotic fruits such as durian and mangosteen. Its top attractions are the Philippine Eagle, one of the most massive eagles in the world, which can be an unforgettable experience for visitors of all ages.

According to Raine Catague, the capacity of the city landfill in Carmen, Tugbok District, is only 700,000 to 800,000 tons, but it has already exceeded over 900,000 tons ("Editorial: Davao", 2019). Moreover, according to recent reports from CENRO, the government will open a new dumping site at the exact location. Hence, the target area of the researchers was in New Carmen Sanitary Landfill, located explicitly in Davao City, and regions outside its geological map were not included. For more information on the location, refer to the picture below.

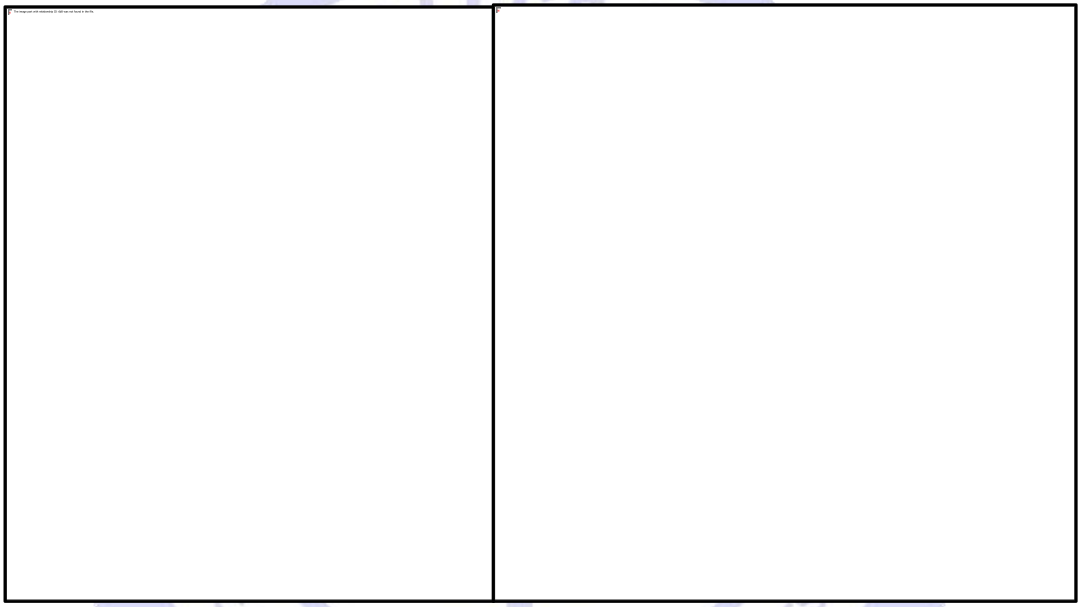

Figure 2. Research Locale

Data Gathering Procedure

This study followed some procedures for the researchers to attain the objectives. The researchers first sought approval from the school principal and the school president to conduct this study by giving a letter of permission. Also, the researchers submitted a letter to the City Environment and Natural Resources Office (CENRO) to ask for approval to get the data, particularly the annual solid waste generation of Davao City from 2011 to 2021 and the capacity of the New Carmen Sanitary Landfill. Then, the researchers prepared another letter for the Philippine Statistics Authority (PSA) to ask for their consent to obtain the data, specifically about the

population growth of Davao City from 2011 to 2021. After acquiring the data needed, the researchers compiled and sealed them for further analysis, computation, and interpretation.

Ethical Considerations

According to DePoy and Gitlin (2016), research ethics is a concept that most commonly refers to guidelines for proper behavior during research thoughts and action processes, specifically human subject protection. Thus, ethical considerations play a vital role in promoting the aim of the researchers in this study, such as knowledge, truth, and error avoidance. As studies frequently require considerable collaboration and coordination among individuals from many fields and organizations, the researchers applied the qualities and ethical principles vital to the study, such as social justice, honesty, and confidentiality.

Social Justice is one of the fundamental principles of research dictating that all individuals should have equal rights and opportunities. It fosters societal equity and fairness (Online MSW Programs, 2022). Further, Mollenkamp (2022) explained that it is a subtype of justice that refers to the division of resources, opportunities, and advantages. Its perspectives emphasize the role of fairness or impartiality in how those things are distributed. Hence, this study has a social significance or value, for it talked about the survival of beings and involved the environment.

Honesty is an ethical obligation that entails being accurate and truthful about oneself, personal work, and the work of others (American Speech-Language-Hearing Association, 2018). Resnik (2020) stated that it is crucial to strive for honesty in all scientific communications, accurately describe the information, findings, methods, and status of publications, and avoid making up, falsifying, or representing data incorrectly. In this study, the researchers should avoid manipulating the data gathered to maintain the integrity and objectivity of the research. Correspondingly, the tables, graphs, figures, numbers, and information should remain the same and not be tampered with by any change.

Confidentiality is an ethical duty that refers to the obligation of the researchers to keep private information secure and protect against illegal access, use, disclosure, alteration, loss, or theft (Government of Canada, 2018). It is also defined as protecting private correspondence, including papers or grants submitted for publication, employee records, trade, and

patient records (Resnik, 2020). In this study, the needed data may be sensitive to be acquired for the public, which is why a consent form with complete details and objectives of the study should be submitted and approved before the organizations involved can cooperate and give the necessary data. Moreover, confidentiality must be maintained wherein the researchers must safeguard the data to ensure the privacy of information.

Data Analysis

The researchers used the Line Plot to address research question 1 in determining and analyzing the trend and frequency of each variable. Peters (2021) asserts that line plots connect separate data points with lines, displaying quantitative values over a set time interval. It is used to visualize changes over time and as a comparison tool to contrast differences for more than one group.

On the other hand, the researchers used another forecasting method the called Autoregressive Integrated Moving Average (ARIMA) for research question 2 to predict the possible amount of each variable. ARIMA model is used in statistics and econometrics to quantify events that occur over time. It is a type of regression analysis that measures the strength of one dependent variable with other variables that change. In a series, the model is used to interpret previous data or forecast future data (Hayes, 2021). Specifically, the researchers applied lag differencing to the non-stationary Line Plots. With this, the p, d, and q values were set by visual inspection of the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF). Then, the researchers used auto.arima function to identify the possible best-fit models. After identifying five candidates of models, the Aikake Information Criterion (AIC) was compared. The model with the least AIC value was used to forecast the variables.

Moreover, the researchers employed no statistical tools to research question 3 since the needed data from the City Environment and Natural Resources (CENRO) already provided the answer. Lastly, the researchers employed the Ratio and Proportion to address research question 4 in assessing the capacity of the New Carmen Sanitary Landfill based on the forecasted solid waste generation. The concept of ratio and proportion are crucial in mathematics and many other academic disciplines. Many phenomena may be described as a proportionate connection between certain factors, which produces a brand-new, original entity. Mathematical

awareness is facilitated by conceptualization, knowledge, abilities, and expertise with these ideas. More significantly, these abilities support relational or proportional reasoning, which is essential for the growth of analytical mathematical reasoning (Ben-Chaim, Keret, & Ilany, 2012).

Chapter 3

RESULTS AND DISCUSSION

This chapter contains the results and discussion after the collection of data and their analysis. This chapter also answered the questions found in the statement of the problem of this research paper.

Research Question Number 1: What are the annual solid waste generation and the population growth of Davao City in the past eleven years, from 2011 to 2021?

Figure 3. Solid Waste Generation of Davao City from 2011 to 2021

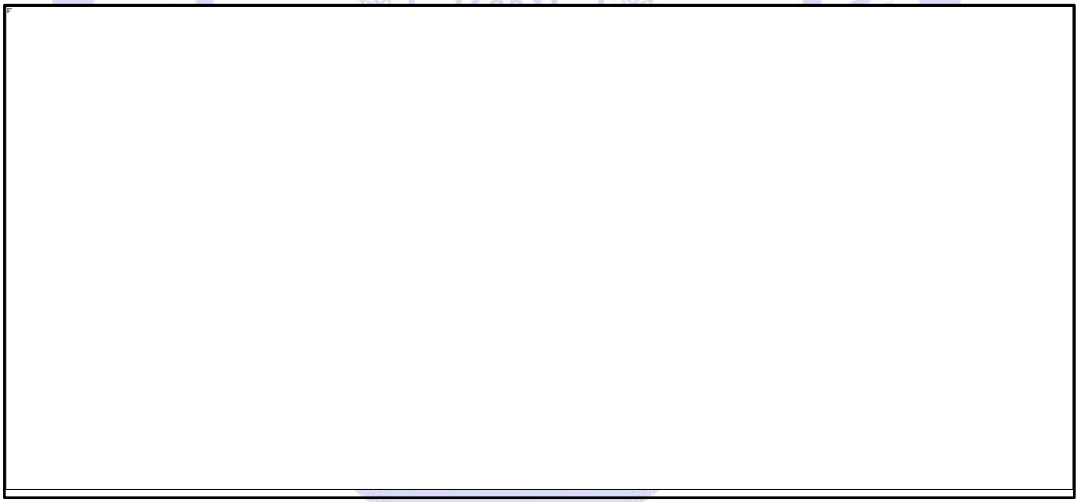

Figure 3 shows the Line Plot of the solid waste generation in Davao City from 2011 to 2021. Remarkably, this graph presented one significant trend, which could be seen from 2011 to 2021. This graph segment showed an increasing trend with a growth ranging from 436,218.00 cu.m to 750,958.62 cu.m each year, making the solid waste generation 457,960.00 cu.m in 2011 and 6,371,878.82 cu.m in 2021. Nevertheless, certain data points decreased in growth since variations in the trend can be observed in the figure, which is considered white noise. From this, it implies that the

solid waste generation in Davao City in the past eleven years has been continually increasing.

The increasing trend of solid waste generation can be seen in various studies and observed in some countries. Tiseo (2022) asserted that millions of tons of trash are produced annually by humans, which has become a massive problem on a global scale. It has been further supported by his later investigation, which found that China generates more than 15% of municipal solid waste (MSW) in the world (Tiseo, 2021). Specifically, the volume of waste in the nation has rapidly increased, reaching 242 million tons in 2019 during the previous few decades (Statista Research Department, 2022). Kumar et al. (2017) also discovered that the urban areas in India presently produce about 170,000 tons of waste each day or 62 million tons yearly, which is expected to increase by 5% annually. Moreover, Al-Maaded et al. (2012) stated that Qatar generates a considerable amount of solid waste per person in the world and produces about 2,000,000 tons of MSW yearly or 2.5 kg of garbage per person.

Figure 4. Population Growth of Davao City from 2011 to 2021

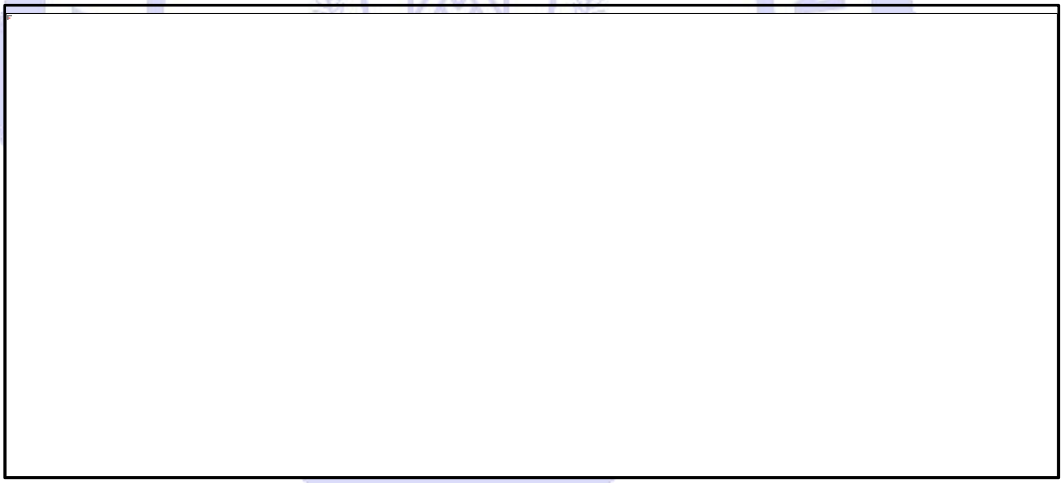

Figure 4 shows the Line Plot of the population growth of Davao City from 2011 to 2021. Remarkably, this graph presented one significant trend, which could be seen from 2011 to 2021. This graph segment showed a constantly increasing trend with a growth ranging from 34,250 to 40,951 each year, making the population 1,488,244 in 2011 to 1,866,401 in 2021. From this, it implies that the population growth of Davao City in the past eleven years has been continually increasing.

The direct trend of population growth and solid waste generation coincides with various studies stating that the amount of waste produced increases along with the rise of population. It can be seen from the studies of Bish (2020) and Marshall and Farahbakhsh (2013) that as the urban population keeps increasing, the consumption of resources grows, which may worsen the risk of environmental damage and could make solid waste management (SWM) an issue to be concerned about. Further, the same scenario is observed in the Philippines, where the nation generates more solid waste as its population, living standards, and urban and rural areas expand (Mawis, 2019). As a result, population growth and waste production in urban settings have demonstrated a relationship such that human settlements can produce a significant amount of solid waste (Omololu & Lawal, 2013).

Research Question Number 2: What are the forecasted solid waste generation and the population growth of Davao City for the next five years, from 2022 to 2026?

Table 1. Top Five Models for Solid Waste Generation

Models	AIC
ARIMA (0,2,2)	27.26
ARIMA (1,2,0)	28.71
ARIMA (0,2,3)	29.26
ARIMA (2,2,3)	29.89
ARIMA (2,2,2)	30.01

Auto-regressive Integrated Moving Average (ARIMA) was used to model the solid waste generation of Davao City using the data from 2011 to 2021. Further, the Akaike Information Criterion (AIC) was used to identify the best model specification to model the dataset. Table 1 shows that ARIMA (0,2,2) has the lowest AIC score, with a value of 27.26 among the models considered by the researcher. From this, it suggests that ARIMA (0,2,2) may be regarded to forecast the solid waste generation of Davao City for the next five years.

Table 2 shows the forecasted solid waste generation of Davao City from 2022 to 2026 in millions. These values were predicted using the ARIMA model with p, d, and q values of (0,2,2). In 2022, the forecasted

solid waste generation will be 7,094,300 ± 155,800 cu.m; the value 155,800 is the margin of error, and 7,094,300 is the point forecast.

Table 2. Forecasted Solid Waste Generation for 2022 to 2026 using ARIMA (0,2,2)

Year	95% Confidence Interval (In Millions)
2022	7.0943 ± 0.1558
2023	7.8395 ± 0.2204
2024	8.5847 ± 0.3606
2025	9.3299 ± 0.5497
2026	10.0751 ± 0.7738

Adding and subtracting the point forecast with the margin of error will result in its high value of 7,250,100 and low value of 6,938,500, which is the forecast interval. In 2023, the forecasted solid waste generation will be 7,839,500 ± 220,400 cu.m. In 2024, the predicted solid waste generation will be 8,584,700 ± 360,600 cu.m. In 2025, the forecasted solid waste generation will be 9,329,900 ± 549,700 cu.m. Lastly, in 2026, the predicted solid waste generation will be 10,075,100 ± 773,800 cu.m. With this, it implies that the forecasted solid waste generation of Davao City for the next five years will still be in an increasing trend, with a percentage growth of 58.12%. For the visual representation, refer to Appendix 6.

Similar conditions are evident in some countries and the findings of several studies with the increasing trend of solid waste generation. Olalo et al. (2022) found that the rising waste production and a lack of waste-related infrastructure would likely impact Davao City. As its population and economy grow, more waste is being produced in the city. Also, according to the Senate Economic Planning Office (SEPO), the amount of waste produced daily in the Philippines increased substantially from 37,427,46 tons in 2012 to 40,087,45 tons in 2016 (Mawis, 2019). In the United States, the amount of waste created did not decrease and may even be much more than initially estimated (Law et al., 2020; Lee et al., 2016). With that, the constant rise of solid waste generation in the coming years will most likely impact the health

of the people, environment, and wildlife (Altaf, 2019; Omang et al., 2021; Vinti et al., 2021).

Table 3. Top Five Models for Population Growth

Models	AIC
ARIMA (1,2,0)	– 130.20
ARIMA (3,2,0)	– 130.00
ARIMA (2,2,0)	– 129.64
ARIMA (3,2,1)	– 129.23
ARIMA (1,2,2)	– 128.83

Table 3 shows that ARIMA (1,2,0) has the lowest AIC score, with a value of – 130.20 among the models considered by the researcher. From this, it suggests that ARIMA (1,2,0) may be regarded to forecast the population growth of Davao City for the next five years.

Table 4 shows the forecasted population growth of Davao City from 2022 to 2026 in millions. These values were predicted using the ARIMA model with p, d, and q values of (1,2,0). In 2022, the forecasted population growth will be 1,907,800 ± 1,400; the value 1,400 is the margin of error, and 1,907,800 is the point forecast.

Table 4. Forecasted Population Growth for 2022 to 2026 using ARIMA (1,2,0)

Year	95% Confidence Interval (In Millions)
2022	1.9078 ± 0.0014
2023	1.9496 ± 0.0045
2024	1.9918 ± 0.0096
2025	2.0345 ± 0.0169

2026	2.0775 ± 0.0269

Adding and subtracting the point forecast with the margin of error will result in its high value of 1,909,200 and low value of 1,906,400, which is the forecast interval. In 2023, the forecasted population growth will be 1,949,600 ± 4,500. In 2024, the predicted population growth will be 1,991,800 ± 9,600. In 2025, the forecasted population growth will be 2,034,500 ± 16,900. Lastly, in 2026, the predicted population growth will be 2,077,500 ± 26,900. With this, it implies that the forecasted population growth of Davao City for the next five years will still be in an increasing trend, with a percentage growth of

11.31%. For the visual representation, refer to Appendix 7.

Similar patterns are observed in several studies with the increasing trend of population growth. David et al. (2014) found that the Philippines is still struggling to find effective methods to manage population growth. Evidence linking population expansion to poverty highlights persistently high fertility rates as a significant barrier to poverty reduction. According to the World Population Review (2022), there will be no evidence of a population drop in the United States during the next century. As a result, the constant rise of population growth in the coming years would most likely impact the environment and the people. Bish (2020) stated that the growing population would unavoidably add to pressures that exacerbate climate change by accelerating deforestation, decreasing biodiversity, and increasing pollution and emissions. Relative to this, the same studies realized that the hazard to the sustainable use of natural resources arises from rapid population increase will become a significant factor in the deterioration of the environment and poses a threat to the continuation of sustainable human life (Maja & Ayano, 2021; Mittal & Mittal, 2013).

Research Question Number 3: What is the capacity of the New Carmen Sanitary Landfill?

Figure 5. Map of the New Carmen Sanitary Landfill (Existing and Proposed)

Figure 5 illustrates the map showing the properties of the New Carmen Sanitary Landfill, both existing, which was opened in 2010, and proposed, which may be opened in 2023. Considering the surrounding area of the location, the spring source has a 500 m radius that affects 28,920 sq.m of the proposed landfill, which will not be used as a potential site for dumping the wastes. With that, the proposed landfill will have an area of 65,482 sq.m and a cell depth of 60 meters. Multiplying the area and the cell depth will result in its capacity of 3,928,920 cu.m. Moreover, the current landfill has an area of 38,077 sq.m and a cell depth of 60 meters. Multiplying the area and the cell depth will result in its capacity of 2,284,620 cu.m. Adding the capacity of the existing and proposed landfill will result in a total capacity of 6,213,540 cu.m.

Landfilling is one of the most common solid waste management techniques. It is where trash is disposed of, and it has special qualities that keep the land and water in the area clean. Before selecting the proposed

landfill site, CENRO chose potential locations that were ecologically compatible. Several studies support this notion that choosing a suitable landfill location depends on various standards and conditions, necessitating research and multiple-factor assessments (Rezaeisabzevar et al., 2020; Yildirim et al., 2018). Alavi et al. (2013) outlined the criteria for selecting a landfill site following the laws and regulations. These include surface water, delicate ecosystems, land cover, urban and rural areas, land uses, proximity to highways, slope, and land type. Since selecting a landfill site is a challenging procedure that must consider various factors, it is imperative to find a practical way to link engineers to choose the optimal landfill location (Mortazavi Chamchali et al., 2021).

Research Question Number 4: Can the New Carmen Sanitary Landfill still hold the forecasted solid waste generation of Davao City for the next five years?

Table 5. Ratio and proportion of the capacity of the New Carmen Sanitary Landfill to the forecasted solid waste generation

Ratio: 1 cu.m of the capacity : 1 cu.m of solid waste	
Let *a* = capacity *b* = solid waste	*a* □ *b* 1 cu.m of the capacity □ 1 cu.m of solid waste □ **TRUE**
Capacity of the landfill: 6,213,540 cu.m **Solid waste generation (2026):** 10,075,100 cu.m	*a* □ *b* 6,213,540 cu.m □ 10,075,100 cu.m □ **FALSE**

Table 5 shows the ratio and proportion of the capacity of the New Carmen Sanitary Landfill to the predicted solid waste generation for the next five years. The ratio of the capacity to the solid waste is 1:1, meaning that

for every cubic meter of the capacity, there is also a cubic meter of solid waste. Also, the capacity should be greater than or equal to the generated solid waste to accommodate the waste being dumped in the landfill. Based on the findings of the gathered data, the total capacity of the existing and proposed landfill, which is 6,213,540 cu.m, is not greater than or equal to the predicted solid waste generation, which is 10,075,100 cu.m. Therefore, it indicates that the forecasted solid waste generation of Davao City will exceed the capacity of the New Carmen Sanitary Landfill for the next five years.

The problem with waste generation exceeding the capacity of its landfill can be seen in various studies. Youcai (2018) found that waste dumped in landfills might take decades or even hundreds of years to decompose, which can contribute to the need for much more storage space for the landfill to accommodate the increasing volume of waste being dumped every day. In India, it is anticipated that by 2031, urban areas of the nation will produce 165 million tons of waste annually and 463 million tons by 2050. Due to this, the local government foresees that the waste generation of the country might surpass its landfill capacity in the following years. As a result, around 2.5×10^7 cu.m of landfill space, or 1,175 hectares of land area, will be needed to accommodate the amount of waste produced in the subsequent years (Joshi & Ahmed, 2016).

It has been the same case in Davao City that the landfill in New Carmen has already accumulated 900,000 tons of waste since 2016 despite having a maximum capacity of between 700,000 and 800,000 tons. In response, the local government has proposed a waste-to-energy (WTE) facility at Biao Escuela, Tugbok District (Garay & Bernardo, 2020; Garcia, 2022). This facility will burn and convert non-hazardous wastes into usable forms of energy. As stated by George et al. (2022), Pongrácz et al. (2004), and Tadese et al. (2022), the lack of sufficient disposal sites may impact the population and the urban environment, which makes sustainable and integrated solid waste management (SWM) an effective solution for the worldwide issue of the rapid growth of solid waste.

Chapter 4

CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion and recommendations drawn from the data discussed and analyzed in the previous chapter.

Conclusion

Based on the findings of the study, the annual solid waste generation and the population growth of Davao City have both been increasing over the previous eleven years. Similarly, its forecasted solid waste generation and population growth are also expected to expand over the next five years, with growth rates of 58.12% and 11.31%, respectively. The researchers can therefore deduce that the production of waste may rise along with the increase in the population, which exhibits a direct increasing trend with each other. Additionally, the total capacity of the existing and proposed landfills is not greater than or equal to the predicted solid waste generation. The data suggest that the projected solid waste generation of Davao City will surpass the capacity of the New Carmen Sanitary Landfill for the next five years.

Recommendations

The following are the recommendations of the researchers for the improvement of this paper. Firstly, future researchers can conduct a study on the factors affecting the rise in solid waste generation and population growth in Davao City. Secondly, future researchers can compare the predicted values produced by the ARIMA model using other statistical methods. Thirdly, future researchers are recommended to gather thirty to fifty years of past data on the variables to have more accurate forecasted values.

Fourthly, even though policymakers have already developed several orders, policies, and other strategies to address the issue, there is still a problem with its implementation and monitoring since the projected solid waste generation with the population growth have constantly increased over the years. With that, they can further strengthen the enforcement and application of these initiatives to mitigate the rise of population and trash production. Lastly, given the forecasted number of solid waste generation and population growth for the next five years, this can be a reference and guide to call the inventors and engineers of the country to develop new and advanced technologies that can reduce the size or bulk of the waste to lessen the space it will occupy on the landfill.

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THE RELATIONSHIP OF INDOOR TEMPERATURE AND INDOOR TOTAL VOLATILE ORGANIC COMPOUNDS

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ABSTRACT

Adverse air pollutants were the sources of indoor air pollution. One of the factors that cause many health issues is Volatile Organic Compounds (VOCs). It was established that some indoor VOCs were released as temperatures increased from furniture and other indoor settings. As a result, the general aim of this study was to examine the indoor TVOC concentration level and determine the relationship between the indoor temperature within some offices and laboratories at the identified school. Moreover, a quantitative comparative-correlational research design was used for this investigation. The analysis of variance (ANOVA) and T-test were used to compare the differences in indoor TVOC concentration according to the different times of the day and room ventilation, respectively. On the other hand, correlation was used to determine the relationship of the variables. Results showed no significant differences in TVOC concentration variation between different times of the day and room ventilation. Further, the TVOC concentrations for the morning, noon, and afternoon are within the same range at 0.015 mg/m^3. Furthermore, the TVOC concentration from natural ventilation, which is 0.015mg/m^3, is within the same range as the TVOC concentration from mechanical ventilation, which is 0.016 mg/m^3. Meanwhile, the study rejected the null hypothesis of the correlation of the two variables in terms of the different times of the day, particularly during the morning and noon, and in terms of the type of ventilation, particularly rooms with natural ventilation. However, the null hypotheses were hereby rejected the correlation during the afternoon and rooms with mechanical ventilation.

Keywords: Indoor temperature, indoor TVOCs, health effects, TVOC variation, descriptive-correlational, natural ventilation, mechanical ventilation, analysis of variance (ANOVA), T-test, correlational.

INTRODUCTION

Background of the Study

Volatile Organic Compounds (VOCs) were gases that came from products or processes and were released into the air. They were usually found in consumer goods, such as paints, sealants, and furniture, frequently present indoors. Thus, indoor VOCs had become a public health concern, where people spent most of their time indoors where air exchange was minimal due to a lack of ventilation. According to Montoya, Vargas, and Aguilar (2018), VOC contains various air toxicants such as Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX). Being exposed to VOCs causes adverse health concerns, particularly respiratory health. Also, inhaling VOCs irritates the eyes, nose, and throat, causes breathing problems and nausea, harms the central nervous system, and affects several other organs, possibly leading to cancer (Environmental Protection Agency [EPA], 2022).

On the other hand, indoor temperature was one of the factors that affected the release of VOCs. Further, studies proved that some environmental spaces, indoor decorations, furniture and other indoor materials affect the Total Volatile Organic Compounds (TVOC) (Qi et al., 2019). In the study of Zhou, Liu, Ding, and Wu (2019), they used a wood-based panel to assess the impact of temperature and humidity on the release of TVOC. It was revealed that increasing the ambient temperature and relative humidity causes the release of TVOC, affecting its peak concentration and stable concentration, with a more significant influence on formaldehyde release. Hence, the higher the temperature, the more influential the effect of formaldehyde release concentration on the specified temperature range of wood-based panels, and the longer time necessary for

formaldehyde release from the artificial board to reach the maximum concentration.

Indoor VOC concentrations were approximately 5-10 times greater than outside conditions (Jia, Batterman, & Godwin, 2019). In Shanghai, China, a study was conducted on the properties of VOCs in newly renovated homes. It implicates the negative health consequences of exposure to chlorinated hydrocarbons in indoor air (Dai et al., 2017). On the other hand, the study of Zhou et al. (2017) explained that the combination of temperature and humidity as a sink effect significantly impacts indoor VOC pollution in newly renovated residences in Xi'an and Hangzhou, China. The presence of VOCs was higher by approximately 10–15 times than before it was renovated.

In the Philippines, an assessment by Sakilan and Demayo (2015) about the sources of indoor air pollutants and health concerns was conducted in Iligan City. The study stated that pollutants from domestic items and improper ventilation were sources of pollution for inhabitants. The use of solid fuels, which emit toxic smoke and chemicals, as well as poor sanitation and small indoor living spaces, exacerbate the problem in slums.
Indeed, indoor VOCs were determined as a present pollutant in the areas.

Meanwhile, a study in coastal areas was conducted in various households in three different provinces on the southern island of Mindanao: Zamboanga, Maguindanao, and Tawi-Tawi. The study indicated that natural ventilation characteristics could be significant determinants of exposure to certain indoor air pollutants but less for others. Moreover, it has been shown that kitchen characteristics and ventilation conditions can play an essential role in influencing concentration levels. It was also revealed in their study that natural ventilation had higher TVOC levels than mechanical ventilation (Saksena, Subida, Büttner, & Ahmed, 2016). Thus, it was determined that temperature and indoor air rate of change had been found to directly affect TVOC concentrations in the study of Güneş, Yalçin, and Çolaklar (2022).

Moreover, VOCs can be produced by furniture and other indoor spaces as temperatures increase (Qi et al., 2019). Indeed, it was determined that the facilities of the identified school have furniture, and some were defined as close indoors where VOCs can be emitted. Yet, no studies were conducted to determine the amount of VOC in the different offices and laboratories of the participating school where the study was conducted. Thus, the investigation was pursued.

Statement of the problem

The purpose of this study was to assess the indoor TVOC concentration level, and determined the relationship to the indoor temperature of some offices and laboratories in the identified school. Specifically, this study sought to answer the following questions:

1. What is the average room temperature of some offices and laboratories in the identified school, in terms of:

1.1 different times of the day;

1.1.1 morning (7:00);

1.1.2 noon (12:00); and

1.1.3 afternoon (5:00)?

1.2 type of ventilation;

1.2.1 natural; and

1.2.2 mechanical?

2. What is the average indoor TVOC concentration level of some offices and laboratories in the identified school, in terms of:

2.1 different times of the day;

2.1.1 morning (7:00);

2.1.2 noon (12:00); and

2.1.3 afternoon (5:00)?

2.2 type of ventilation;

2.2.1 natural; and

2.2.2 mechanical?

3. Is there a difference in the indoor TVOC level of some offices and laboratories in the identified school, when compared according to:

3.1 different times of the day:

3.1.1 morning (7:00);

3.1.2 noon (12:00); and

3.1.3 afternoon (5:00)?

3.2 type of ventilation;

3.2.1 natural; and

3.2.2 mechanical?

4. Is there a significant relationship between indoor temperature and TVOC concentration level in the laboratories and offices of the identified school when measured according to:

4.1 different times of the day:

4.1.1 morning (7:00);

4.1.2 noon (12:00); and

4.1.3 afternoon (5:00)?

4.2 type of ventilation;

4.2.1 natural; and

4.2.2 mechanical?

Chapter 2

METHODS

In this chapter, the research design, research instrument, and research locale are presented. Further, the data gathering procedure and data analysis are also discussed.

Research Design

This study employed a quantitative comparative-correlational research design. Quantitative research describes a collection of techniques, approaches, and presumptions to investigate numerical patterns to research psychological, social, and economic phenomena (Killam, 2022). Further, comparative research design analyzes and synthesizes trends, similarities, and differences between two or more examples with a similar focus or objective (Goodrick, 2014). On the other hand, the correlational research design examines relationships between two or more variables without allowing the researcher to control or manipulate any of them (Bhandari, 2021).

This study has two presented variables: the indoor TVOCs and indoor temperature of the particular time interval of weekdays. The comparative approach was applicable in the study since it aims to compare the TVOC concentrations present in the school's indoor facilities. They were measured during the different times of the day and types of ventilation. Conversely, correlation is also helpful in the study because the researchers determined the relationship between indoor TVOC and indoor temperature. Ultimately, quantitative descriptive-correlational is the most suited research design for attaining the study's goals.

Research Locale

The researchers conducted their study inside the premises of the identified school. This is a private Catholic school. Moreover, the school offers three levels of education: primary and secondary, including junior high school, offering all the academic strands for the senior high school, and tertiary. The identified school is in its 75th year of service, and as a result,

its facilities and services have evolved. Since the school has a more comprehensive office, high technological facilities and laboratories, the researchers determined the location's suitability for the proposed study as the materials and equipment inside each facility could influence the air quality. Thus, it allowed the researchers to determine how indoor temperature affected indoor TVOC.

Specifically, to obtain the desired data, the researchers conducted their investigations in the school's facilities, which were frequently used by students, teachers, and staff and contained various pieces of equipment and furniture. In particular, the data were collected in the following locations: computer laboratory, TLE laboratory, elementary teachers' faculty room, and the basic education faculty room. Moreover, areas were designated based on the type of ventilation found in these school facilities.

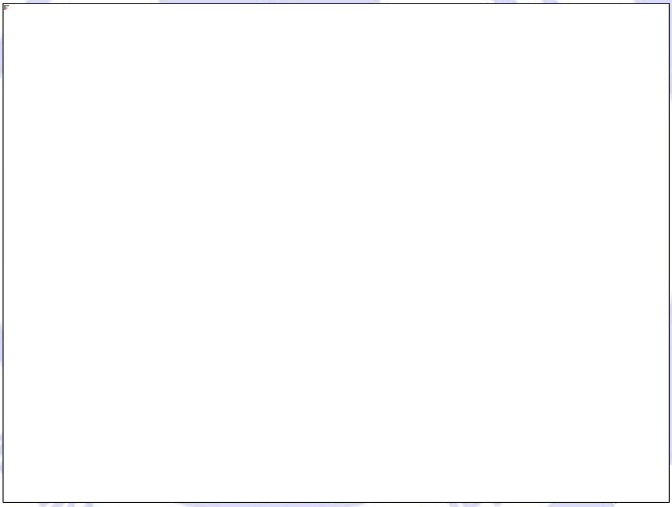

Figure 2. Room 1A: Elementary Teachers' Faculty Room

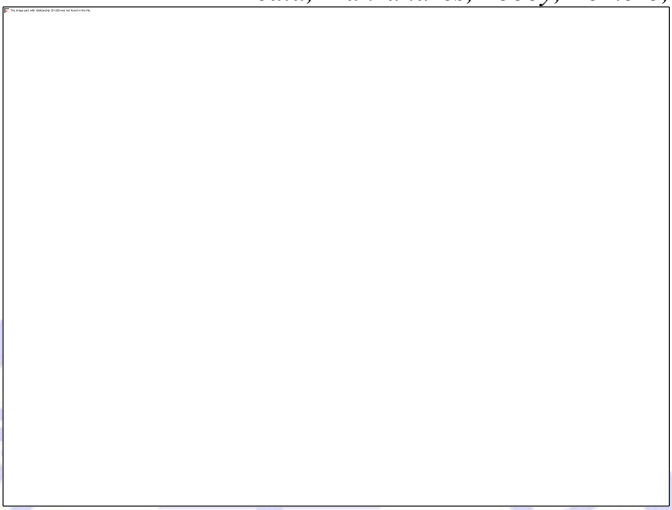

Figure 3. Room 1B: Basic Education Faculty Room

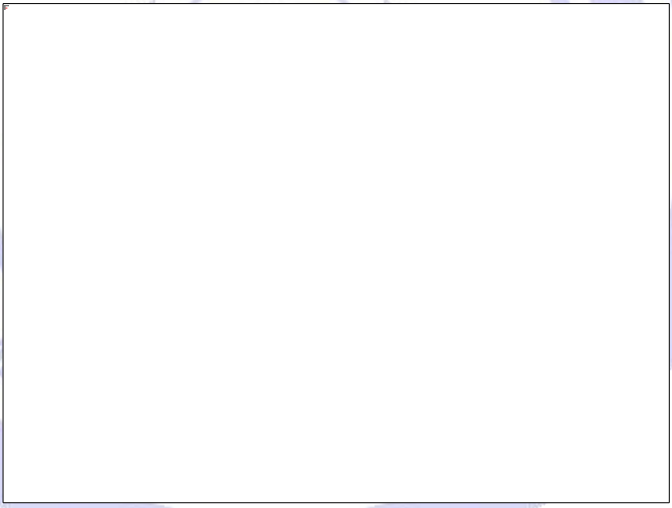

Figure 4. Room 2A: Technical Livelihood Education (TLE) Laboratory

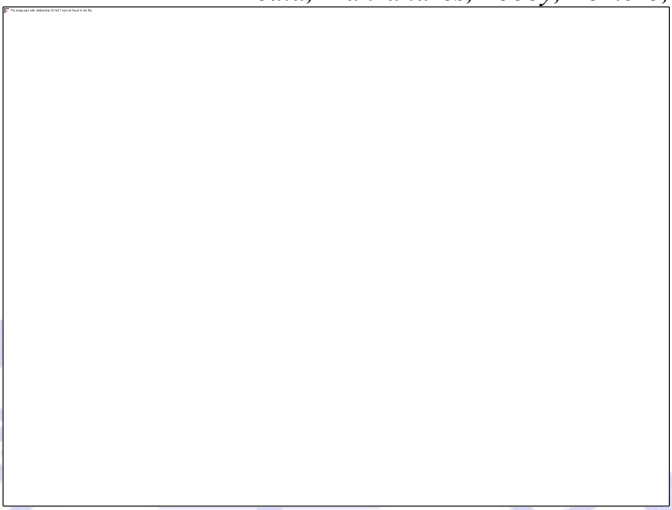

Figure 5. Room 2B: Computer Laboratory

Research Instruments

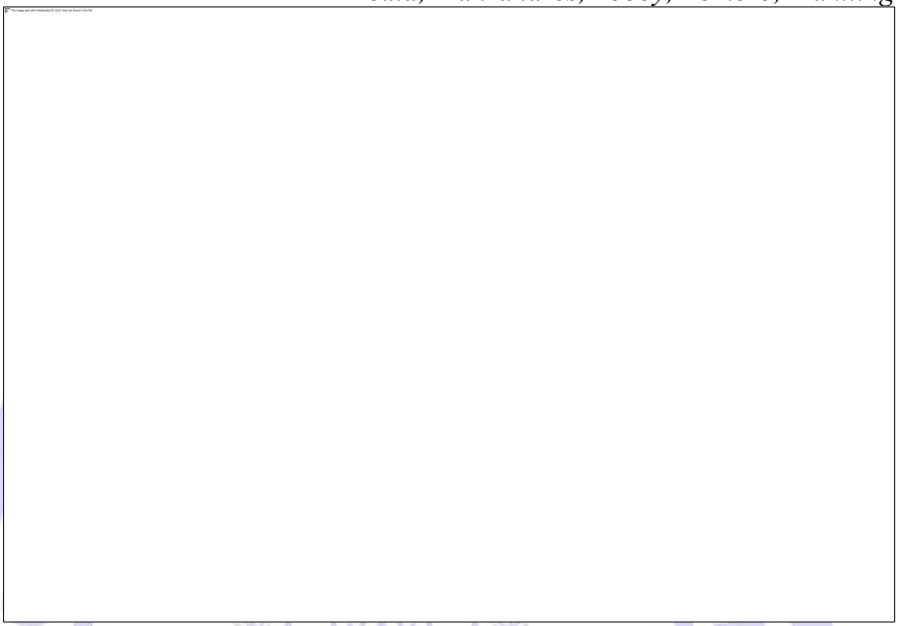

Figure 6. TVOC Meter

To determine the TVOC, a particular device called a TVOC meter was used. A TVOC meter is designed to measure VOC in certain indoor and outdoor places. TVOC meter has already been used in various studies as this device was used to determine the TVOC concentration in indoor air quality inside a salon in Ibadan (Ana, Alli, Uhira, & Shendell, 2019). In addition, it is ideal for making general measurements of mixed gas volatile organic compounds. The device is first turned on by pressing its power button; it counts down from 200 seconds until it shows the current TVOC concentration in the air.

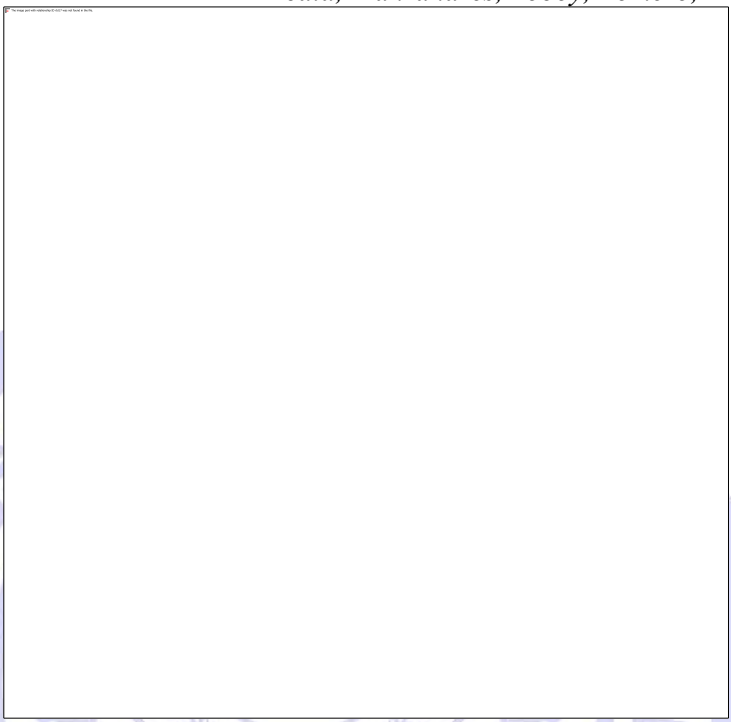

Figure 7. Thermometer

On the other hand, a thermometer gun was used to determine the indoor temperature. The infrared thermometer functions by concentrating infrared rays emitted from the object and channeling them into a detector. Indeed, the thermopile is where the infrared radiation is converted to heat, then to electricity, which the device measures. The thermometer will finally display a reading based on the quantity produced by rays emitted by the object. A thermometer is a quick technique to take a temperature reading in various situations because the reading will be generated in a matter of seconds (Whelan, 2020).

Data Gathering Procedure

To ensure the scientific soundness of this research, it needs to follow due process. Before conducting the study in the specified areas, the researchers wrote a letter to the school's administration requesting permission to pursue the investigation, and the researchers waited for one week. In addition, after the letter was approved, the researchers gave a letter to the facilities in charge. After all the letters were approved, the data were gathered to assess the indoor TVOC concentration level and its relationship to the indoor temperature of the school facilities. The schedule for collecting the data of the TVOC and temperature is as follows: in the morning (7:00), noon (12:00), and afternoon (5:00). The researchers also considered the number of rooms with natural and mechanical ventilation.

Additionally, each facility has two trials, each recorded after 7 minutes. Moreover, to measure the indoor TVOC concentration level and indoor temperature in the offices and laboratories in the particular school, the researchers used a device called a TVOC meter and thermometer. Lastly, the data were collected over 30 days.

Data Analysis

The process of systematically applying statistical and logical techniques to describe, illustrate, condense, recapitulate, and evaluate data is known as data analysis (Heeringa, West & Berguland, 2017).

Mean is used to determine the TVOC concentration level and indoor temperature in a different timeframe that helps to answer research questions 1 and 2. The arithmetic average of all the terms is the most typical formulation for the mean of a statistical distribution containing a discrete random variable. Further, the mean of a data set is the sum of the observations divided by the total number of observations that can be used to compute the mean. It is the most often used measurement and is relatively simple to add (Mishra et al. 2019).

On the other hand, research question number 4 has two segments; 4.1 and 4.2. In solving number 4.1, the researchers used the Analysis of Variance (ANOVA), a statistical analytics tool, to divide the observed aggregate variation found in a data set into two parts; systematic and random factors (Kenton, 2022). Meanwhile, SOP 4.2 utilized the t-test, which is employed to compare the means of the two

groups. It is frequently used in hypothesis testing to establish whether a procedure or treatment truly affects the population of interest or whether two groups differ (Bevans, 2020).

Moreover, the researchers used the Pearson correlational tool for research question number 5 to establish the relationship between the TVOC level and indoor temperature in the school. Pearson's correlation coefficient is a test statistic used to determine the statistical relationship, or association, between two continuous variables. Accordingly, a positive correlation indicates that if variable A increases, variable B also increases, whereas a negative correlation means that if variable A increases, variable B decreases (Nettleton, 2014). Moreover, table 1 below shows the interpretation of the possible value of Pearson r:

Table 1. Pearson Correlation Coefficient

Pearson r	Interpretation
(+) (-) 1	Perfect Correlation
(+) (-) 0.75 to < (+) (-) 1	Very High Correlation
(+) (-) 0.50 to < (+) (-) 0.75	Moderately High Correlation
(+) (-) 0.25 to < (+) (-) 0.50	Moderately Low Correlation
0 to < (+) (-) 0.25	Very Low Correlation
0	No Correlation Correlation

Ethical Consideration

The researchers followed ethical considerations throughout the study and ensured no moral principle was violated. In fact, in research, there are sets of regulations needed to apply that will guide one's research design and practices, which are called ethical considerations (Bhandari, 2021). Hence, the researchers ensured to follow the following ethical principles:

Social Value is the first ethical principle that is considered. Liddell and Baron (2021) stated that this principle is an action for the benefit of others while promoting their welfare and safety. On the other hand, the study was conducted to contribute to the body of knowledge and people's perception of temperature and its cause in the surrounding air. The researchers ensured that the study was significantly valuable for the majority and did not cause harm for everyone in maximizing the tremendous impact of the study.

Confidentiality is the second ethical principle that was considered. The obligation of an individual or organization to protect secret information was referred to as the moral duty of secrecy. Protecting data from unauthorized access, use, disclosure, alteration, loss, or theft is part of the ethical duty of confidentiality (National Research Ethics
Committees, 2015).

Chapter 3

RESULTS AND DISCUSSION

The findings of the data analysis and a discussion of the study's problem statements are presented in this chapter. Additionally, this provides an interpretation and analysis of the findings.

Research Question #1: What is the average room temperature of some offices and laboratories in the identified school, in terms of the different times of the day and type of ventilation?

Finding the relationship between indoor temperature and indoor TVOC at various times of the day is the main objective of this study. To achieve this goal the researchers gathered the data with the help of a thermometer in measuring the indoor temperature. Hence, the following table provides the average room temperature at various times of the day and in different types of ventilation.

Table 2. Average room temperature in terms of the different times of the day

Indoor Temperature in Celsius (°C) in:			
	Morning	Noon	Afternoon
Room 1A: Conference Room	27.7	29.7	29.3
Room 1B: Basic Education Faculty Room	26.6	29.0	28.0
Room 2A: TLE Laboratory	27.4	29.9	28.9
Room 2B: Computer Laboratory	24.2	25.1	24.2
MEAN	**26.4**	**28.4**	**27.6**

Table 2 displays the average indoor temperature over four rooms—the conference room, the basic education faculty room, the TLE laboratory, and the computer laboratory—as well as the average indoor temperature during various hours and days. Moving on to the average mean of the indoor temperature of the different times of the day, the highest indoor temperature was recorded at noon, which was 28.4°C and the lowest indoor temperature was recorded in the morning, which was 26.4°C. Lastly, the average indoor temperature was detected in the afternoon, which was 27.6.

A study that supports this stated that the temperature characteristics, particularly in the air, could alter at any moment (Lee & Kim, 2012). Moreover, in desert regions, bright skies could result in high temperatures affecting buildings' outside and inside temperatures and it was claimed that a room's temperature might change at any time based on the outside temperature or by utilizing an air conditioner (Khandelwal, Goyal,
Kaul, & Mathew, 2018).

Table 3. Average room temperature in terms of the type of the ventilation

Indoor Temperature in Celsius (°C) in:		
	Natural Ventilation	Mechanical Ventilation
Offices	28.9	27.9
Laboratories	28.7	24.5
Mean	**28.8**	**26.2**

Table 3 shows several temperature-related tests conducted in offices and laboratories under various natural and mechanical ventilation conditions. Offices with natural ventilation typically have temperatures higher than those with mechanical ventilation, while laboratories with natural ventilation typically have temperatures higher than those with mechanical ventilation. Therefore, natural ventilation, which is equivalent to 28.8°C, had the higher average mean indoor temperature across all ventilation types, while mechanical ventilation, which is equivalent to 26.2°C, had the lower average mean.

According to a Chinese study, air conditioners provide heating and cooling thermal power to balance the flow of heat within a structure and maintain a consistent interior temperature. The building's heated/cooled spaces can be characterized as a single isothermal air volume with a separate thermal capacitance (Zhao & Wang, 2022). Moreover, the result supported the theory of Hasselaar (2006), who stated that rooms with different types of ventilation have different rates of indoor air quality.

Research Question #2: What is the average indoor TVOC concentration level of some offices and laboratories in the identified school, in terms of the different times of the day and types of ventilation?

TVOC concentration level of the research locale was identified as the dependent variable in this study. To determine how indoor temperatures affect the indoor TVOC, the researchers recorded

the TVOC concentration simultaneously with the indoor temperature with the use of a TVOC meter. Hence, the table below shows the results of the different times of the day and from the different offices and laboratories.

Table 4. Average indoor TVOC concentration level in terms of the different times of the day

TVOC concentration level (mg/m^3) in:			
	Morning	Noon	Afternoon
Room 1A: Conference Room	0.016	0.015	0.015
Room 1B: Basic Education Faculty Room	0.015	0.016	0.015
Room 2A: TLE Laboratory	0.015	0.015	0.015
Room 2B: Computer Laboratory	0.016	0.016	0.017
MEAN	**0.015**	**0.015**	**0.015**

Table 4 presents details on the concentration of TVOC at various periods of the day, including morning, noon, and afternoon. Based on the table, the TVOC concentrations of the different rooms were different during the different times of the day. Yet, the difference between each result was not that so big. As a result, the average of all rooms during the different times of day was just the same as 0.015 mg/m^3.

The result was somehow supported by the study of Chen (2021), stating that the ambient VOC concentration could vary with time due to interseasonal variations, however, this contradicts the study of Hori, Ishimatsu, and Toru (2013), saying that in all rooms TVOC concentration was generally low during the day and increased during the night. This concentration change corresponds to the ventilation cycle in the building.

Table 5. Average indoor TVOC concentration level in terms of the type of the ventilation

TVOC concentration level (mg/m^3) in:		
	Natural Ventilation	Mechanical Ventilation
Offices	0.015	0.015
Laboratories	0.015	0.016

Mean	**0.015**	**0.016**

Table 5 revealed the average mean of the two areas which are the natural ventilated area and mechanical ventilated area. The TVOC concentration level of the naturally ventilated area is 0.015 mg/m^3 and in the mechanically ventilated area, it is 0.016 mg/m^3. The result showed that the two ventilations have a very close concentration level of TVOC.

This result is supported by the study of Zhou et al. (2017) which stated that the sink effect of the temperature and humidity in newly restored homes in Xi'an and Hangzhou, China, had the biggest effect on indoor VOC pollution. The level of VOCs was about 10 to 15 times greater. It is quantitatively calculated what proportion of a given VOC constituent furniture and building constructions contribute to the TVOC concentration. However, the result contradicted the theory of Hasselaar (2006), called Ventilation Theory and Practice in Dwellings. It states that rooms with different types of ventilation have different rates of indoor air quality. Further, rooms with mechanical ventilation tend to have a lower rate of air pollution.

Research Question #3: Is there a difference in the indoor TVOC level of some offices and laboratories in the identified school, when compared according to the different times of the day and types of ventilation?

Table 6: The difference in the TVOC concentration levels in terms of the different times of the day

ANOVA						
Source of Variation	*SS*	*df*	*MS*	***F***	***P-value***	***F crit***
Between Groups	3.99389E-07	2	1.99694E-07	**0.044548**	**0.956436**	**3.021012**
Within Groups	0.001600343	357	4.48275E-06			

Total	0.001600742	359				

The statistical data for the indoor TVOC in terms of number when compared if different times of the day were shown above. Table 6 shows that the F-value 0.044548 was lower than the F-Critical value 3.021012 when compared and the result shows that there is no significant difference. In addition, the p-value 0.956436 was greater than the margin of error of 0.05, which implied that the null hypothesis is accepted.

The result contradicts the study of Al-Hemoud et al. (2017), stating that the VOC analysis revealed random variation in each measurement. Still, there were noticeable differences in the weekday concentrations in morning, noon, and afternoon reported in higher VOC levels. Considering that the concentrations are high during different times of the day. In addition, the concentration also depends on what type of ventilation and place. Thus, this contradicts the study, which states that VOC measurements have a random variation.

Table 7. The difference in the TVOC concentration levels in terms of the type of the ventilation

t-Test: Two-Sample Assuming Equal Variances		
	Natural Ventilation	*Mechanical Ventilation*
Mean	0.015123889	0.015555556
Variance	2.30735E-06	1.30195E-06
Observations	60	60
Pooled Variance	1.80465E-06	
Hypothesized Mean Difference	0	
df	118	
t Stat	**-1.760001359**	
P(T<=t) one-tail	0.040499429	
t Critical one-tail	1.657869522	

P(T<=t) two-tail	**0.080998857**
t Critical two-tail	**1.980272249**

In this table, the two types of ventilation revealed their average TVOC concentration level which is 0.015 mg/m^3 in natural ventilation and 0.016 mg/m^3 in mechanical ventilation. The t-test result comparing the data of natural ventilation and mechanical ventilation revealed that in comparing the t-critical and t-value, the t-critical 1.980272249 is greater than the t-value -1.760001359 which implies that there is no significant difference. Thus, the P-Value 0.080998857 is greater than 0.05, which means that the null hypothesis is accepted. On the other hand, it is observed that mechanical ventilation has higher readings of TVOC concentration levels compared to natural ventilation. Yet, there is only a small difference between the two rooms.

This result was supported by the study conducted by the Zendher which stated that natural ventilation sometimes has certain limitations, which mechanical ventilation might help to overcome. Moreover, natural ventilation does not have a controlled, mechanical method to guarantee that a house or structure is consistently ventilated. By leaving doors and windows open and letting air in, one may create natural ventilation. More frequently, air "leaks" via tiny gaps and fissures in the building's exterior, make less airtight dwellings more susceptible to air intrusion (2014).

Research Question #4: Is there a significant relationship between indoor temperature and TVOC concentration level in the laboratories and offices of Holy Cross College of Calinan, when measured according to the different time of the day and type of ventilation?

Table 8. The correlation of indoor temperature and indoor TVOC in terms of the different time of the day

Time	Pearson r	Interpretation	p-Value	Decision of H_O
Morning	0.1004	Very Low Correlation	0.2754	Accept

Noon	-0.0643	Very Low Correlation	0.4853	Accept
Afternoon	-0.3051	Moderately Low Correlation	0.0007	Reject

Table 8 shows that the correlation between indoor temperature and indoor TVOC at different times of the day varies. For morning and noon, the values of their Pearson r are between the range of 0 to < (+) (-) 0.25, thus it indicates that there is only a very low correlation between the two variables during these times of the day. This is supported by the p-value 0.2754 and 0.4853, respectively. Therefore, the researchers failed to reject the null hypotheses since the p-value is higher than the alpha, which is set at 0.05, indicating that there is no significant correlation between indoor temperature level and TVOC in terms of different times of the day.

However, table 8 also shows that the correlation between the two variables during afternoon is -0.3051, indicating that there is a moderately low correlation between the two. Further, the correlation is with a p-value of 0.0007. Thus, the researchers rejected the null hypothesis and accept the alternative hypothesis because the p-value is less than the alpha, stating that there is a significant correlation between indoor temperature level and indoor TVOC in terms of different times of the day.

It is supported by the study of Jiang et al. (2017) stating that the temperature and relative humidity have a considerable impact on chemical emissions from building materials. However, there are many other affecting elements, such as temperature range, VOC type, and material type. The increase in temperature and humidity does not always occur. However, Suzuki (2019), said that the number of VOCs increase between 1.5 and 129 times when the temperature goes from 15 to 30 degrees Celsius, and between 1-32 times when the relative humidity goes from 50% to 80%.

Table 9. The correlation of indoor temperature and indoor TVOC in terms of the type of the ventilation

Room	**Pearson r**	**Interpretation**	**p-Value**	**Decision of H_O**

Natural	0.1267	Very Low Correlation	0.3347	Accept
Mechanical	-0.3124	Moderately Low Correlation	0.0123	Reject

The correlation between indoor temperature and indoor TVOC in the type of ventilation is shown in Table 9. For natural ventilation, the table revealed that the correlation between the two variables is 0.1267, indicating that there is a very low correlation between the two variables. Moreover, it is supported by the p-value of 0.3347. Therefore, the researchers failed to reject the null hypothesis stating that there is no significant relationship between the indoor temperature level and indoor TVOC in terms of the type of ventilation since the p-value is higher than the alpha.

Whereas, for mechanical ventilation, the correlation is determined as -0.3124 signifying that there is a moderately low correlation between the two variables. On the other hand, the correlation is with a p-value of 0.0123 resulting in rejecting the null hypothesis and accepting the alternative hypothesis stating that there is a significant relationship between indoor temperature level and indoor TVOC in terms of t type of ventilation.

On the other hand, air ventilation and other processes improve IAQ and reduce contamination; however, ventilation can also be considered a source of contamination and exposure (Abouleish, 2021). Thus, rooms with different ventilations may have different indoor air quality. Moreover, according to EPA (2022), shade and ventilation can help regulate the temperature indoors. Additionally, ventilation aids in the removal or dilution of interior sources of air pollution. This lowers the number of pollutants and enhances the quality of the air indoors. However, indoor factors may also consider to affect the indoor air quality such as presence of the different type of furniture (Lafond, 2019).

CONCLUSION AND RECOMMENDATIONS

This chapter contains the conclusion and recommendations drawn from the data analyzed in the previous chapter.

Conclusion

The results revealed that there are no significant differences in TVOC concentration variation between different times of the day and different room ventilations. Thus, the two null hypotheses, which claimed that there are no significant differences in TVOC concentration throughout different times of the day and across various room ventilation, were therefore accepted. The TVOC concentrations for the morning, noon, and afternoon are all within the same range. Further, the TVOC concentration from natural ventilation is within the same range as the TVOC concentration from mechanical ventilation.

Meanwhile, the correlation between the two variables during the different times of the day, between the morning and noon, were determined to have a very low correlation and the null hypothesis is accepted. However, during the afternoon, it was revealed that there is a moderately low correlation. Therefore, the null hypothesis is hereby rejected. On the other hand, the correlation in terms of the type of ventilation revealed that rooms with natural ventilation have a very low correlation resulting in accepting the null hypothesis. Meanwhile, rooms with mechanical ventilation have a moderately low correlation between the two variables. Thus, the null hypothesis is rejected.

Finally, the researchers concluded that the TVOC concentration levels in the four rooms were very low and below the comfort limit. Therefore, there is no need to be concerned because the research's findings indicated that there are no negative repercussions on health.

Recommendations

The following are the recommendations for the students, teachers, school administrators, and future researchers for improving this study. First, for the students and teachers, as the other literature review shows that electrical devices may also emit VOCs, they are

advised to refrain from using electrical devices if not needed. Further, for the teachers to spread awareness about the nature of different air pollutants and their sources, particularly the VOC, they can conduct seminars about indoor air pollution.

On the other hand, for the school administrators, since the study revealed that there is a low concentration of TVOC, it is recommended to find ways to maintain the low concentration of TVOCs. Indeed, removing that furniture made of particle board and replacing it with hardwood furniture is the best way. Paints are one of the primary sources of VOCs, therefore, it is recommended to use low-VOC paint for renovations of the facilities. For rooms with mechanical ventilation, administrators can put air purifiers to filter VOCs and other air pollutants.

Additionally, for future researchers, since the study did not go into great detail about the other various sources of VOCs, it would be better if more studies in the future would concentrate on identifying the other sources of VOCs. As this study only focused on temperature, future studies are advised to look into the other variables that affect the TVOC, such as the humidity, the number of people, and the size of the indoor facility. Lastly, another statistical approach, particularly regression, is recommended to determine which is more detrimental among the factors.

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THE LEVEL OF THE IMPACT OF COVID-19 PANDEMIC TO THE ORGANIZATIONAL PERFORMANCE OF SMALL AND MEDIUM-SIZED ENTERPRISES (SMEs) IN CALINAN POBLACION

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ABSTRACT

SMEs are essential to economic development since they provide goods and services that meet the needs of their customers. However, the COVID-19 pandemic threatens its survival globally and nationally for SMEs is one of the most vulnerable sectors for business loss. The goal of the study is to determine the level of impact of COVID-19 pandemic and the mandated health protocols to the organizational performance of SMEs in Calinan, Davao City. With this, this could help the entrepreneurs track their development and plan their operations to have a general notion of which aspects of the business they will focus on, stay afloat, and avoid bankruptcy during the pandemic. The data were collected using survey questionnaires. They were processed, analyzed, and interpreted using percentage. The overall mean was used to verify that the SME's financial operation (3.56), human resource management (3.84), and logistics (3.49) in Calinan, Davao

City are highly impacted by the COVID-19 pandemic. The mandated protocols (2.55), on the other hand, have a strong impact to the SMEs organizational performance. Therefore, the researchers concluded that the COVID-19 pandemic and the government health protocols have a high impact on the SMEs organizational performance.

Keyword: *Small and medium-size enterprises (SMEs), Financial Operation, Human Resource Management (HRM), Logistics, Organizational Performance*

Chapter 1

INTRODUCTION

Background of the Study

A small-to-mid-size enterprise (SMEs) is a business with revenues, assets, or numbers of employees that fall below a certain level. SMEs contribute to about 70% of total employment and generate between 50% and 60% of value added (Ward, 2020). However, the findings show that, although being the majority of stores in the country and providing a significant economic boost, they still lack organizational capacities (Garengo and Bernardi, 2018). Stated by Rodrigues, Franco, Sousa, and Silva (2021) on their study, SME owners lack necessary skills and knowledge to manage their business organizational performance. Therefore, the COVID-19 pandemic has posed major and diverse obstacles for it requires adjustments in business and its organizational performance management, that added to the uncertainty on how to keep operations running (Omar and Morales, 2021).

Worldwide, as stated by Donthu and Gustafsson (2020), the COVID-19 pandemic has serious economic effects to numerous countries. According to Gamage et. al (2020), the pandemic showed significant worldwide challenges for SMEs, which are the global market competition, global finance and economic crises, information and communication technologies, the creation of multinational and transnational firms, and consumer shifts and preferences. Economic and financial crises occur in the global economy on a cyclical basis, and they are one of the worldwide difficulties facing every corporate entity, particularly SMEs in the globalized economy.

Nationally, caused by COVID-19 pandemic, SMEs have been greatly affected on their financial, management and development (Flaminiano, Francisco, Paolo, and Caboverde, Ed, 2021). As stated on the study of Reyes (2020), COVID-19 impacted the Philippine economy, with growth, employment, and general productivity all falling into recession, due to the nationwide lockdown. The commercial sector was compelled to tackle the issues posed by the pandemic, particularly its danger to company continuity and survival, as the pandemic resulted in a series of business closures, supply chain disruptions, and substantial employment cutbacks.

Locally, the Davao City government has continued to seek for solutions to assist businesses that have suffered losses as a result of the COVID-19 outbreak. During the lockdown, the disruption of raw material availability had a severe impact on business operations, and sales performance suffered as a result. Furthermore, around 20%–33% of SMEs are facing severe supply chain interruptions (Loarden et. al., 2022).

Statement of the Problem

This research aimed to determine the level of the impact of COVID-19 pandemic to the organizational performance of SMEs in Calinan, Davao City which could help the entrepreneurs track their development and plan their operations for the future. Specifically, the objective of this report is to find out the following:

1. What is the level of the impact of COVID-19 pandemic to the organizational performance of SMEs in Calinan Poblacion in terms of the following:

    1.1 Financial Operation;

    1.2 Human Resource Management (HRM); and

    1.3 Logistics?

2. What is the level of the impact of COVID-19 pandemic protocols to the organizational performance of SMEs in Calinan Poblacion?

Chapter 2

Methods

Research Design

This study utilized the descriptive research design where the researchers examined and interpreted the behavior of the discipline without manipulating it (VOXCO, 2021). It also involved the recording, describing, analyzing and the presentation of the current system, composing or process of phenomena. So basically, descriptive research design was used in observing and interpreting the subject without changing or influencing the behavior of it.

This design was appropriate to the current study since the researchers observed the organizational performance of SMEs in Calinan Poblacion during the pandemic and interpreted the gathered data through presenting them without altering the SMEs organizational performance.

Research Locale

The research was conducted in Calinan, Davao City. It is a third-class district that is situated in Davao Del Sur. It is a fast-developing district where a lot of enterprises were already built, especially SMEs. Another perk why Calinan Poblacion has been chosen is that, the researchers lived in the community; some are on the outskirts, which can be easier to navigate the SMEs because of the safety protocols that should be followed.

Data Gathering Procedure

This study followed some procedures in order for the researchers to attain the objectives. A letter was specifically sent to the school president, principal, and chosen SMEs in Calinan, Davao City for approval. The letter contained the research paper's purpose, significance, and background. Right after the approval, the researchers forwarded the google form link to the respondents' various social media accounts. Before administering the surveys, the researchers thoroughly discussed the study with the respondents, and the research instrument and its objective were clarified. Thus, the researchers properly oriented the respondents about the correct manner of accomplishing the questionnaires to ensure the validity and reliability of the results.

Finally, the researchers checked on a daily basis to see if all respondents had completed the survey. The researchers tallied all the information obtained from the respondents. The researchers, then, evaluated and interpreted the findings. Conclusions were drawn from the data, and conclusions were formulated based on the study's outcomes and findings.

Data Analysis

The data gathered were presented in tables and in tabular forms and were generally viewed to answer the specific problems in chapter 1. The data were gathered, organized, and tabulated by the researchers. Appropriate statistical treatment used to analyze the data.

Mean

Mean implies average and it is the sum of a set of data divided by the amount of data. Mean can prove to be an effective tool when comparing different sets of data. This was used to get the total mean of the effects of covid-19 pandemic and covid-19 pandemic protocols of the selected SMEs in Calinan Poblacion.

Chapter 3

RESULTS AND DISCUSSION

In this chapter, the researchers present, interpret and analyze the data gathered during the conduct of this study.

Research Question #1. What is the level of the impact of COVID-19 pandemic to the organizational performance of SMEs in Calinan Poblacion in terms of financial operation, human resource management, and logistic

Table 3. Level of the impact of the COVID-19 pandemic towards the SMEs financial operation.

Table 3 the levels of the effects of COVID-19 pandemic to the financial operation of SMEs in Calinan Poblacion. Based on the result, the overall mean of the effects of COVID-19 pandemic in financial operations is 3.56, described as high. More particularly, revenue is 4.11, gross profit is 4.00, and current cash flow is 3.67 described as high, while liabilities and loan expenses is 3.00, described as moderate.

The result of the study above was supported by the research of Bakhtiari (2020), in which he claimed that majority of SMEs had to close operations, experienced reductions in sales, had a hard time maintaining the enterprise current cash flow, underwent an increase of liabilities, and faced significant falls in revenue. Furthermore, Ichsan (2021) also stated that, SMEs faced financing payment difficulties for Covid-19 pandemic has hit the banking system, resulting in bad financing due to debtors' disbursements, supply chain disruption, decreased demand, and lower sales and profit. On the other hand, the study conducted Scheinkman (2020) stated that 43% of SMEs had temporarily closed due to the pandemic. According to him, respondents had temporarily closed largely pointed to reductions in demand, net loss, inability to pay off debts and employee health concerns.

Table 4. Level of the impact of the COVID-19 pandemic towards the SMEs human resource management.

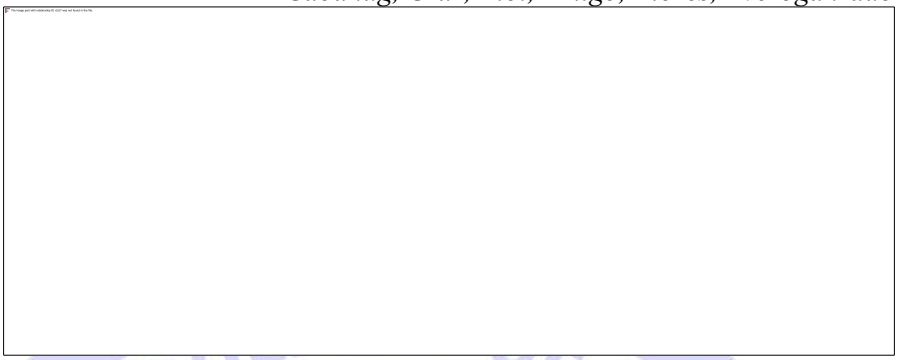

Table 4 shows the level of COVID-19 pandemic to Human Resource Management of SMEs in Calinan Poblacion. Based on the result, the overall mean of the effects of COVID-19 pandemic on HRM is 3.84, described as high. In the study, there are five indicators of HRM, namely: implementation of new policies and practices having a mean of 4.67 and employee's efficiency with 4.33 mean described as very high. Moreover, The study's result presented above was supported by the claim of Yang and Miraglia (2021) which stated that SMEs made significant changes to the HRM policies and practices during the pandemic. Factors such as, arranging flexible working conditions, furloughing employees, providing training on virtual meetings (Teams or Zoom), and freezing recruitment and moving to e-recruitment for the outbreak of COVID-19 have severely affected the SMEs' overall business performance. Moreover, compared with largecompany employees, SME employees are more affected by the crisis, experiencing layoff and pay reduction (Beglaryan & Shakhmuradyan, 2020).

Table 5. Level of the impact of the COVID-19 pandemic towards the SMEs logistics.

C. Logistics		
Indicators	Mean	Interpretation
Shipping	3.89	High
Supply	3.22	Moderate
Production efficiency	3.56	High
Price mark-up	3.33	Moderate

Delivery	3.44	High
Overall	3.49	High

Table 5 shows the level of the impact of COVID-19 pandemic to the logistics of SMEs in Calinan Poblacion. Based on the result, the overall mean of the impact of COVID- 19 pandemic on logistics is 3.49, described as high. In the study, there are five indicators of Logistics, namely: shipping with a mean of 3.89, production efficiency with a mean of 3.56, and delivery with a mean of 3.44, described as high. On the other hand, price mark- up and supply obtained a mean of 3.33 and 3.22 respectively, described as moderate.

Such findings were supported by the claim of Liu, Liang, Bao, Qin and Lim (2020), which stated that the covid-19 pandemic has an impact to the five logistics, namely: sharp- drop of demand, shortage of transportation, disruption of logistics network, change of service mode, and increase in operating costs and number of loss-making enterprises. Tembo (2020) also added that the covid-19 pandemic has disrupted the supply chains, reduced international travel by about 70%, crashed commodity prices - particularly of oil and metals - and reduced exports of products, and vehicles by over 20%.

Research Question #2. What is the level of the impact of COVID-19 pandemic protocols to the organizational performance of SMEs in Calinan Poblacion?

Table 6. Level of the impact of COVID-19 pandemic protocols to the SMEs organizational performance

Indicators	**Mean**	**Interpretation**
Liquor ban	3.33	Moderate
The application of curfew	3.22	Moderate
Mandatory use of face shields	3.41	Weak
Conducting RT-PCR test monthly	1.78	Very Strong
Implementation of Community Quarantine (ECQ, MECQ, GCQ, MGCQ)	2.33	Strong

The prohibition of seniors and minors to establishments	2.56	Strong
Hand sanitizers and foot bath stations in all establishments	2.67	Moderate
Mandatory use of Safe Davao QR (DQR) for all establishments	2.67	Moderate
Skeletal System	1.67	Very Strong
Work from home	1.89	Strong
Overall	**2.55**	**Strong**

Table 6 shows the level of the impact of the COVID-19 pandemic protocols to the SMEs organizational performance in Calinan Poblacion. Based on the result, the overall mean of the level of the impact of COVID-19 protocols is 2.55, described as high. Moreover, skeletal system's mean is 1.67, while work from home is 1.78 both described as very strong. The conducting of RT-PCR test monthly is 1.89, implementation of community quarantine (ECQ, MECQ, GCQ, MGCQ) is 2.33, and prohibition of seniors and minors to establishments is 2.56, described as high. On the other hand, hand sanitizers and foot bath stations in all establishments is 2.67, mandatory use of Davao QR (DQR) for all establishments is 2.67 as well, the application of curfew is 3.22, and liquor ban is 3.33, interpreted as moderate. Lastly, the mandatory use of face shields is 3.41, described as low.

Small and Medium Enterprises (SMEs) are sectors that are most affected by the pandemic, where the implementation of social restrictions has resulted in decreased income and also changes of the SMEs business patterns (Irawan, 2020). More specifically, the results of the study shown above was supported by the claim of Plenner (2020) which stated that, tactics implemented by the government officials including social isolation, sheltering at home, limited travel, community quarantine, work from home, skeletal system, and the shutdown raise the danger for SMEs business continuity. Fairlie (2020) also stated that stores, factories, and many other businesses have closed due to the different policy mandates and health concerns. It is also stated by Khalid (2020) that the Enhanced Community Quarantine (ECQ) and other community quarantine forced most establishments to close, and this is one of the many reasons why SMEs are having a hard time to cope with their losses.

Chapter 4

CONCLUSION AND RECOMMENDATION

This chapter presents the conclusion of the study, with regard to the findings, and the generated recommendations of the researchers of this study.

Conclusion

Based on the results of the study, the level of the impact of COVID-19 pandemic to the SME's financial operation, human resource management, and logistics are 3.56, 3.84, and 3.49 respectively that indicate a high level of impact on the SMEs organizational performance. The researchers, therefore, concluded that the COVID-19 pandemic has a high level of impact to the financial operation, human resource management, and logistics of SMEs in Calinan Poblacion.

On the other hand, the result of the gathered data regarding the level of the impact of the COVID-19 pandemic protocols to the SMEs organizational performance is 2.55, described as strong. Thus, the researchers concluded, that the Covid-19 pandemic health protocols have a strong impact to the organizational performance of SMEs in Calinan Poblacion. As a result, the outcome of this study supported the first claim about the high level of impact of covid-19 pandemic to the SME's financial operation, human resource management, and logistics. It was discovered that the different COVID-19 health protocols mandated by the government are one of the strong reasons why SMEs organizational performance is affected by the pandemic.

Recommendation

Based on the findings of this study, the following recommendations are suggested.

SME owners must renegotiate their contracts. They can take a look at their accounts payable. They can gather all their vendor contracts, prioritize them, and then start negotiating things like reduced payments or extended terms. Some suppliers might disagree, but others will likely support you since they do not want you to fail. If they are renting their place, owners can also work with their landlords to try to forgo rent payments for a set amount of time.

SME owners must also collect any outstanding cash. Owners must reach out to those who owe them money and collect. If SMEs are holding an

invoice until work is finished, the researchers suggested that they should not; instead, give them bill for the portion that was completed. They can also ask customers for prepayment of a future activity. The SMEs whole strategy is to stay liquid, so they could offer a discount on next year's activity if people pay up front.

Further, SME owners can reduce their staff costs. As painful as it is, they have to reduce their staff as much as possible, either through layoffs or furloughs. Thus, for those who remained employed, owners must make across-the-board significant pay cuts.

Lastly, they must increase their productivity. Owners must do as much work as viable with the least amount of people. Right now, it will be better off working longer hours with a smaller group than less hours with a larger group. Owners can also increase efficiency by working online.

In conclusion, the critical thing SME owners must make sure is that they can reduce expenses, reduce the cash outflows, work with all their suppliers and creditors, and see if they can maintain a solvent business, because if the society does not have small businesses, our economy will be much harder to restart.

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THE IMPACT OF COVID-19 PANDEMIC ON THE WATER DEMAND IN CALINAN POBLACION, DAVAO CITY

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ABSTRACT

This study assessed the impact of COVID-19 Pandemic on the water demand in Calinan Poblacion, Davao City. The assessment was done by comparing the water consumption of the residential and commercial consumers before and during the pandemic time. Hence, the study used the

quantitative comparative approach in pursuing the investigation. From the data that were collected, it was found out that residential water demand during pre-pandemic time and pandemic time shows no significant difference. The same result was observed when the water consumption of the commercial sector before and during the pandemic period reflected no significant difference. However, the slight increase in residential water demand was observed which is opposite with the commercial water demand which shows a little decrease during pandemic. This signifies that the COVID-19 pandemic somehow affects the water consumption of the residents in Calinan Poblacion, Davao City.

Keywords: *Residential water demand, commercial water demand, no significant difference*

INTRODUCTION

The earth is composed of about 71% of water, and within this body of water consists of about 96.5% saltwater and 3.5% freshwater (Williams, 2014). Thus, water is at the center of sustainable development and is essential for human survival. On the other hand, global water resources are recoded to reach a total of around 1.4 billion cubic kilometers. Unfortunately, only about 213,000 cubic kilometers are accessible to humans (World Water, 2019). Additionally, the annual average water footprint was reported as 1.385 million liters per person, which is equivalent to 3,800 liters daily (Water Footprint, 2021). In terms of residential water consumption, public water suppliers provided approximately 23,300 Mgal/d of water for 283 million people in single-family and multifamily dwellings in 2015 (Water Resources, 2019).

In the statement of Cooley (2020) in Portsmouth, England, it was mentioned that the residential water demand had increased by about 15% during the lockdown while the non-residential water demand had declined by 17%. Moreover, in San Francisco, California, the residential water demand also increased by about 10% while non-residential water demand declined by 32%. Therefore, it is believed that the lockdown has caused households to drastically change their typical consumption behaviors since water is generally used in order to perform daily activities across a variety of major categories, resulting in an initial sharp increase in spending, especially on essentials and food items (Abu-Bakar, Williams, & Hallett, 2021). This fundamentally became a possible factor that affected water demand all throughout the world (Boretti & Rosa, 2019).

Moreover, it was expected that the water demand would increase even after the lifting of Enhanced Community Quarantine (ECQ) as the

people adapt to the new normal. The persistent advice by the World Health Organization (WHO) and the government that frequent and thorough handwashing with soap and water, regular sanitation in households, taking baths, and washing or sanitizing belongings after work or returning home should be observed to be safe during the COVID-19 pandemic (WHO, 2020). Thus, water become even more important during this time where the world is facing the health crisis. However, it is sad to note that due to the change in water demand, an observable water interruption exists, leading to a water deficiency in some areas (Petruzzello, 2021).

Alarmingly, it has been observed that as the population grows, there is an increasing number of competing commercial demands on water resources for the communities (Boretti, 2019). As a matter of fact, some countries such as Qatar, Israel, and Lebanon continue to experience water scarcity causing the prevalent lack of access to water to execute at least the basic hand-washing techniques in the area (Tripathi, 2019). This issue becomes more alarming because the world is currently facing the COVID-19 pandemic (WHO, 2020). Further, the issue is also focused on the awareness of individuals to the vitality of water in reducing the global burden of diseases and improving the health of populations. Hence, scarcity of water in this time of pandemic imposed a massive health and economic burdens on communities around the world (Cooley, 2020) and even impacted the water demands (Guarino, 2020)

In the Philippines, inadequate and intermittent water supply in Metro Manila and in other parts of the country could incite serious health consequences (Samion, 2020). As a matter of fact, the World Health Organization is worried about the reported annual water shortages because it could worsen the situation regarding the Corona virus outbreak by making the spread more rampant or out of control. It is important for communities and health workers to have access to safe and adequate water at all times to protect them from the spread of infection (Disease Control, 2019; Macasero, 2020).

In Davao City, the second district city councilor, Danilo C. Dayanghirang (2014), confirmed that the city has undergone some kind of water crisis, not just in the second district but also in the first and third districts. Factors like the variability in climate, demographic patterns, unsustainable water-use patterns, leakage, theft, and poor management were most likely the explanations for why about 50% of the water supply in the city never reaches its designated consumers (Water Supply, 2021). In supporting to this, the Davao City Water District (2021) had issued that in Barangay Toril last March 6, 2021, there were still conflicts as regards to the

low water pressure in the area. As a result, water interruptions were observed even amidst pandemic. This lack of water supply reaching every household can lead to less sanitation and allows pathogens to easily penetrate the body, hence leading to health issues (Khambete, 2019).

As a matter of fact, Davao City has recorded that detrimental water supply causes cholera, dysentery, typhoid, polio, and especially diarrhea, which are critical when not treated immediately (WHO, 2019), specifically in the areas of Buhangin District after confirming spikes of cases regarding these health issues (Diarrhea, 2015). Also, the mayor of Santo Tomas, Davao del Norte declared a diarrhea outbreak in the barangay after the local government recorded 171 total cases with one death from drinking contaminated tap water (Colina, 2021). This proves that contaminated water and poor sanitation have a link to the transmission of diseases (WHO, 2019)

With all the data presented in the preceding paragraph, it can be noted that an increase in water demand is evident, especially at this time when the world is trying to combat the pandemic. Also, it is emphasized in the third paragraph that this increase in water demand will continue since the so-called "new normal" will now become the society's normal set-up. Therefore, data-based and informed strategic planning is critical for development planners and local government units. One of the strategies that can be implemented is to locally analyze and focus on exact figures. Therefore, the researchers found the need to present a clear picture of the water demand of the residential and commercial sectors in Calinan Poblacion, Davao City.

Statement of the Problem

The purpose of the study was to determine the impact of the pandemic on the water demand in Calinan, Davao City. Specifically, it aimed to answer the following questions:

1. What is the residential water demand in Calinan, Davao City from January to August when classified as:

    1.1 pre-pandemic time 2018-2019; and

    1.2 pandemic time 2020-2021.

2. What is the commercial water demand in Calinan, Davao City from January to August when classified as:

    2.1 pre-pandemic time 2018-2019; and

2.2 pandemic time 2020-2021.

3. Is there a significant difference in the water demand in Calinan, Davao City during the pre-pandemic and pandemic time when classified as:

3.1 Residential Water Demand

3.2. Commercial Water Demand

Chapter 2

METHODS

This chapter presents the description of the research method and procedure of the study. This presents the study's research design, research locale, data gathering procedure, and data analysis.

Research Design

A research design enables the researchers to proceed in the right direction without any deviation from the tasks. It is an overall, detailed strategy of the research process (Somasundaram, 2019). Also, it acts as the study's structure and tries to work to address all the research questions. Moreover, a comparative research design was used as the research method for this study because the researchers compared two separate records in an attempt to find its differences (Adiyia & Ashton, 2017). In this study, a quantitative comparative research design was employed. It is a research method that compares two groups in an attempt to draw a conclusion about them, as well as determine their similarities and differences (Richardson, 2018).

A comparative research design was repeated in this study since the researchers simply observed the data to clearly identify the possible differences between the compared data. Also, this type of research design is best applied when there is a feasible comparison of data and the data needed for comparison is available. This design is best at determining differences, hence it is helpful in assessing the changes of water demand as an impact of the COVID-19 pandemic in Calinan Poblacion, Davao City.

Research Locale

The conduct of this study was in the locality of Calinan Poblacion, Davao City, which is considered one of the commercial areas present in the third district of Davao City. The place is known not only because of the king of birds, the Philippine Eagle, but also of its chocolate which is considered

one of the finest in the world. Additionally, Calinan is also blessed with a variety of fruits such as durian, mangosteen, rambutan, lanzones and many more (Philatlas, 2019). The researchers' target area was specifically located in the vicinity of Calinan Poblacion. Other areas outside the geological map of Calinan Poblacion were not included. For more information about the location, refer to the picture below.

Data Gathering Procedure

Before the onset of data gathering, permission from the school administrators on the conduct of the study was sought. A letter was sent to inform the school principal about the nature of the study. After getting the approval from the school authorities, another letter was crafted and sent to Davao City Water District (DCWD) requesting the company to furnish the statistical record of residential water demand and commercial water demand in Davao City during the pre-pandemic and pandemic periods from January to August through the use of online platforms.

Upon conducting this study, the consideration of ethics was imperative. These moral principles are able to guide the researchers to conduct a study without the intention of harming the accomplices of the study, whether intentionally or unintentionally (Singh, 2019). This also allows the researchers to create a just, responsible, and common-sense study. The organizations associated with this study were primed to ensure that the confidentiality of the data gathered is secured as there would be no different people who have access to it aside from the researchers and their research adviser. The organizations involved have the option of withdrawing their approval of the letters required to collect the data.

The researchers acquired the needed data, and the gathered data were compiled and wrapped for interpretation and analysis. The data were computed for interpretation and compared to other acquired data for statistical comparison. The impact of the COVID-19 pandemic on residential and commercial water demand during the pre-pandemic and pandemic periods was prepared for analysis and for the comparison of both records.

Data Analysis

A t-test was utilized in this study to find the difference between the effects of the COVID-19 pandemic on water demand in Calinan Poblacion, Davao City. The researchers made use of the t-test statistical test because it compared two variables present in this study, as well as it determined their differences. Moreover, as stated by Bevans (2020), a t-test is a statistical test that is used to compare the means of two groups.

On the other hand, the difference between the two sets of data gathered was acquired through the t-test statistical tool. Also, the gathered data in each category, including both residential water demand and commercial water demand, was compared as well. Likewise, there were no statistical tools employed in getting the answers to the research questions 1 and 2 since the data gathered provided the answers.

In the field of statistics, t-test was used in assessing whether there is a significant difference between two groups' means. Also, t-tests examine if two sets of normally distributed data are similar or dissimilar by comparing their standard deviations and means, respectively (Statistical Tool, 2017). In addition, higher values of the t-score indicates that a large difference exists between the two sample sets while smaller values of the t-score indicates that a more similarity exists between the two sample sets (Hayes, 2021).

All the data gathered were run through Microsoft Excel. The use of Microsoft Excel's t-test illustrated the difference between the two sample sets. The researchers were able to determine whether the two sample sets differ or are similar after encoding the data to Microsoft Excel. Since the results showed the difference or similarities between the sample sets, it answered the research question 3.

Chapter 3

RESULTS AND DISCUSSION

This chapter thoroughly discusses the results and findings after the data points were gathered. Further, the research questions found in the statement of the problem in Chapter 1 were answered.

Research Question 1: What is the residential water demand in Calinan, Davao City from January to August when classified as pre-pandemic time 2018-2019 and pandemic time 2020-2021

Table 1. Residential Water Demand in Calinan, Davao City from 2018-2021 for the months of January to August

YEAR (January to August)	WATER CONSUMPTION (in cubic meters)	AVERAGE CONSUMPTION PER CONNECTION PER DAY (in cubic meters)
2018 (Pre-pandemic)	583,752	0.77

2019 (Pre-pandemic)	538,289	0.76
2020 (Pandemic)	544,531	0.76
2021 (Pandemic)	607,923	0.79

Table 1 shows the corresponding water consumption of the residents in Calinan, Davao City from January to August in 2018-2019 before the pandemic hit the country. Shown also in the table is the water consumption on the same months, January to August, of 2020-2021 when the country was experiencing health crisis due the COVID-19 pandemic. It can be gleaned from the table that before the pandemic, the residential water consumption of Calinan in 2018 from January to August was 583,752 m3, or equivalent to 0.77 m3 per day. On the same months in 2019, the residents' water consumption was recorded to be 538,289 m3 or equivalent to 0.76 m3 per day.

On the other hand, the recorded water consumption in 2020 on the same months, January to August, was 544,531 m3, or equivalent to 0.76 m3 per day and 607,923 m3, or equivalent to 0.79 m3 per day in 2021. It is important to remember that in 2020-2021, various forms of community restrictions and lockdowns were in place due to the pandemic. As a consequence, a change in the residential water demand can be noted in the figures reflected in table 1. Specifically, for 2018-2019, pre-pandemic time, the average water consumption was 561,102.2 m3 which is lower than the 576,277 m3 in 2020-2021 during the pandemic time.

The trend in the change in water demand from the period covered in this study is clearly shown in Figure 3.

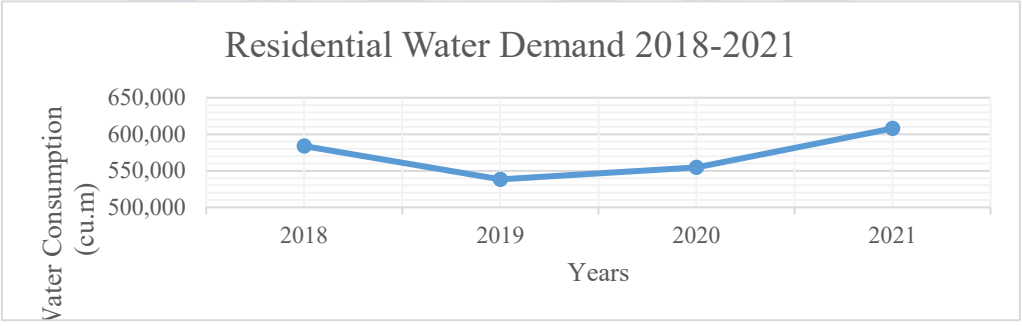


Figure 3: Residential Water Demand in 2018-2021

The graph in figure 3 illustrates a decrease in water consumption in 2018 to 2019. However, an increase was observed from 2019-2021. Further,

it can be noted that the increase from 2020-2021 is higher than the increase from 2019-2020.

The observations noted above are supported by the study conducted by Sonowal (2017) stating that the decrease in residential demand is often caused by climate conditions, economic status, the number of establishments, environmental changes, water supply systems, and the size of a city. Futher, the study of Velayutham (2019) mentioned that residential water demand can also increase due to the vitality of water in regards to health, hygiene, and entertainment. Furthermore, the study of Cooley (2020) demonstrated that in Portsmouth, England, an increase of about 15% in residential demand is observable, particularly during the lockdown. This drastic change in the residential water demand is caused by people's more indoor activities than any outdoor activities due to the reasons that regulations such as social distancing and other measures are implemented to attain safety against the pandemic (Cooley, 2020; Dezecache, Frith, & Deroy, 2020).

When the World Health Organization declared that COVID-19 was a global pandemic (WHO, 2020), most governments worldwide agreed to compose a declaration of lockdown (Sick-Samuels, 2021), leading people to stay at home for safety (Oosterhoff, Palmer, Wilson, & Shook, 2020). Due to this, changes in residential water demand occurred because people were doing more indoor activities that used water during the pandemic, such as cooking, washing dishes, flushing toilets, showering, and sanitation (Cooley, 2020), as well as leisure, comfort, hygiene, convenience, and aesthetics (Pan et al., 2018). Moreover, it was suggested by the World Bank Group (2020) that water, sanitation, and hygiene (WASH) are some of the common practices that can prevent individuals from acquiring the virus. Due to these concerns, and with adherence to the government's policies, residential water demand massively increased coming from a sudden drop, specifically in the years when the pandemic began (Fowler, 2020).

Research Question 2: What is the commercial water demand in Calinan Davao City from January to August when classified as pre-pandemic time 2018-2019 and pandemic time

Table 2. Commercial Water Demand in Calinan, Davao City from January to August when classified as Pre-pandemic time 2018-2019

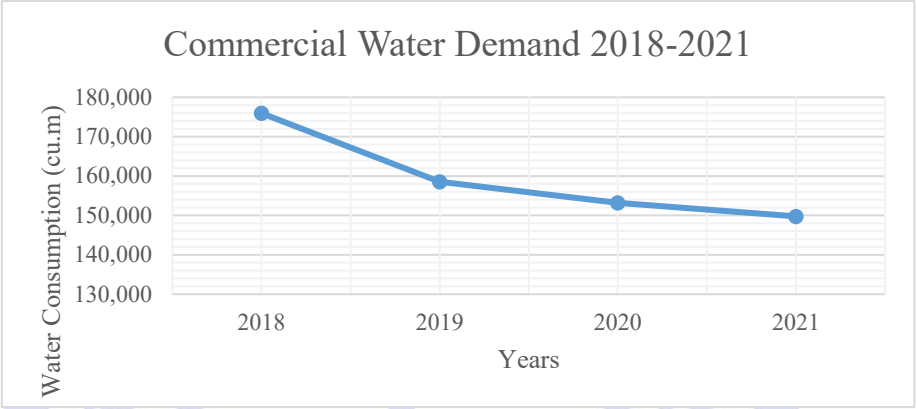
YEAR (January to August)	WATER CONSUMPTION (in cubic meters)	AVERAGE CONSUMPTION PER CONNECTION PER DAY (in cubic meters)
2018 (Pre-Pandemic)	175,963	1.36
2019 (Pre-Pandemic)	158,558	1.24
2020 (Pandemic)	153,166	1.13
2021 (Pandemic)	149,761	1.11

Table 2 shows the corresponding amount of water consumed for commercial use in Calinan, Davao City from January to August in 2018-2019 before the pandemic hit the country. Presented in this table also is the water consumption on the same months, January to August, of 2020-2021 when the country is experiencing health crisis due the COVID-19 pandemic. It can be gleaned from the table that before the pandemic, the commercial water consumption of Calinan in 2018 was 175,963 m3, or equivalent to 1.36 m3 per day from January to August and 158,558 m3, or equivalent to 1.24 m3 per day in 2019.

On the other hand, the recorded water consumption from 2020-2021 on the same months, January to August, was 153,166 m3, or equivalent to 1.13 m3 per day, and 149,761 m3, or equivalent to 1.11 m3 per day respectively. It is important to recall that in 2020-2021, various forms of community restrictions and lockdowns were in place due to the pandemic, prohibiting consumers to have face-to-face social contact with retailers. As a consequence, a change in the commercial water demand can be noted in the figures reflected in table 2. Specifically, for 2018-2019, pre-pandemic time, the average water consumption was 167,260.5 m3 which is lower than the 151,463.5 m3 in 2020-2021 during the pandemic time.

The trend in the change in water demand from the period covered in this study is clearly shown in Figure 4.

Figure 4: Commercial Water Demand in 2018-2021



The graph illustrates that from 2018 to 2019, the water consumption greatly decreased while it continued to decrease constantly until 2021. This means that the commercial water demand in Calinan Polacion, Davao City is constantly decreasing from pre-pandemic time until pandemic time.

The observations noted above are consistent with the theory proposed by Maslow (1943) stating that demand is affected by the human needs and human motivations as a result with the interaction of an individual with the environment. Although commercial refers to the services or to the establishments that allow people to gain and benefit money (Commercial, 2020), due to the closure of most non-essential commercial facilities (Melville-Shreeve, Cotterill, & Butler, 2021), the commercial water demand had decreased since the spread of the pandemic. In addition to this, the pandemic also severely affected the global economy and financial markets due to lockdowns for the safety of individuals during pandemic (Pak, et al., 2020). However, despite this concern, most individuals continued to seek for ways to obtain at least the basic needs and wants (Bartik, et al., 2020) in order to ensure safety and entertainment during lockdowns (United Nations Conference on Trade and Development, 2020). Moreover, as a result of public adherence to the new normal (Sick-Samuels, 2021), most individuals made use of online platforms to gain entertainment, as well as spending time in online shopping (Tymkiw, 2021). In fact, a data gathered by Ouellette (2022) showed that online shopping massively grew that nearly hit the market size of 4 trillion during 2020 and was predicted that in US alone, around 300 million more online shoppers will exist in 2023. Additionally, in order to attain safety against the pandemic, the government executed actions declaring that social distancing and other measures of prohibiting individuals from having face-to-face interactions, or by limiting social interactions in overall, can limit the spread of the virus as affirmed by Dezecache, Frith, and

Deroy (2020). With this unaccustomed form of providing services, the use of commercial water had decreased as influenced by the closure of commercial establishments such as schools, universities, restaurants, and public transport (WHO, 2020).

Research Question 3: Is there a significant difference in the water demand in Calinan, Davao City during the pre-pandemic and pandemic time when classified as Residential Water Demand and Commercial Water Demand

Table 3. The difference between the residential water demand during pre-pandemic and pandemic time

Residential Water Demand	P-value	Commercial Water Demand	P-value
Pre-pandemic Time	0.376470676	Pre-pandemic Time	0.132773283
Pandemic Time		Pandemic Time	

Table 3 reveals that there is no significant difference in the two variables involved in terms of the residential water demand of the residents in Calinan, Davao City before the pandemic and the pandemic time. With the p-value of 0.376470676 which is greater than 0.05, this means that there is no significant difference between the variables. Although the results showed no statistical difference, the graph in figure 3 made the impact of the COVID-19 pandemic obvious, providing evidence of the change in residential water demand in Calinan, Davao City.

Moreover, table 3 also reveals that there is no significant difference in the two variables involved in terms of the commercial water demand before the pandemic and the pandemic time. This is due to the p-value of 0.132773283 which is greater than 0.05 which statistically means that there is no significant difference between the variables. Although the results showed no statistical difference, the graph in figure 4 made the impact of the COVID-19 pandemic obvious, providing evidence of the change in commercial water demand in Calinan, Davao City.

The mean and the standard deviation of both residential water demand and commercial water demand after computation are clearly shown in Figure 5 and Figure 6.

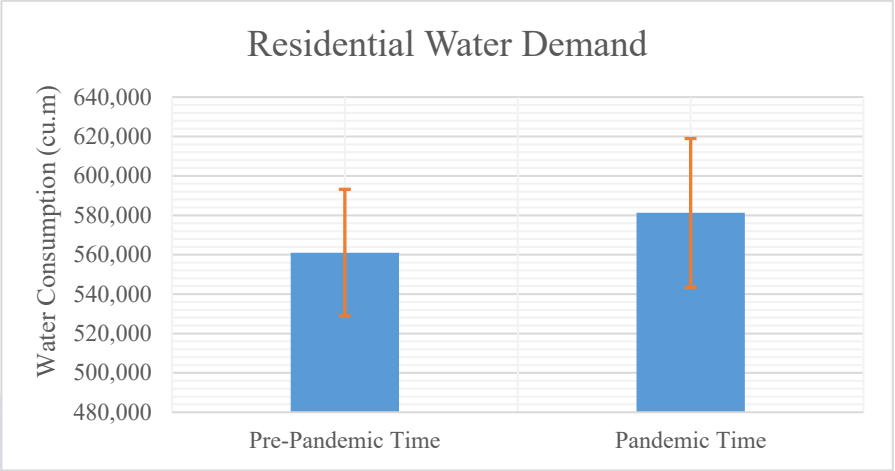


Figure 5: Mean and Standard Deviation of Residential Water Demand

The graph illustrates that the average residential water consumption during pre-pandemic time is lower in comparison with the residential water consumption during pandemic time. In clarity, the blue-colored bar represents the mean while the orange-colored line represents the standard deviation. As shown in the illustration, height of both bar is not entirely different with each other, meaning to say that the residential water demand has no significant difference.

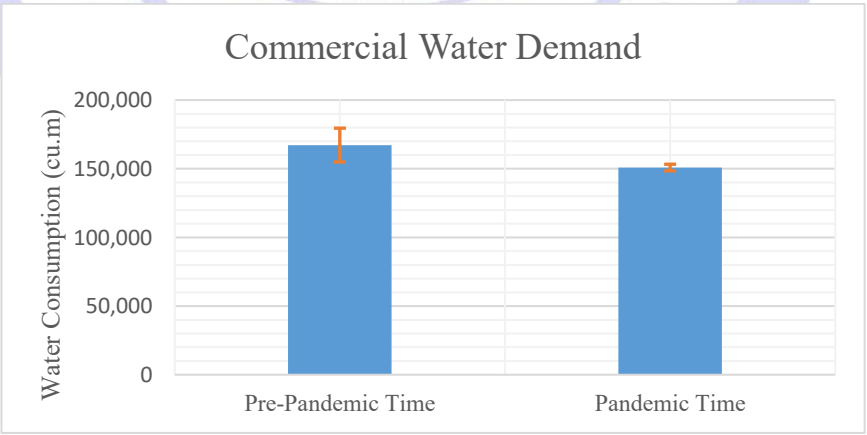


Figure 6: Mean and Standard Deviation of Commercial Water Demand

The graph illustrates that the average commercial water consumption during pre-pandemic time is higher in comparison with the commercial water consumption during pandemic time. In clarity, the blue-colored bar represents the mean while the orange-colored line represents the standard deviation. As shown in the illustration, height of both bar is not entirely different with each other, meaning to say that the commercial water demand has no significant difference.

The results gleaned above are similar to the study of Otaki, Honda, and Ueda (2020) revealing that the difference of water consumption as the results in residents' inconvenience or dissatisfaction shows no significant difference as the coding of the gathered data showed a p-value of 0.42. This is because people can freely use water depending on their needs and preferences. Likewise, during the start of the pandemic, the World Bank Group (2020) suggested that through following WASH, the residents may efficiently prevent the spread of the virus. Also, Cooley (2020) stated that during the pandemic, people used water more frequently inside residential areas and used less water in commercial areas. This explains that the human needs and preferences affecting water demand usually involved to the vitality of water in prevention against pathogens (Velayutham, 2019).

Moreover, the observations noted above are also consistent with the theory proposed by Maslow (1943) stating that demand is affected by the human needs and human motivations as a result with the interaction of an individual with the environment. Also, human preferences greatly changed due to the implementations of lockdowns (Pak, et al., 2020). Thus, this led the population to seek for other ways to attain at least the basic needs and wants (Bartik, et al., 2020) even through online shopping (Tymkiw, 2021). This explains that water demand is also depending on the decision of the people to attain safety amidst pandemic (Morgan, 2020).

Chapter 4

CONCLUSION AND RECOMMENDATIONS

The conclusions and recommendations drawn from the data analyzed in the previous chapter is found in this chapter.

Conclusion

Based on the data gathered, the total residential water demand in Calinan Poblacion, Davao City during the years 2018, 2019, 2020, and 2021 in the months of January to August is 2,284,495 m3, having the average of 561,102.2 m3 in 2018 and 2019, during the pre-pandemic time, and an

average of 576,277 m3 in 2020-2021, during the pandemic time. Specifically, the water consumption during pre-pandemic time had decreased from 583,752 m3 to 538,289 m3 while the water consumption increases from 544,531 m3 to 607,923 m3 when the world is facing health crisis due to the COVID 19. It can be concluded that the pandemic impacted the residential water demand in Calinan Poblacion based on the recorded data.

On the other hand, the total commercial water demand in the same area during the months of January to August was 637,448 m3, having the average of 167,260.5 m3 in 2018 and 2019, during the pre-pandemic time, and the average of 151,463.5 m3 in 2020 and 2021, during the pandemic time. Thus, the figures on water demand of the commercial sector clearly showed the impact of the pandemic with a decreasing pattern. However, the statistical computations exposed a p-value of 0.376470676 of the residential water demand during pre-pandemic time and pandemic time which means it has no significant difference. Lastly, the results of the computations exposed a p-value of 0.132773283 from the commercial water demand during pre-pandemic time and pandemic time which means it has no significant difference as well.

Recommendations

Based on the results that are shown and processed into interpretation, the future researchers are recommended to gather data of the residential and commercial water demand that range from January to December in the years 2018 to 2022 to completely identify the total annual water consumption befitting in the categories. Additionally, they can expand the years of both pre-pandemic time and pandemic time to acquire a larger set of data leading to the enhancement of the accuracy of results. Secondly, since this study is only limited to Calinan Poblacion, Davao City, future researchers are recommended to conduct this study in a bigger context, which is to completely assess the water demand in whole Davao Region or even cover the whole Region XI. This is one way of maximizing available data for more accurate and effective strategies on water conservation. Another study can also be conducted including the industrial and agricultural sectors since the current study is grounded to assessing the impacts of water demand in both residential and commercial categories only to enhance the reliability of the study.

Moreover, as the results suggest there is an increase in residential water demand during pandemic time. The residents in Calinan Poblacion, Davao City are recommended to practice water conservation techniques in

order to preserve water for future purposes. Therefore, an effective information drive about water conservation shall be conducted. This can be initiated by the barangay officials to make it more focused and in small-scale. Also for the DCWD, the need to craft effective programs, strategies and initiatives to monitor water consumption to prevent exhaustion of the water source not only during this time of the pandemic.

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

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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 to mitigate the resulting risks and impact considering the combustion process involved.

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

INTRODUCTION

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 like 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

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

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
	Global warming		
	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.	Environmental consequence	6
	Air pollution		
Environment (IE)	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		

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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SMART IRRIGATION TECHNOLOGY IN PHILIPPINE AGRICULTURE; A 5 –YEAR EFFECTIVITY ASESSMENT

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ABSTRACT

This study assessed the effectiveness of the smart irrigation implementation in the Philippine Agriculture for the past 5-Years. This identified the different implemented smart irrigation technologies, their portrayed impacts and their level of effectiveness. The study used quantitative content analysis approach. Research articles and project reports were gathered from trusted online publications and scholarly engines that talk about smart irrigation technology. The study found out that smart irrigation implementations have significantly contributed to high water use efficiency, have been significantly informative and have been promoting less labor. However, the impact on crop growth, though enhanced, was not that significant. The need for technical knowledge training was also identified so as the need for the cost was also found out to be one major attribute in the implementations of these.

Keywords: *Smart Irrigation Technology, Arduino, Rainfall Dependency*

INTRODUCTION

Maintaining the wellness of plant growth has been a challenging aspect in the field of agriculture, making it the biggest purchaser of water. It represents about 84% of the complete water use in Asia, 72% around the world, and 87% in creating nations. Water, being one of the major factors enabling photosynthesis occurrence in plants, is a vital entity to be considered and sufficiently supplied in order to attain productive outcomes in terms of crop production (Agriculture Victoria, 2018). Irrigation systems will be effective if there is a responsible and sustainable supplication of water throughout the process rendering plants a productive growth. Relative to this, rainfall serves an important factor in crops' growth as this waters plants naturally.

A good rainfall frequency and enough water sustenance can cause crops to grow productively and faster, cutting down germination time and the seedling to harvest duration. Crops entirely depend on water for survival (Sigfox, 2018). Relative to this, farmers in areas with no systematic irrigation systems, just operate manual irrigations and depend on rainfalls. This context brings issue regarding the plant growth productivity especially in seasons of drought. Nowadays, rainfall frequency is not that easily anticipated already due to climate change which brings big impact to crops' development. Climate change causes alteration in air and ocean currents which changes weather patterns (Environmental Protection Agency, 2017).

A study conducted in South Asia involving parts of Pakistan, India and Nepal found out that climatic variability poses a threat in their agricultural livelihood as insufficient amount of water is inundated to the crops due to irregular rainfall frequency (Rasul et al., 2019). Thus, rainfall dependency brings issue towards crop development in the region especially that climate change prevails. Such irregularity in precipitation patterns will have big effects on agriculture in the long run (Lal, 2011). With this, adaptive capacities and innovations in response to rainfall insufficiency (climatic risks) in irrigating plants, will be a beneficial influence on agricultural productivity (Panda, Sharma, Ninan & Patt, 2013). Innovations are musts to enhance agricultural sustainability in

South Asian countries amidst irregular rainfall frequency due to climatic variability (Springer, 2019).

In the Philippines, agricultural sectors and farmers somewhat experience difficulty in productive crop growth sustenance due to the reduced irregular rainfall brought by climate change. In fact, the Department of Agriculture suggested to take advantage in rainy seasons through collecting and storing water in order to constantly provide irrigation to crops as the rainy season duration or pattern cannot be trusted anymore (Department of Agriculture, 2015). Relative to this, Basconcillo et al. (2016), stated in their conducted study in Cagayan Valley, Philippines that irregular rainfall and climatic inconsistency causes negative impacts on crop production affecting people's livelihood especially that the province mainly depends on rainfall for agriculture. It pushed them to study and understand climatic changes in seasonal rainfall and mean temperature in Cagayan Valley to have possible plans of adaptations addressing the threat of rainfall dependency for agricultural productivity. With the mentioned details, it is clearly manifested that dependency on rainfall as irrigation for crops in today's climatic situation, results ineffectiveness and insufficiency towards crop growth and production.

With the traditional form of irrigation in the absence of rainfall, farmers manually operate and have to spend much time in manipulating hoses and buckets to water the plants. Such work is so laborious especially if the irrigation source is distant from the crop field. This results in effortful intervention of farmers during irrigation operation. As how important irrigation is for crops, is also how laborious task it is for the farmers to operate manually especially in drought seasons. Manual irrigation requires much effort and is time consuming (Mayuree, Bagubali & Aishwarya, 2019). But with these agricultural innovations, there appears also a challenge for the agricultural sector upon actual integration due to the need of advanced technological knowledge and finance.

Relative to the Philippines as a developing country despite not being the world's least technologically advanced country, is far from the

top leading ones and undeniably struggles in climbing up the top list. Given the existing economic challenges, the country strives to level up with other technologically advanced nations. Based on the Department of Science and Technology on a 2017-statistics, the Philippines was in the 83rd out of the 138 countries identified as having the readiness in terms of technology (Flipscience, 2017). Moreover, according to Global Innovation Index 2018, Philippines got the 73rd rank out of 131 economically developing countries. In 2019, it ranked 54th and moved up to 50th rank based on Global Innovation Index 2020 (Department of Science and Technology, 2020). In 2013, case studies have been carried out on the causes of the poor performance of National Irrigation System. Many concerns can be traced to flawed economic and technical assumptions during the planning and design phase so as problems during the construction phase of irrigation systems (Inocencio & Barker, 2018; Moya, 2013). Gaps have been found between design assumptions and actual operations causing systems to ineffectively perform. However, the mentioned study encompassed solely about the irrigation systems which do not involve automatic mechanisms as that of smart irrigation systems. In the current years, smart irrigation systems have been rampant due to the more evolving era of technology. With this, the researchers wanted to assess the effectiveness of the Philippine agricultural technological development specifically in the aspect of smart irrigation technology in the past five years.

Statement of the Problem

This study aimed to assess the effectiveness of smart irrigation system technology in Philippine Agriculture in the past 5 years specifically from 2015 to 2020. Thus, the researchers sought to answer the following questions:

1. What are the smart irrigation innovations implemented in the Philippine agricultural field in the past 5 years?
2. What are the impacts of the implemented smart irrigation technology in Philippine agriculture in the past 5 years?

3. What is the level of effectiveness of each impact of implemented smart irrigation technology in Philippine agriculture in the past 5 years?

METHODS

In this part, the research methods are discussed. This presented the research design, ethical considerations and data analysis which included the sampling frame, unit of analysis and coding and procedure scheme.

Research Design

The researchers used content analysis approach in the conduct of the study. Content analysis research approach refers to the act of categorizing, coding, analyzing set of media or communication pieces which can be written, oral or visual (books, newspapers, speeches, social media posts, photographs, etc.). This is used in determining patterns, messages and concepts of communication or media content. Thus, inferences about the themes made are concluded after analysis (Scribbr, 2020). Quantitative content analysis specifically focuses more on counting and measuring which are commonly in the form of word frequencies depending on the established coding rules as opposed to qualitative content analysis which deals more with interpreting and understanding.

This study utilized quantitative content analysis research design in which the researchers answered the research questions through coding and analyzing texts from the gathered research articles and project reports about smart irrigation implementations in Philippine agriculture. The researchers analyzed and quantified meanings, contexts and connection of words, phrases and ideas, then came up with inferences about information portrayed within the gathered research articles and project reports. Such were analyzed and coded by the researchers quantitatively following the set coding rules.

Sampling Frame

In the conduct of the study, 5-10 mixed research articles and project reports were used as samples which were randomly chosen online. The samples were about the implemented smart irrigation innovations in Philippine agriculture for it to be valid. Abstract, results and discussion and recommendations in research articles were the parts focused on. While in project reports, the whole article was used as no literatures are commonly included here unlike with research articles. Moreover, the research articles and project reports were gotten anywhere from scholarly engines (google scholar engine, research gate, academia, etc.), conference proceedings publications (IEEE, AIP etc.), technological organization forums and agency websites of Philippine government (DOST website, DA website etc.) where information are really authentic and trusted. The timestamp was from 2015 to 2020. This year range chosen as 5-year time period is enough to assess the development of smart irrigation technology implementations in the Philippines.

Unit of Analysis

Deciding on and choosing the unit of analysis is an essential part of content analysis approach as this serves as the basis in the development of codes so as the process of which the coding will be done (Roller & Lavrakas, 2015). Unit of analysis refers to the basic entity that is analyzed particularly in content analysis. This is the specific unit that are being coded, categorized and based on in the making of themes and inferences. These can be words, phrases, paragraphs, articles, newspapers, speeches, interviews and other media pieces (Trochim, 2020).

In this study, the words and phrases within the research articles and project reports were the units of analysis. The frequency of the word and phrases' concepts that describe the smart irrigation technology implementation gave the quantitative data that the researchers needed in answering the research questions. Relative to this, coding sheet with respective categories were used in quantifying the descriptive words/phrases about the smart irrigation technology.

Coding and Procedure Scheme

Five to ten research articles and project reports were used in the study as samples. A coding sheet or table was made by the coders where significant words and phrases were put so as other information related to answering the research questions. The identified significant words/phrases were the codes. Codes with the same contexts or ideas were grouped in creating a theme. The number of identified codes that make up each theme was put in the frequency column. The said table was made up of columns, namely: Sample No., Irrigation Technology, Significant Words/ Code, Theme and Frequency of Significant Words and Phrases as shown in the next page.

Table 1. Coding Sheet 1 Sample

Sample #	Irrigation Technology	Significant Words or Phrases (Codes)	Theme	Frequency
Sample #1	*Arduino Smart Irrigation	*effortless * spend less effort	Less Labor	2
		*yields satisfactory harvest	Better crop production	1
		*costly *requires finance	Expensive	2
Sample #2	*GSM-based Irrigation	*time-saving	Efficient	1
		*money is needed	Expensive	1

Sample # and Smart Irrigation Technology columns were filled in correspondingly based on what sample # was being analyzed and the irrigation technology tackled in it. Private information such as author's name and organizational names were not mentioned. Hence, the Smart Irrigation Technology column answered the research question no. 1. Such identified smart irrigation technologies were then furtherly categorized into four based on the common frameworks present on these. The similarities in terms of how these operate which depends on its framework are the bases on the categorization.

The themes from the codes were the bases in determining portrayed impacts to answer research question no. 2. In cases where themes with the same idea were present in other samples, the frequencies of such were added to get the total frequency of that theme. Corresponding percentages were then solved using the formula: Total Frequency/Total Number of Codes X 100%. Another table was made for this procedure as shown in the table below.

Themes	Total Frequency	Percentage
Efficient	1	1/7 X 100% = 14.29 %
Better crop production	1	1/7 X 100% = 14.29 %
Expensive	3 (1 + 2)	3/7 X 100% = 42.86 %
Less Labor	2	2/7 X 100% =28.57 %
Total	7	

Table 2. Coding Sheet 2 Sample

The acquired percentages were the bases in answering the research question number 3 about the level of effectiveness with respect to the themes identified. The themes entailed the portrayed effects of the implemented smart irrigation technology. Each theme has its

corresponding percentage for the level of effectiveness. After coding and acquiring the quantitative data, inferences were made by the researchers.

The following are the definitions of the used terminologies for better understanding.

Codes – These are the significant descriptive words or phrases identified.

Themes – These are the capturing idea of synonymous codes.

Frequency – This is the total number of codes.

Note: The identification of codes or significant words was anchored on the research questions that the researchers wanted to answer. Moreover, a coding draft appended in the appendix 2 was initially made before putting up the data to Coding 1 and Coding 2 tables.

Chapter 3

RESULTS AND DISCUSSION

This part entails the presentation of the results from the data gathering of the researchers. Discussions relative to the research questions established in the study are also contained in here together with visual representations and tables for better understanding. Studies from the review of related literatures are also presented to show either agreements or disagreements to the results of the study.

Research Problem #1: What are the smart irrigation innovations implemented in the Philippine agricultural field in the past 5 years?

Identified Smart Irrigation System	Framework
Solar-Powered Smart Agricultural Monitoring System with GSM	Solar-Powered Smart Irrigation System

Solar-Powered Irrigation System with Satellite-based Monitoring System	
Solar-Powered Water Advisory for Irrigation Scheduling System (WAISS)	
Evapotranspiration-based Irrigation System using Raspberry Pi	Weather-Based Irrigation System
Evapotranspiration-based Irrigation system with IoT	
Web-Based Application Smart Irrigation System	Web-Based Smart Irrigation System
Self-Activating Based Irrigation System	Simple Smart Irrigation System
Evapotranspiration-based Irrigation system	
Fuzzy Rule-Based Smart Irrigation System	

Table 3. Categorization of Implemented Smart Irrigation Systems based on Framework

The table on the previous page encompasses the various types of implemented smart irrigation technology in the Philippines for the past 5 years. These have been identified by the researchers within the analyzed mixed research articles and project reports. This was then categorized by the researchers based on its common framework.

Nine implemented smart irrigation systems have been identified by the researchers as described in the table. Among these, there are similarities with regard to the frameworks which were then furtherly categorized into 4 as shown on the right column of the table.

Solar-Powered Smart Irrigation System

This contraption primarily has solar energy as the main source in powering up the water pump along with the automatic water flow control through moisture sensors. This system conserves electricity by reducing the usage of grid power and conserves water by reducing water losses (Harishankar, Sathish Kumar, Sudharsan, Vignesh, & Viveknath, 2014).

Weather-Based Irrigation System

Weather-based Irrigation System uses local weather data in setting up irrigation schedules. On a daily basis, a weather station or remote weather service monitors conditions such as temperature, wind, solar radiation and humidity. Smart irrigation controllers interpret and combine that data with site-specific variables such as soil type and sprinkler application rate to adjust watering run times or schedules (HydroPoint, 2020).

Web-Based Smart Irrigation System

The web based smart irrigation system operates through online platform. Farmer can monitor the sensor values and field status on a webpage or clod platform. From the webpage farmer can know the water pump status and the soil moisture level (Sunehra, 2019). The data pass through a cloud platform or internet before reaching the operator. Internet availability is highly needed for such system to function well.

Simple Smart Irrigation System

This type of smart irrigation system is the basic form of a smart irrigation system and is the foundational framework of the other types. This technology uses sensors to measure the actual moisture content of the soil. The microcontroller which acts as the brain of the system then decodes such data and adjusts the time of irrigation water based on these. If the optimum soil moisture level is not met, the pump either starts or stops irrigating. (National Association of Landscape Professionals, 2017)

Research Problem #2: What are the impacts of the implemented smart irrigation technology in Philippine agriculture in the past 5 years?

Category	Impacts
Solar-Powered Smart Irrigation System	Water efficient, Less Laborious
Weather-Based Irrigation System	Water efficient, Informative, Costly, Less Laborious, Need for Technical Knowledge, Enhanced Yield
Web-Based Smart Irrigation System	Water efficient, Informative, Costly, Less Laborious, Need for Technical Knowledge
Simple Smart Irrigation System	Water efficient, Informative, Less Laborious

What are the impacts of the implemented smart irrigation technology in Philippine agriculture in the past 5 years?

Table 4. Portrayed Impacts of Implemented Smart Irrigation Systems

Table 4 shows the identified portrayed impacts after the analysis of the different research articles and website reports about smart irrigation implementations in the Philippines for the past 5 years. Each identified category has its respective impacts. Water efficient impact and less laborious impact are the common aspects among the categorizations. Meanwhile, Weather-Based Irrigation System and Web-Based Smart Irrigation System have the greatest number of identified impacts. The complex structure of these makes such more costly and demands for enough technical knowledge in terms of the functionality. On other hand, the Solar-Powered Smart Irrigation Category and Simple Smart Irrigation System have less identified impacts but are all favorable due to its basic but efficient framework.

Research Problem #3: What is the level of effectiveness of implemented smart irrigation technology in Philippine agriculture in

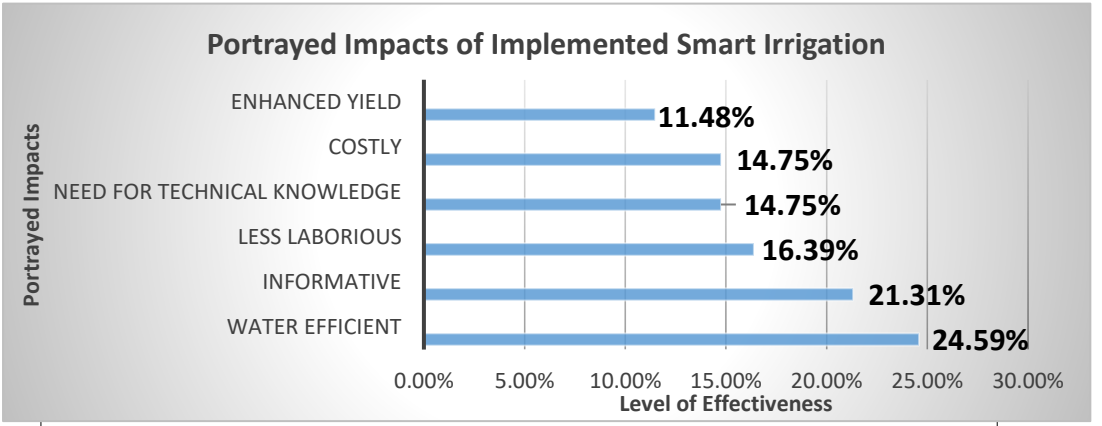

Figure 2. Level of Effectivity of Portrayed Impacts

The table summarizes the level of effectiveness of each portrayed impact of the smart irrigation technology implementations. Evidently, water efficiency impact has the highest level of effectiveness of all with a percentage of 24.59 %. This was followed by the capability of delivering agricultural information to the farmers with a percentage of 21.31 %. The embedded weather monitoring system, soil moisture monitoring and message alert systems to name some significantly contribute to this impact. Moreover, with 16.39 % effectiveness, less laborious impact ranked third. Having the same percentage of 14.75 %, costly impact and the need for technical knowledge such as trainings for the farmers ranked 4th. Lastly, with the lowest percentage of 11.48 %, having an enhanced yield impact ranked last.

Water Efficient

The impact of having efficient water use was in consonance to the study conducted by Rasyid et al. (2015) in which the utilization of smart

irrigation systems with attached sensors contribute to the efficient and enough withdrawal of water. This brings efficiency relative to water use.

Day	Automatic Irrigation (Liters of water used per day)	Manual Irrigation (Liters of water used per day)
Day 1	0.8	3.54
Day 2	0.63	3.64
Day 3	0.64	3.64
Day 4	0.73	3.54
Day 5	0.65	3.64
Day	Automatic Irrigation (Liters of water used per day)	Manual Irrigation (Liters of water used per day)
Day 6	0.65	3.58
Day 7	1.01	3.59
Day 8	0.57	3.64
Day 9	0.49	3.54
Day 10	0.57	3.64
Day 11	0.98	3.74
Day 12	0.39	3.74
Day 13	0.48	3.64
Day 14	0.58	3.74
Total	9.17	50.85

Table 5. Study Results of Abaya, De Vega, Garcia, Maniaul and Redondo (2017)

The table above delineates the outcomes of the study conducted by Abaya, De Vega, Garcia, Maniaul and Redondo (2017) which agrees to the results. Clearly, there is a huge difference between the manual irrigation system and automatic irrigation system in terms of water consumption after a 14-day experiment on a specified crop done by the aforementioned researchers. Smart irrigation systems only consumed a

total of 9.17 liters compared to the manual type having consumed a total of 50.85 liters.

Informative

The "informative" impact being on the top 2 is supported by Darshna et al. (2015). In their study, with the installation of advanced Arduino hardware and monitoring technology, agricultural important parameters such as soil moisture level and soil temperature are monitored making farmers knowledgeable about these. Moreover, Parameswaran and Sivaprasath (2016) showed the capability of SMS commanding system-based irrigation to render information about the crop field parameters wherever and whenever farmers can be.

Less Laborious

In support in less laborious impact, it has been revealed also by Magyar (2010) that the utilization of data processing hi-tech gadgets such as sensors makes out a better agricultural operation. Moreover, Brown (2018) claimed that innovations in the agricultural aspect improve personal satisfaction for farmers as their works are lessened.

Need for Technical Knowledge

The need for technical knowledge with a percentage of 14.75 % suggests the need for trainings and other activities that aim to educate farmers about the functionality of implemented smart irrigation systems. Augier, Baudequin and Isbérie (2016) stated that in order to improve irrigation performance, it is necessary not only to promote the implementation of innovative irrigation methods but also enhance farmers' skills to control and manage their irrigation system more efficiently during its operation.

Costly

Having the same level with the need for technical knowledge impact, the costly impact of smart irrigation systems was due to the need of advanced technological equipment such as sensors, solar panels and hi-tech modules to name some. As the SSWM (2011) pointed out, there will be cost difference between manual irrigation systems and smart irrigation systems the fact that in the traditional way, there is no need for technical equipment which costs significantly. This explains indeed such portrayed costly impact.

Enhanced Yield

Having the least percentage of 11.48 %, the study inferred that implemented smart irrigation systems have insignificant effect on the growth and production of crops. Though there is that enhancement on the crops yield, it does not portray a very big difference.

Week	Smart Irrigation System		Manual Irrigation System	
	Height of the Crop (cm)	Length of the Outer leaf (cm)	Height of the Crop (cm)	Length of the Outer leaf (cm)
1	3.6	1.1	3.5	1.1
2	4.9	2.8	4.5	2.8
3	7.2	4.5	7.3	4.6
4	7.9	5.5	8.5	5.8

Table 6. Study Results of Dela Cruz et al. (2020)

The result was in consonance to the study conducted by Dela Cruz et al. (2020) as shown in the table on the previous page. In a 4-week experiment conducted by the said researchers on a mustard green crop, they have found out that there was no significant difference on the height of the crop and the length of the outer leaf of the crop between the smart irrigation system implementation and the manual one.

CONCLUSION AND RECOMMENDATION

This section delineates the insights of the researchers and the suggestions with regard to the presented results in chapter 3.

Conclusion

Based on the findings about the effectiveness of smart irrigation implementations in the Philippines in the past 5 years, the researchers came up with the following conclusions:

The identified smart irrigation implementations in the Philippines entail that the country despite struggling in leveling with other technologically advanced countries, can raise its flag. The implemented solar-powered smart irrigation with monitoring systems, weather-based smart irrigation system or web-based smart irrigation system as categorized in chapter 3 involves technological contraptions that are efficient and beneficial to the farmers and agricultural sectors.

Based on the impacts identified together with their level of effectiveness, smart irrigation technologies in Philippine agriculture for the past 5 years have contributed to significant water efficiency. This has been really put into account which is a good thing especially that the world is facing risks relative to water crisis. This anchored to responsible water use and greatly helped in its promotion especially that in the Philippines, lots of agricultural lands really make use of water for irrigation. Also, such innovations have been significantly informative about agrarian parameters. The capability of the smart irrigation implementations to provide real time monitoring with regard to important agricultural parameters just like soil moisture level, weather and many more provided essential information to the farmers and agricultural operators. This impact made them knowledgeable of the needs to be sufficed in their crop fields. Less laborious impact was also significantly identified having the third highest level of effectiveness. The capability of these smart irrigation systems to offer efficient experience towards the farmers in terms of labor is also another beneficial impact to consider.

However, out of the mentioned positive impacts above, technical knowledge and high cost are needed in order to effectively implement and operate such smart irrigation systems. The implementations of these systems will be futile if the farmers lack the knowledge of using such. Moreover, having better smart contraptions installed in crop fields means more cost. However, if sustainability and efficiency relative to crop production and farmers' operation are the paybacks for such expenditure, the expense is worth it. Lastly, smart irrigation contraptions have brought enhancements on the crop yield but it was not that significant. This entails that although smart irrigation systems render enough water to the plants, enough amount of nutrients and fertilizers are still needed for more enhanced crop yield which were out of the scope of the study.

Recommendations

Based on the acquired results, the researchers wanted to recommend the following:

Firstly, the Philippine government and other non-government organizations must put into considerations the financial aspect for the implementations of the smart irrigation technology. They must provide cost-efficient innovations for the farmers to benefit effectively. Also, financial support for agricultural sector particularly in the smart irrigation innovation implementations must be focused on.

Secondly, together with smart irrigation implementations, there should be a reinforced training of farmers in line with the proper use and technical knowledge needed in operating the smart irrigation systems. Moreover, together with these trainings are additional information dissemination on what other agricultural parameters should be considered in order to significantly boost more the growth of crops. This can enhance more the farm crop production in the long run helping the overall economy.

This study only focused on the assessment of the effectiveness of smart irrigation system implementations in Philippine agriculture for the past 5 years. Thus, it did not cover the detailed contributing factors that affect the level of effectiveness of each portrayed impact. Hence, future researchers can study the factors affecting each specific portrayed impact. This can provide more detailed information about those entities needed in order to significantly increase the level of effectiveness for each positive impact which can still be done through content analysis methodology.

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Working While Studying: The Lived Experiences of Working Students

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ABSTRACT

The life of a student is a tough journey, how much more to those who have to work and study simultaneously? Being a working student is never easy; they have to give their full strength on working and their full effort in studying. This study aimed to explore the experiences of working students while studying such as their motivations on becoming working students, the problems that they encounter while studying and working at the same time and how they cope with it. This study used qualitative analysis to expose patterns in thought and attitude. Three emergent themes were formulated from their motivations on becoming working students. They are financial support, self-development and Internal motivation to integrate theory and practice. The problems that they encounter while studying and working have generated two themes which are enumerated as experiences for the betterment of working students and the disadvantages and weaknesses. Lastly, three more themes were uncovered

as to how the participants cope with the problems that they encounter as working students. Those are effective management, think positive and losses.

Keywords: *Working students, explore, experiences, motivations, problems*

INTRODUCTION

Filipino parents value education as one of the most important legacies they can impart to their children. They believe that having a better education opens opportunities that would ensure a good future and eventually lift them out of poverty. Thus, they are willing to make enormous sacrifices to send their children to school (Dolan, 1991, De Dios, 1995, & LaRocque, 2004). However, with poor families, basic needs such as food and shelter are prioritized over education since they have very limited resources. Thus, some students are doing some jobs to support their studies.

It is not easy to live a life as a student who works for his/her tuition and other expenses. It takes a great deal of courage, power and positivity before they can be considered a student at work. Today, it is common for a wide range of students to combine academic study with work as their families can no longer support them financially. Being a working student is never easy; they have to give their full strength on working and their full effort in studying. It makes them limit their leisure time as they have to focus on their studies and on their work and they have to perform well in academics and on their jobs.

Globally, there are about 56.7 million students enrolled in college or 33% of the total population. The survey of 2,128 students found that nearly half of students – 45% – have a part-time job, including a third of students now working part-time during term time. The number of working students has risen two percentage points in 2013. Most students are working, at least in part, because of money concerns, with 55% on food and household bills (Gil, 2014).

Here in the Philippines, there are about 216,000 students who are currently working while studying. College students are about 8% of the population. In Calinan District, there are a total of 18 working students currently enrolled in an institution where 10 of which are stay-out, 6 stay-in and 2 of which work on a farm.

As of 2017, 268 colleges and universities have increased their tuition as approved by the Commission on Higher Education. 16 of which are from Davao City including the school year 2017-2018 (Commission on Higher Education). Having higher tuition means more financial problems; more students will be opting to work as a student assistant in schools.

Given the situation, the researchers felt the urge to pursue this study, knowing that being a regular student is already hard, how much more to those who have to work and study? The desire to help the working students and the people around, this is also beneficial not only to working students but also to the different sectors of society.

Statement of the Problem

The purpose of this study is to explore the experiences of students who are studying at the same time working. It specifically, aimed to answer the following questions:

1. What are your motivations of being a working student?
2. What are the struggles you experience being a working student?
3. How do you cope with the problems that you encounter as a working student?

METHODOLOGY

This chapter contains the description of the methods and processes that were used in this study. This presents the usage of the research design,

research participants, sampling techniques, research locale, research instruments, data gathering procedure, ethical considerations, trustworthiness of the study, the role of the researchers and data analysis.

Research Design

This study used qualitative analysis to expose patterns in thought and attitudes. The study used Husserlian Phenomenology which was developed by Edmund Husserl, a research style that focuses on the interpretation of the different experiences of individuals (Van, 1990).

Qualitative analysis was used to dig deeper into the working students' motivations in working while studying, the problems that they encounter while working and studying at the same time and how they cope with it which Hatch (2002) describes that qualitative research is into everyday living. Husserlian Phenomenology was used in the study because the study focused on the interpretation of different experiences of working students such as their motivations in working while studying, the problems that they encounter while working and studying at the same time and how they cope with it.

Research Locale

The study was conducted in a private institution in Calinan, Davao City, a district located in the City of Davao in the province of Davao Del Sur. The school offers tertiary education which accepts student assistants. The students who are accepted as student assistants work in different areas and facilities. The institution best fits the locale of this study because it has the necessary participants needed in this research.

Figure 2. Calinan, Davao City, Davao Del Sur (Satellite view).

Data Gathering Procedure

In conducting this research, the researchers used triangulation method to increase the credibility and validity of research findings. Credibility refers to trustworthiness and how believable a study is; validity is concerned with the extent to which a study accurately reflects or evaluates the concept or ideas being investigated. Triangulation, by combining theories, methods or observers in a research study, can help ensure that fundamental biases arising from the use of a single method or a single observer are overcome. Triangulation is also an effort to help explore and explain complex human behavior using a variety of methods to offer a more balanced explanation to readers. It is a procedure that enables validation of data and can be used in both quantitative and qualitative studies (Noble & Heale, 2019). This involves cross-checking multiple data sources of information and collection procedures to ensure that the data on which we rely are valid and bias-free and to assess the extent to which all evidence converges. In other words, it offers multiple sources of evidence to identify uncertainties, consistencies and potential biases.

Before collecting the data, the researchers asked permission through a letter of approval from the administration. Moreover, the participants were informed of the purpose of the analysis. The researchers obtained each participant's informed consent and guaranteed the freedom of choice that would provide the avenue for voluntary participation or decline in the study. The participants were also informed of the purpose, the idea of the study and the questionnaire. The researchers assured the confidentiality of the answers of the participants.

In collecting the data, the printed research questions were handed out and were collected by the research adviser. Additionally, there was no

video or audio take during the obtainment of the data. The gathered data were fetched by the researchers and codes were used to protect the identity of the participants.

Ethical Considerations

In this study, there are three ethical considerations: the confidentiality of the participants, the attainment of permission for the interview and the participants' right to withdraw their statements.

First, the participants were given code names to secure their identity and confidentiality of their answers, second, the letters of permission that the researchers made for the respondents to be able to gain knowledge about their rights to accept or decline as a respondent of the study. These letters were signed by the researchers and the participants of the study and by doing so, considering that they have understood the terms and conditions set and stated in the letter before proceeding to the interview. Lastly, if ever the participant decides to withdraw or retract their statements, the data gathered were considered null and will not be included in the research.

Data Analysis

In analyzing the data of this study, the Colaizzi's Method was used. However, this study modified some steps and only followed up to the third (3) step. The following steps represent Colaizzi's procedure in conducting phenomenological data analysis that: (1) reading and re-reading of each transcript is a must to generate a sensible thought about the whole content; (2) for the individual transcript, important testimonials that relates to the phenomenon under the study should be culled; (3) meanings should be generated from the valuable statements from the informants.

In the research, relevant bracketing was introduced. Thus, this was the initial phase of the phenomenological reduction procedure (Moustakas,1994). All the known ideas on the phenomenon were either set aside or bracketed as far as possible at hand.

RESULTS AND DICUSSION

This chapter deals with the presentation, analysis and interpretation of data with regard to the nine emergent themes produced. They are presented and analyzed according to the order of the research questions specified in Chapter 1. This chapter presents the eight emergent themes.

Research Question #1. What are your motivations of being a working student?

Table 1: *The thematic analysis about their motivations for becoming a working student.*

Theme	Significant Statements
Financial support	*-I want to become independent. I don't want to be a burden to my parents.* *-For me it is just to get the experience and additional financial support.* *-I believe that education is important, but we also need money for studying. So, seeking money is also important.*
Self-development	*-Personally, I want to increase my skill.* *-I can get experience* *-I feel that I am in need to improve my quality in life.* *-Decided to further my study even though I have to work as well.*

	-Focus on working and studying at the same time to get life experience.
Internal motivation to integrate theory and practice	*-Theoretically, it is very good actually. But to integrate and do both at the same time, it is very difficult.* *-To lift up my family from being poor* *-To achieve my goals in life*

This research question tried to explore the perceptions of students on working while studying. Based on the participants' responses, it is confirmed that financial support, self-development and internal motivation to integrate theory and practice are among the driving forces of working while studying at university. From the responses, it can be inferred that the participants seemed to fully understand the motivation and reasons behind working while studying.

Struggling about financial support is a very common problem that they have experienced as working students. They worry about being unable to pay debts over the short or long term and it complicates the students especially those who are financially struggling to perform and lead a better life in college. Sometimes, they choose to work while studying in order to increase their skills and at the same time to get a life experience. Finding internal motivation to integrate theory and practice might be difficult but it is essential in order to achieve personal goals.

Moreover, some of them said that in order to survive, they need to learn how to become independent in order to overcome financial problems. One of the participants stated that:

- "I want to become independent. I don't want to be a burden to my parents, so I

can pay my own expenses and tuitions fees. Besides, I can gain experience". (WS7)

Aside from the financial support that the participants have experienced and still experiencing, there are also some self-development from being a working student that could improve their skills and abilities. The participants said that being a working student could help them gain a life experience. As a matter of fact, it is a burden on them, but it could be a great opportunity to improve themselves on their future career paths. Having early experience of work as a training and practice could improve themselves, which could make them more flexible and suitable for the kind of work they want.

Furthermore, it helps them to focus on working and studying at the same time in terms of gaining knowledge and life experiences. Another participant stated that:

- "I feel that I am in need to improve my quality in life. So, I decided to further my study even though I have to work as well". (WS6)

No matter how difficult the situation of the working students, another way that they have dealt with is by internal motivation in order to integrate theory and practice. Others may have experienced difficulties and stresses, but nevertheless it taught them a great experience. The feeling of working hard and achieving the goals in life are irreplaceable. Some said that they just focus on their goals and what they want to make out of themselves, planning about their dreams and goals in life on how to overcome difficulties.

Moreover, the difficulties they experience while working hard taught them to be strong and motivated themselves to help their family. This is indeed expressed by one of the participants.

- "*To lift up my family from being poor".(WS8)*

Working while studying occurs for many reasons and it is primarily because of financial instability which is very evident in the

community. Money is needed by the students to pursue their college. However, not everyone has enough money to support higher education which leads others opting to become a working student. This can be further strengthened according to Bailey and Phillips (2015) who stated that a lot of teenagers who work in the Philippines are those who have no ability to fund their tuition, school bills and their family income.

Although financial problems are one of the main reasons, working students consider working while studying as a training ground to further improve themselves. This becomes an avenue for self-development where the students claimed to have more valuable experience that may help them in the future. Riani (2011) stated that it is because of having more experiences in different circumstances it will help people to easily adapt after graduating. Further, the study of the College of St. Scholastica (2018) revealed that students working while studying help them master time management and expand their circle of friends. This shows that working while studying does not always negatively affect working students rather it helps them develop themselves.

Research Question #2: What are the struggles you experience being a working student?

Table 2: *The thematic analysis about experiences of participants.*

Themes	Significant Statements
Experiences for the Betterment of Working Students	*- I cannot easily join in the School Activity because since I am a working student, you have many responsibilities at your workplace.* *- I have to wake up early to do my responsibilities.* *- I'm not paying my tuition every month at the school.* *- I became dean's lister in our school, i thought it's impossible*

	since I'm too busy in the office of the President but the thing realizes me that everything is possible if you call upon His name asking guidance and wisdom of our Almighty Father. *- Becoming a working student molded me for who I am right now, my spiritual aspect was deeply bolded.* *- You can use internet, computer, and printer for free.* *- It's not easy because you need to be smart in managing your time in order for you to finish your task and responsibilities, wake up early, work the whole day, and study at night. And your responsible for all the properties of the school assigned to you.*
	- I am more flexible and have more potential to do things with my own capabilities and skills. *- Made me more responsible and I'm using my time wisely.* *- Experience from Industry, teaches time management, you don't have to worry about school fees.* *- I learned more things and I am financially okay and I don't have problems in terms of tuition* *- And I am more independent in doing my task and responsibilities*

	as a student, daughter, and a worker at the same time. *- You know how to deal the moods of others, to respect one another, to be faithful in your assign task, to become a responsible working student. You know to manage your time and learning how to become an independent person.* *- I have my experience already to do work at office or in any kind of work.* *- Ranked as the 44 Dean's Lister and awarded as one of the Honest Student of our Institution, and also the appreciation from the employees and other PM Sisters that I am a "small but terrible person".*
The Disadvantages and Weaknesses	*- You'll not be able to get all your subjects* *- You cannot always do the things you are doing when you are not working student before.* *- I don't have time to my personal things like have more family bonding and activities in community.* *- Time management in which we know that it's not easy to manage in time in doing a lot of things like your personal time, work time, and school works time.* *- Increase stress level*

	- no time for study, sleepless, time for myself, no time for my family. *- You must be strong physically and emotionally for many challenges that you will encounter.* *- I gain much weight because of stress.*

Being a working student is a serious matter to be involved especially when one is left no other choices but to consider it because of some reasons. Most of them have encountered different **experiences for the betterment of working students** which consist of both good and bad experiences. Some of the **difficult and bad experiences** are the struggles of the working students about managing their time, which is common for a working student. Also, they do not just worry about their work and studies but also for their health, which is the most affected one as it raises the level of stress that could affect their condition and might lead them to sickness. Furthermore, many of them experience issues on managing their time and they suffer from low self-esteem. Since they frequently feel pressure and stress, they have experienced that because they are too focused on their studies and work, and cannot seem to interact well with other people to give them assistance. They often have a hard time deciding between their work and studies when met at the same time, but all of these are for the benefit of a working student.

In addition, some of them said that, there are different experiences for a student that push them to be better. They need to be strong enough to face the challenges as working students. This is confirmed by one of the participants who stated that:

- It's not easy because you need to be smart in managing your time in order for you to finish your task and

responsibilities, wake up early, work the whole day, and study at night. And your responsible for all the properties of the school assigned to you (WS8).

- I have to wake up early to do my responsibilities. (WS7).

Aside from the bad experiences that the participants have experienced, there are also some **good experiences** that could improve their skills and abilities. The participants said that being a working student could help them to be aware on how to manage their time and to gain experience. As a matter of fact, it is a burden to them, but it could become a great opportunity to improve themselves for their future career paths. Having an early experience of work as a training and practice could improve themselves which could make them more flexible and suitable to a kind of job they want.

Furthermore, it helps them to be more aware of their surroundings and know how to handle other people. One participant said:

- *You know how to deal the moods of others, to respect one another, to be faithful in your assign task, to become a responsible working student. You know to manage your time and learning how to become an independent person (WS5).*

Moreover, some of them also received achievements from their institution and received praise from other people. This was reflected from a participant who stated that:

- *I was ranked as the 44 Dean's Lister and awarded as one of the Honest*
  student of our Institution, and also the appreciation from the employees

and other PM Sisters that I am a "small but terrible person" (WS8).

However, there are still negative impacts to the working students that they cannot avoid that causes their **disadvantages and challenges**. There are disadvantages and challenges that can affect the students' performance in studying.

A participant said dealing with studies and work at the same time is difficult. It lessens the leisure time they had which is the only time they can relax and take a break from a long time of work and studies. It could affect them physically and mentally. A participant also stated some of the disadvantages that they encounter:

- *Time management in which we know that it's not easy to manage in time in doing a lot of things like your personal time, work time, and school works time (WS5).*

- *You cannot always do the things you are doing when you are not working student before (WS2).*

Furthermore, this only signifies that there are many working students who are suffering from less time which also causes mental problems because of an extreme pressure from work and studies. This makes a working student sleepless and stressed which affects both their studies and work. A participant also stated that:

- *You'll not be able to get all your subjects (WS1).*

- *No time for study, sleepless, time for myself, no time for my family (WS7).*

The working students change based on their own experiences and challenges. Experiences consist of both good and bad that greatly affect the physical, emotional, and the personality of the working students. It can also give them difficulties in their daily lives but the benefits are much bigger.

There are two themes that emerged from the second question. The first theme is all about the different experiences of the working students.

This shows the benefits which are the things that they gain. The second theme focuses on the challenges faced by the participants and on how they overcome the problems. It is all about the disadvantages which make them fall.

Many would like to be working students but only some survive. Different challenges and hardships are waiting which could alter their performance in working or in studying. Higher dropout rates, delayed graduation rates, and poor academic results are only a few of the negative consequences. Communication and problem-solving skills are just a few of the benefits. Through the different obstacles, working students will gain experience and different skills. Moreover, the disadvantages are the consequences from experiencing hardships that become their weaknesses which could bring them down as they experienced or still experiencing.

Research Question #3: How do you cope with the problems that you encounter as a working student?

Table 3. The thematic analysis of how working students cope with the problems they encounter

Theme	**Significant Statements**
Effective Management	*Time management, know your priorities* *Time management (creating schedule for working &studying)* *Time management & transportation*
Think Positive	*Study hard & maximizing time. Pray, Stay Positive, & taught myself to be physically, mentally, & emotionally strong* *Pray, Seek for advice from parents, Think positive* *Think positive & let the plan of Lord be your light* *Concentrate, Think positive, & Never give up* *Concentrate, Think positive, & Never give up* *Pray & positive mindset* *Believe in yourself, find motivation, & try harder* *Think positively*

	Trusting God *Trust God first*
Losses	*Allowance, time, & accomplishing tasks* *Low motivation, many distractions*
	Lack of concentration, not enough time, stress *Loss of self-confidence & perseverance in work* *Discouragement, myself Laziness*

An increasing proportion of students interested in taking part-time jobs to support themselves through school have resulted in higher university tuition and financial turmoil. Whereas for many of these students, the ability to work and engage in learning at the same time is an excellent opportunity, part-time employment can also bring time management skills to the test. For adult learners who handle multiple priorities in life, such as academic studies and jobs, as a working student **time management** is increasingly difficult. Effective management plays a key role, and the ability to prioritize is essential to sustaining a harmonious and healthy lifestyle. Effective time management offers numerous advantages that make life easier.

Becoming effective at time management enables students to become much more disciplined, more assured, and more productive in learning. Where participant 1 stated:

- *"Time management, know your priorities" (WS1)*

Working Students are regarded as hard workers. Working hard sometimes leads to over-commitment and may lead to fear that the game will be lost. In order to complete all tasks in the given time, these students are stressed. Working while you study gets you a different perception of the experience of the institution. All working students understand how complicated it can become, tend to range from friends to classes and employment. The students who are pursuing their education and earning at the same time are of great concern. They want to earn their education while providing for themselves and their families.

Since their goals are high, along the way, they overcome challenge after challenge. As the participant 8 stated:

> *- "Allowance, time, & accomplishing task" (WS8)*

Moreover, some of them also encountered different challenges emotionally, Participant 6 stated that:

> *- "Lack of concentration, not enough time, stress" (WS6)*

The first theme is all about effective management of working students. This focuses on the effective management which the participants apply, as they manage challenges in their studies and work. Whereas, the participants are able to effectively manage specifically their time while working and studying.

Having time management is very important. Some students say that they can do better in school with a job because it can help them plan out carefully (Carnevale, Smith, Melton & Price, 2015). Imagine a working student without applying time management skills or mechanisms to help them cope with their situation they will not be able to accomplish their tasks and succeed. These students applied coping mechanisms, which help them manage their time and their schedules. Thus, they must strike a healthy balance between their work and studies.

The second theme is all about coping with challenges. The participants deal with the problems and difficult situations and try to come up with solutions. Moreover, it focuses on how the participants get through with their challenges.

Being a working student is not easy. It takes some qualities and strategies to cope with the problems and meet the needs in order to survive. Being a working student needs some strategies to survive this kind of life. When a working student encounters difficulties, coping mechanisms play a significant role to effectively cope with difficulties while working and

studying. A working student who has mental, emotional, and physical support from the group or institutes where he or she belongs greatly affects his or her coping mechanism skills. Therefore, the support of the people around him or her is highly needed, as well as for him or her to help portray his or her daily responsibility while working and studying.

Lastly, the third theme is all about challenges encountered by the participants. The participants encountered challenges in their studies and work which gave them burden to accomplish their tasks and achieve their goals in their daily lives. The most common challenge encountered by the participants is financial support. That is why they chose to be a working student.

Being a working student is already a big responsibility to handle with. Unfortunately, some challenges that a working student encounters make the situation even harder. These challenges might greatly affect the studies and work of a working student if he or she could not manage it properly.

CONCLUSION AND IMPLICATIONS

This chapter presents the discussion of the potential implications of our findings referring to the research questions specified in Chapter 1.

Conclusion

In this study, along with eight emerging themes discovered we can conclude that many working students are experiencing financial difficulties. However, it is not just about financial difficulties that others decided to become working students but because they can gain new experiences and skills that can help them in the future. Time management is one of the most common skills that they obtained by being a working student aside from lifting themselves from the burden brought by financial instability which greatly aided them in balancing their responsibilities.

However, life is not always cupcakes and rainbows because the burden that they carry on is heavy. Being a working student is never easy

as they have to deal with various obstacles such as not having enough time, lack of concentration due to many responsibilities and discouragement. Working students need to work and study at the same time, they also have to prioritize both work and school simultaneously leaving their health and their personal lives last. Despite those, they also learned how to cope with the problems that they encountered by praying and thinking positively. They are also training themselves to be physically, mentally and emotionally strong for them to be able to cope with the problems they encounter.

Implications

Being a working student is physically and mentally challenging. Based on the study, it is implied that working students experience many changes in almost every aspect of their lives be it emotional, physical or mental.

As working students, there are many obstacles that they might face however they should not be discouraged, instead they use that as a stepping stone to succeed. For them to survive, they must keep going; do their best because once they say that "I can't do it" or "I quit," they cannot gain skills. Treat the time for studying like the time for working as both are important. Time management is essential in working while studying. They must always remember that there is light at the end of the tunnel and that hard work will always pay-off.

To the parents, they need to support and guide their children in every way possible by encouraging them to continue pursuing their dreams. Moral support is what is most important when faced with a difficult situation which is inevitable especially when you are a working student. Just by knowing that someone is on their side supporting them is an assuring feeling and makes them feel that they are valued. This boosts the strengths and abilities of a person by knowing that they are not carrying the burden alone.

As a teacher, they should try to understand the situation that the working students are in, given that the work is hectic and the class schedule is tight. They should be considerate at times because it is not easy to work and study at the same time with many deadlines to catch up. Instead, motivate their students to pursue their dreams. The same goes through with regular students especially in group works where every individual must do his/her part.

Schools should arrange the schedules of their working students by having a balanced time for work, school and rest given that working and studying are mentally, emotionally and physically draining. Rest is one of the most essential parts in the students' well-being. In addition, by letting the students rest, they will also be able to give time for themselves and their personal lives.

For organizations and institutions, they should try to understand that the situation of their employees who are working and studying is not easy for they have to give their best effort in school and work that might cost them their health and wellness which may lead to poor performance in their job. Thus, it is vital that they should be considerate to such employees.

Lastly, for the future researchers, they have to increase the number of participants for them to attain more key themes and more accurate results. They can also specify as to what kind of working students that will be included in the study to see the difference of the situation.

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Assessing the Presence of Heavy Metals in Decapturus Punctatus (Round S cad) in Calinan Market

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ABSTRACT

Fishes which naturally habituate and depend on the aquatic environment are essential to the dietary needs of the human beings. However, even if how fresh these fishes are, once contaminated with toxins they become a threat to human health. Toxins such as lead, cadmium and mercury can easily accumulate in the different parts of the fish. Thus, consumption of fishes that contain these heavy metals can lead to serious health risks and adverse implications. Hence, this study was carried out to determine the levels of lead, cadmium and mercury in the common fish species in the locality which is Decapterus punctatus. Samples were collected from a market and dissected to two different specimens which are the internal organs and the edible part. These samples were tested once using Dry Ashing - Atomic Absorption Spectrometry (AAS) for lead and cadmium and Cold Vapor - Atomic Absorption Spectrometry (AAS) for mercury. In addition, the results were compared to the standard for heavy metals by WHO and FAO. Results showed that only cadmium exceeded the standard with a level of 2.54 pm and 0.08 pm for both the internal organs and edible part respectively with a mean of 1.28 pm. This was compared to the WHO and FAO standard for cadmium

which is 0.005 ppm. Although there is zero level of lead and lower levels of mercury in the tested samples, the result is still alarming since cadmium can accumulate in the human kidney and can cause organ impairment and even lung dysfunction. This requires a serious approach since the fish specimen tested is one of the common fishes sold in the market and are mostly consumed.

Keywords: *Heavy metal accumulation, atomic absorption spectrometry, fish consumption, optimal standards, part per million (ppm)*

INTRODUCTION

Fish consumption has been increasing steadily, with the world per capita fish consumption increased from an average of 9.9 kg in the 1960s until it was estimated that it fuelled up to 18.6 kg in 2010 (FAO State of World Fisheries, Aquaculture Report, 2012). Thus, limited number of edible fishes can affect each person's dietary needs and its statistical count. However, marine pollution or contamination was mentioned as one of the contributors that can affect the edibility of fishes. Ocean contamination is the involvement of harmful contaminants that an ecosystem cannot easily tolerate. Man-made contaminants such as pesticides, plastics, herbicides and fertilizers accumulate at the depths of the ocean that affect marine organisms and are included to the food chain when these organisms like fish are consumed by humans (Marine Pollution, 2017). In Europe, heavy metal stored in fatty tissue and bioaccumulate if the fish are further contaminated (Stratford, 2016). In addition, an analysis was conducted and revealed that exposure to heavy metals or metalloids have possible linkage to risk of conditions such as heart disease even at low doses. Thus, people who are more exposed to heavy metals like lead, cadmium and copper are about 30 to 80 percent prone to cardiovascular diseases (Rettner, 2018).

On the other hand, three cities in India were analysed by Indian Institute of Technology-Hyderabad and the results showed that 5.5% of the people tested had mercury levels above the US-EPA reference for heavy metals. This could be because of the people are consumers of small

fishes and species that belong to lower trophic levels that are mostly consumed in US and EU (Livemint, 2019). Moreover, in Malaysia, traces of heavy metals were alarming the researchers as they found out higher levels of nickel, cadmium, and lead. Center for Marine and Coastal Studies have found 0.472 particles per million (ppm) levels of nickel compared to the standard which is 0.0055 pm in sea water. Lead and cadmium were also above permissible levels with 0.804 pm and 0.065 ppm levels respectively, given that lead should only be at 0.005 pm and 0.0002 pm for cadmium (Loh, 2019).

In Metro Manila, Philippines, a study proved that heavy metal contamination in air, soil, and water could possibly pollute rice varieties and fish species (Solidum, 2014). From the results obtained through Flame Atomic Absorption Spectrophotometry (FAAS), fish samples tested were positively contaminated with lead, where all parts and kinds of fish exceeded the standard limit for lead in food. Also, in Sarangani bay waters were also confirmed to have affected its marine animals with heavy metal concentrations specifically lead, cadmium and mercury. Internal organs of the fish samples were contamination among fishes has been an issue. Food and Agriculture Organization (2018) found out that heavy metals in fish, such as tuna and swordfish are mostly relevant. These fishes at the top of the food chain tend to accumulate vital amounts of heavy metals, particularly mercury, in their muscular tissues. The data interpretation show that lead, cadmium and mercury are the metal contaminants highlighted to be affecting the selected fish species. Moreover, heavy metals such as lead, cadmium and mercury are part of the contamination of the bodies of water and aquatic creatures. Marine animals like fish can easily absorb metals and regulate their bodies to accommodate them. They are easily stored in fatty tissue and bioaccumulate if the fish are further contaminated (Stratford, 2016). In addition, an analysis was conducted and revealed that exposure to heavy metals or metalloids have possible linkage to risk of conditions such as heart disease even at low doses. Thus, people who are more exposed to heavy metals like lead, cadmium and copper are about 30 to 80 percent prone to cardiovascular diseases (Rettner, 2018).

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absence of proper drainage and treatment offices. Leachate, particularly blended with substantial metal synthetic compounds, for example, lead and mercury which are very dangerous, will cause cancer-causing impacts. CENRO has resolved to fix the leaking sanitary landfill dependent on its course of events (Salveron, 2017). This issue was interrelated to the fact that these could be brought up to the nearby bodies of water and can further contaminate or cause complications. The locality of Calinan has different fish species consumed by the citizens to fulfill their dietary needs. It has been continuing to grow its population and the usage of steels and alloys to store and catch fishes possibly have affected the fish species being sold. Given the information about heavy metals and its adverse effects to the human body, it imposes a great risk for those who are unaware about this. The Calinan Public Market has not yet tested the status of the fishes being sold. Thus, the researchers felt the urgency to conduct this study to bring awareness and enhance the safety of the consumers by identifying the heavy metal content of the fishes.

Statement of the Problem

The research aimed to assess the heavy metal content of the selected fish species in the market of Calinan, Davao City. Specifically, it sought to answer the following questions:

1. Is there a presence of heavy metal in Decapterus punctatus in its internal organs and edible parts?

2. What is the level of heavy metal content in Decapterus punctatus in its internal organs and edible parts?

3. Is the level of metal content in Decapterus punctatus within the permissible limit set by World Health Organization (WHO) or Food and Agriculture Organization (FAO)?

METHODS

In this chapter, the research design, research locale, sampling, data gathering procedure and data analysis are discussed.

Research Design

This study employed the descriptive-quantitative research design. Descriptive research design systematically describes the facts and characteristics of the area of the interest. It also determines the frequency of occurrences and discovers the relationships among selected variables (Dulock, 1993). Moreover, descriptive research is the identification of the attributes of a phenomenon through observational basis or examination of situations as it occurs in its current state (Leedy & Omrod, 2001). The descriptive design is applicable in this study because it only observed and described the results of the assessment of a phenomenon without influencing it in any way (Shuttleworth, 2008). Since there were no manipulations conducted within the variables, the design allowed the researchers to determine the amount of the heavy metals like lead, cadmium and mercury in the internal organs and edible parts of the fish samples. Lastly, it also compares with the optimal standards that were presented in the results of the test.

Research Locale

The current study was conducted in one of the barangays in Davao City which is Calinan. There are 182 barangays located in Davao City (Philippine Statistics Authority, 2019). Calinan is populated with a number of 23, 052 people as of 2015 (PhilAtlas, 2019). Calinan is a small place however populated by huge amount of people due to availability or abundant resources it possesses such as food, clothing and other basic necessities. One market in Calinan was where the study was undertaken. It is where the people of Calinan mostly buy their dietary needs such as fish and meat as it is the nearest market that contains what they need.

Data Gathering Procedure

Prior to the conduct of the study, certain tasks were done. A letter of permission was sent to the school principal and school president asking for the researchers to conduct the study outside the school grounds. Another letter of permission was also given to the barangay captain of the area for the approval in collecting the samples within the barangay. On the other hand, before the samples were collected the researchers asked permission from the vendors where they get the samples at the same time showing the approved letter from the barangay captain. The vendors were informed of their right to say no to the request of the researchers. The names of the vendors and the position of their stalls were not mentioned in any part of the study. Moreover, in the duration of collecting and dissecting on the samples, protective equipment were worn by the researchers. This is to avoid being exposed to hazards when handling chemicals or biological materials and it protects the wearer's personal clothing and exposed skin (Lab Manager, 2009).

The samples collected were contained in clean polyethylene bags for convenience and to avoid further leakage of raw meats and fishes being contained (Plastic bags: Sanitary and Safe, 2017). An estimated total of three kilograms were gathered to attain the 500 grams limit requirement of each part. The edible part and internal organs were composed of gills, kidney, and liver. After the collection, samples were safely transported to a sanitized facility to be dissected. Dissection or separation of the parts of fish samples came after transporting. The researchers first rinsed the samples with distilled water. Distilled water does not contain any minerals or contaminants and its sterile characteristic gives an accurate result in the experiments in the laboratory (The Water Guy, 2019). After rinsing, the fish samples were dissected with clean plastic gloves to avoid further metal contamination. The edible part and internal organs were then placed in different repositories in preparation for weighing and containing in clean polyethylene bags. To ensure the safety of the samples, these were placed in synthetic holders to avoid further metal contamination. Samples were weighed up to the limit requirement for each sample. Lastly, after dissecting the fishes, the samples were brought to the laboratory for

assessment and identification of the content and concentration of lead, cadmium and mercury using Atomic Absorption Spectrometry (AAS). After delivering the samples to the laboratory, the results were expected differently for mercury from lead and cadmium. Lead and cadmium results were first claimed seven (7) days after the samples were brought while mercury was claimed fourteen (14) days after. When the results were received, the levels of lead, cadmium and mercury were then compared to the optimal standard of heavy metals for fish set by WHO and FAO.

Data Analysis

In presenting the data collected, the results were classified using a table, Tabular structure was used to determine the results identified from the different parts of the fish sample. Within the tabular structures were numbers and indications of the levels detected such as ND or not detected and part per million (ppm) as the unit for the levels detected, Moreover, graphical representations were provided to further visualize the results, As for the instrument used in assessing the presence of lead and cadmium, dry ashing was used by the laboratory. Dry ashing is usually done by placing the sample in an open inert vessel and by thermal decomposition using a muffle furnace destroying the fuel (organic) portion of the sample. Typical temperature for ashing is between 450° and 550° C. Magnesium nitrate is often used as an aid for ashing. It is preferable to characterize the sample before muffling. Charring is done with an open flame (Ashing Procedures, 2019). On the other hand, for mercury, Cold Vapour Ashing was used. Cold Vapour Ashing brings mercury through a dryer in the vapour cycle into an optical cell for atomic absorption. Once the elemental mercury is in the absorption cell, it will absorb light at 253.7 nm in logarithmic proportion to its actual sample concentration. Using this concept, the detector is able to determine the amount of mercury contained in the sample in conjunction with the code (Seibel, 2016). Lead, cadmium and mercury levels were distributed according to the results from the different parts. The mean was calculated to get the central distribution of the data. Mean refers to the average value of a group of numbers that could be

gotten by the summation of all numbers divided by the total number of values (Gani, Sykes & Vally, 2016). In the current study, mean was used to identify the average level of each heavy metal to the internal and edible parts of the fish sample. Results were then compared to the optimal standard set by the World Health Organization (WHO). The software Microsoft Excel was used in determining the mean of the level of heavy metals in the internal and edible parts of the fish sample. Microsoft Excel is a software that contains numerous rows and columns that form a table. Additionally, it is a spreadsheet that enables users to record and analyze numerical data (Introduction to Microsoft Excel, 2019. Through the use of the Microsoft Excel, the data were conveniently analyzed and graphed accordingly.

RESULTS AND DISCUSSION

This chapter contains the results that were gathered in the course of the investigation. Interpretation of data, classifying of results gathered and tabular structures of the data are also presented.

Research Question #1: Is there a presence of heavy metal in Decapterus punctatus (Round Scad) in its internal organs and edible part?

Table 1: The Presence of Heavy Metals in the Internal Organs and Edible Part of Decapterus punctatus (Round Scad)

Parameters	Internal Organs	Edible Part
Lead	Negative	Negative

Cadmium	Positive	Positive
Mercury	Positive	Positive

Based on the data presented in Table 1, there are certain types of heavy metals that were found in the edible part and internal organs of the *Decapterus punctatus* (Galunggong). Lead was not detected nor has a presence in the edible parts and internal organs of the fish sample. However, the presence of cadmium and mercury were found positive in the two parts of the fish sample.

Given the results in Table 1, health risks may arise due to the presence of heavy metals despite the fact that the study showed no levels of lead from the edible part and internal organs of the fish sample. These heavy metals are gathered in the essential dietary organs of man such as liver and kidney and it imposes risky consequences since it can cause dysfunction (Mudgal, Madaan & Singh, 2010). In addition, the presence of cadmium and mercury is alarming since these are considered to be the most toxic metals together with lead and arsenic. An excessive concentration of these metals to the environment is detrimental (Pandey & Madhuri, 2014).

Coal burning, iron and steel industry and vehicular emissions are factors of the cause of the presence of these heavy metals especially in the atmosphere. The source of the fishes or the market itself can be ear to these types of sources that contributed to the presence of heavy metals. These are sources similar to China that were observed and recorded (Duan & Tan, 2013).

The presence of cadmium can be concluded that the fishes in the area might have been placed in containers that were coated and have plating since cadmium is used for these functions (Matthew, Rawal & Sharma, 2015). Additionally, the fishes might have been exposed to a smelting factory while being transported. The fish samples could possibly get cadmium from the labourers that have done mining and refinement of zinc

as this could be a by-product of it (Green Facts, 2015). As for the mercury, since it is a natural element that could possibly be found in water, the fish samples tested have been caught far from the seashore that dissolves mercury to methylmercury which is the most toxic form (Johnson, 2018).

Lastly for lead, the results showed to be negative and this can be related to the idea that the fishes being sold in the market are not exposed to mining, manufacturing and smelting activities. Moreover, the transportation of fishes was safe from leaded gasoline and leaded paint which are two of the sources of lead (WHO, 2018).

Research Question #2: What is the level of heavy metal content in Decapterus punctatus (Round scad) in its internal organs and edible part?

Table 2: The Level Heavy Metal Content in the Internal Organs and Edible Part of *Decapterus punctatus* (Round Scad)

Parameter	Internal Organs (ppm)	Edible Part (ppm)	Mean (ppm)
Lead	0	0	0
Cadmium	2.5	0.08	1.29
Mercury	0.0054	0.0337	0.01955

The levels of heavy metal in the different parts of the fish samples are classified and identified in Table 2. As indicated in Table 1, lead showed no results or is not detected in the two parts, thus the concentration level and mean of lead is 0. The number zero (0) was used since the table suggests

numerical values. However, despite the zero level of lead in the two parts, cadmium and mercury showed specific levels that define its positive presence. For the internal organs of the fish sample, cadmium showed to be higher compared to its presence in the edible part with 2.5 part per million (ppm) and to mercury. In contradiction to cadmium, mercury showed to be higher in level in the edible part which is 0.0337 ppm compared to its level in the internal organs. However, the mean of the concentration level of cadmium is much higher than that of mercury with 1.29 ppm. These data imply that effects from cadmium from the edible part portray more risk since it showed higher levels compared to mercury. Also, in terms of internal organs, still cadmium showed to be higher in level compared to the other two heavy metals.

The reason that lead has a negative presence and mercury with lower levels can be related to the fact that the season, place of development of the samples and salinity and temperature of water were in good condition as the samples were transported thus lower levels of heavy metals were found (Alina et al., 2012). For the sources of the tested fish sample, the above mentioned factors that can affect the lead content were in good condition and thus, do not contribute to the lead content of fish sample.

Figure 3: Graphical Representation of the Heavy Metals Lead, Cadmium and Mercury in the Internal Organs and Edible Part of *Decapterus punctatus* (Round Scad)

Figure 3.1 Lead

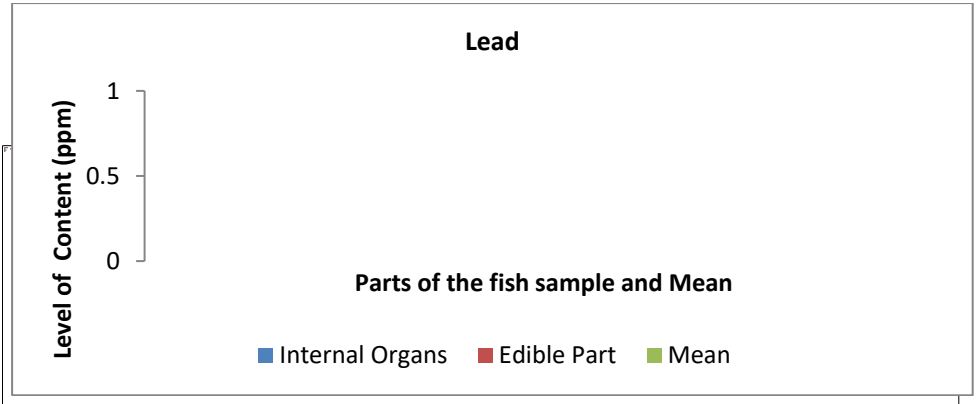

Figure 3.1 shows the results for lead levels in the fish sample. Based on the previous tables showing the presence (Table 1) and the level (Table 2) for lead in both the edible part and internal organs that is 0, the graph does not draw any graphical figure showing its level.

This result implies that consumers are safe with regard to the zero content of lead. The consumers are free from its malevolent effects on the hematopoietic, renal and regenerative and focal sensory system (Flora, Gupta & Tiwari, 2012). Moreover, consumers of the fish sample are safe from health risks in neurological, gastrointestinal, and hematological systems as lead harms these body systems (Emergent Management of Lead Toxicity: Background, Pathophysiology, Etiology, 2019).

Figure 3.2 Cadmium

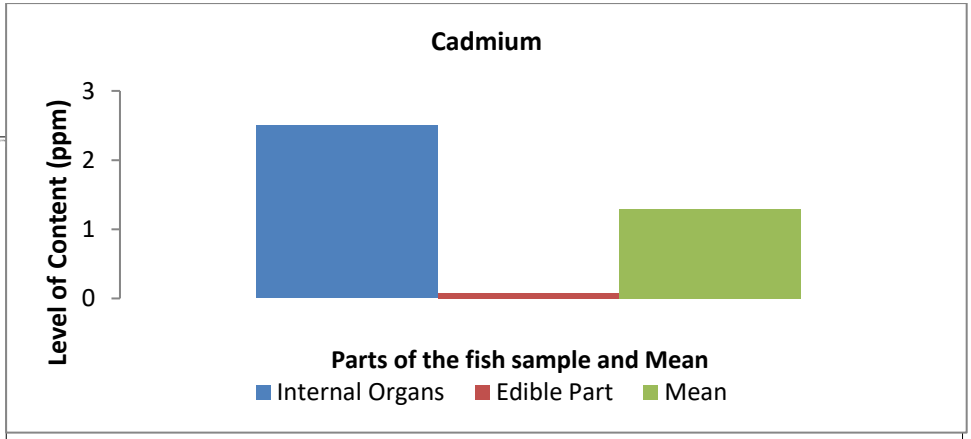

Figure 3.2 shows the graphical representation of cadmium levels in the internal organs and edible part. It clearly shows that cadmium has a relatively high level in the internal organs compared to other parameter in the same part of the fish sample. In addition, cadmium also has the highest level in the edible part and the mean compared to lead and mercury.

Long term exposure to cadmium through air, food, water and soil can damage organ system and bring toxicity for example, skeletal, urinary, reproductive, cardiovascular, and central and peripheral nervous system (Kazemi, 2017). Moreover, death cases due to cadmium were associated with mortality due to lung cancer, pancreatic cancer and leukemia. It was concluded that cadmium contributes to the cancer mortality obtained from the National Center for Health Statistics in USA using urine samples to analyze the data (Adams, Passarelli & Newcomb, 2011).

Figure 3.3 Mercury

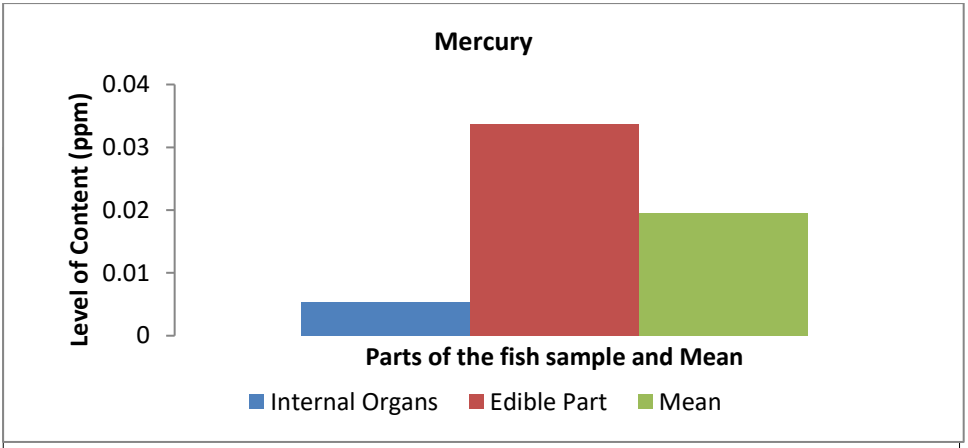

Figure 3.3 presents the graphical representation of mercury content in the internal organs and edible part of the fish sample. When compared to lead, mercury has a higher level but when compared to cadmium, mercury levels are lower. Mercury is in contrast of the other parameters since its level in edible part is much higher than that of the internal organs. With all the comparisons, mercury is in the second place in terms of its level.

Even though mercury has lower levels, when it is accumulated in the human body its levels rise, symptoms like muscle weakness, nausea, difficulty in breathing and changes in vision could possibly occur (Johnson, 2018). It is absorbed in the bloodstream through the intestinal wall and then distributed to the body (Bradford, 2016).

Based on Figures 3.1 to 3.3, cadmium level in the internal organs is relatively high compared to its level in the edible part and in mercury and lead level. Thus, the mean of cadmium also showed to be much higher compared to other parameters. Therefore, as shown in Table 2 and Figure 3, effects from lead do not impose a health risk in consumption of the *Decapterus punctatus*. However, the levels of cadmium and mercury are alarming since it shows an amount of content in the fish sample.

Research Question #3: Is the level of metal content in Decapterus punctatus (Round S cad) within the optimal standard set by WHO or FAO?

Parameter	Internal Organs (ppm)	Edible Part (ppm)	Mean (ppm)	WHO/FAO Optimal Standard (ppm)
Lead	0	0	0	0.5
Cadmium	2.5	0.8	1.29	0.05
Mercury	0.0054	0.0337	0.01955	0.5

Table 3: Level of Lead, Cadmium and Mercury in Comparison to the WHO/FAO Standards

Previous data show negative results for lead, thus it does not exceed the WHO and FAO standards. On the contrary, cadmium levels in both internal organs and edible part exceeded the optimal standard. Cadmium levels in the internal organs and edible part, 2.5 ppm and 0.08 ppm respectively with a mean of 1.29 ppm exceeded the 0.05 ppm standard. When compared to the internal organs and the standard, cadmium level is relatively high with a difference of 2.45 ppm and with a difference of 0.03 ppm for the edible part which is lower than the internal organs. On the other hand, mercury levels showed to be within the optimal standard with

a difference of 0.4946 ppm and 0.4663 in the internal organs and edible part respectively compared to cadmium. Mercury levels in the internal organs and the edible part with 0.0054 ppm and 0.0337 ppm respectively do not exceed the permissible limit. With the given and interpreted data, consumers are safe from health risks of lead and among the heavy metals determined on the study, cadmium showed the greatest number of level to the sample that exceeded its allowable limit. Cadmium demonstrated the best number of level to the example that surpassed its permissible farthest point. Result from the investigation is very disturbing since cadmium is known as a human cancer-causing agent and its basic objective is the kidney for all inclusive community.

Figure 4: Mean Value of Lead, Cadmium and Mercury in Comparison to the WHO/FAO Standards

Figure 4.1 Lead

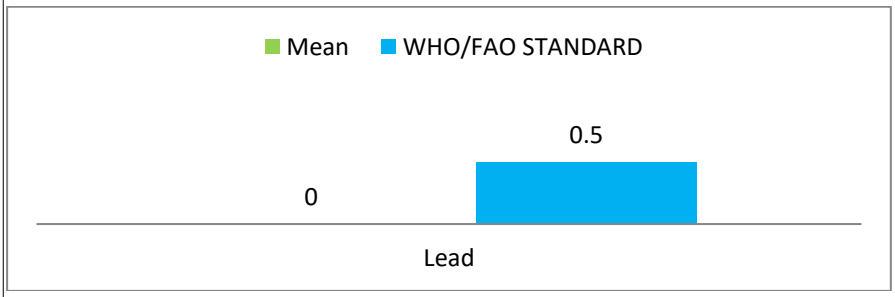

Figure 4.1 represents the graph of the level of lead compared to the optimal standard set by WHO and FAO. Since lead levels are negative in the internal organs and edible part of the fish sample, it does not exceed the standard which is 0.5 ppm. This means that the fish is safe for consumption.

Figure 4.2 Cadmium

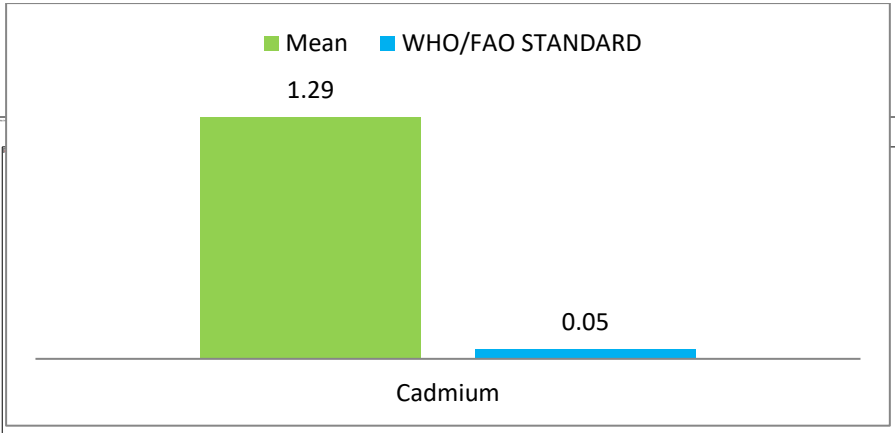

Figure 4.2 shows the graphical representation of the mean level of cadmium compared to the optimal standards set by WHO and FAO which is 0.05 ppm. Given that cadmium has the highest level in the internal organs and edible part in the fish sample (see Table 2 and Figure 3.2) its mean level of 1.29 ppm exceeded the value for optimal standard. Consumers are more prone to the symptoms of cadmium poisoning.

Similarly, the result above is in consonance with a research in Metro Manila. The research identified that cadmium went above the permissible limit, number of fish species went beyond the limit still set by US EPA with 0.05 ppm. These samples were from the heads of *Euthynnus affinis, Epinephelus morio, Selar crumenophthalamus,* and *Decapterus macarellus* at concentrations of 0.0595 ppm, 0.0527 ppm, 0.0585 ppm, and 0.0608 ppm respectively (De Vera et al., 2013).

Cadmium bioaccumulation inside the body caused kidney debilitation and lung brokenness in contaminated people (Bernard, 2008). It has been accounted for that there are countless Filipinos that are experiencing kidney weakness. In the Philippines, as per the Renal Disease Control Program of the Department of Health, it has been reported that there are at least a consistent increase of 10% of the population of Filipino who are diagnosed with kidney diseases (Colina, 2012). This problem can be

attributed to the cadmium contamination of the fishes detected which were widely sold in the Philippine markets.

Figure 4.3 Mercury

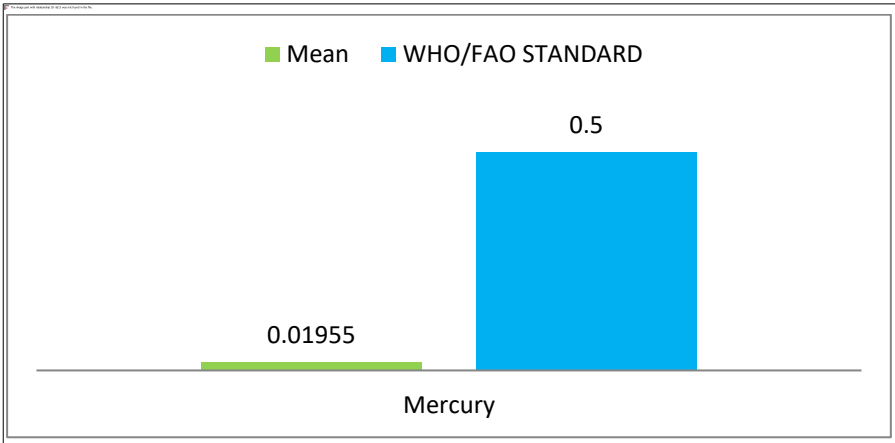

Figure 4.3 represents the mean level of mercury compared to the WHO and FAO optimal standard. With a mean level of 0.01955 ppm, the results do not exceed the optimal standard which is 0.5 ppm. Even though it does not exceed, consumers must still be cautious in consuming the type of fish sample since mercury can still accumulate in the body over time as it is consumed continuously.

Especially in children, they must be extra careful since mercury is linked to Attention Deficit Hyperactivity Disorder. A study in Arctic, Quebec stated that 23 behaviours linked to ADHD and toxic chemicals alter various parts of the brain during the development times of the said children. Additionally, the mothers of the children consume whale and fish that serve as the source of mercury and lead. Interestingly, it was found out that mercury was linked to attention deficit (Cone, 2012).

Each heavy metal was separated to clearly represent the mean of its level and to contrast it to the optimal standards and following implications were presented. As for lead, the graph suggests that it does not exceed the

optimal standards at all while cadmium clearly exceeded the standard with a mean of 1.29 ppm. For mercury, the level does not exceed but has lower level that is within the optimal standard.

The levels of heavy metals in the *Decapterus punctatus* have been identified and analysed. Results showed that among the heavy metals detected; only cadmium has exceeded the permissible limits. Lead on the other hand was determined to be negative; this implies that symptoms like neurotoxic effects are impossible to occur when the said fish is consumed. In addition, levels of mercury have been detected but with small amounts and did not exceed the permissible limit set by WHO and FAO. Thus, the null hypothesis is accepted only for cadmium and the alternative hypothesis was accepted for the lead and mercury.

CONCLUSION AND RECOMMENDATION

In this section, concluding statements and recommendations based on the findings are described. The outcomes of the study are discussed, interpreted and generalized. Recommendations about the study were then followed.

Conclusion

The current study assessed and identified the level of content of the heavy metals, namely: lead, cadmium and mercury. Results were interpreted and were compared to the optimal standard set by the World Health Organization (WHO) and Food and Agricultural Organization (FAO). Through the help of the standards, the researchers were able to determine whether the *Decapterus punctatus* or commonly known as "galunggong" or "moro-moro" are safe to be consumed by the consumers. Among the heavy metals, only lead showed negative results from both the internal organs and edible part of the fish. This means that consumers are safe from the effects of lead when consuming the said fish. However, positive levels of cadmium and mercury in the internal organs and edible part were found. Before concluding that consumers are unsafe, permissible limit set by WHO and FAO were compared to the current level of cadmium and mercury. With a level of 2.5 ppm and 0.08 ppm in the internal organs and edible part for cadmium respectively, these levels

showed to be above the permissible limit which is 0.05 ppm. This is alarming especially for the internal organs since it is considered unsafe and has the largest difference compared to the edible part. Health risks from cadmium are harmful specifically that it targets the kidney. On the other hand, mercury levels showed to be lower with 0.0054 ppm and 0.0337 ppm for the internal organs and edible part respectively and are within the permissible limit set which is 0.5 ppm. Given that interpretation, the *Decapterus punctatus* are safe to be consumed by the consumers within the area of Calinan market with regard to the absence of lead but does impose health risks from cadmium. Though internal organs showed to be higher than in edible parts, this is still a warning since it can be distributed to the other parts of the fish. Mercury level may be low and within the permissible limits. It could still be accumulated when consumed since it shows that there is a presence of it in low amounts.

Recommendations

From the results and significance of the study, further recommendations were formulated:

First, given that the fish sample being assessed was *Decapterus punctatus* or commonly known as galunggong, it is recommended that other types of fish should be studied such as *Chanos chanos* (Bangus), *Oreochromis niloticus* (Tilapia) and *Selar crumenophthalamus* (Matambaka) because these fishes are also available in Calinan public market and they are also consumed by many. Second, since the results represent the heavy metals from the market, it could be upgraded to the source itself where the fish samples are taken to also determine the safety of the body of water and sediments. This is because the bodies of water where the samples are being caught might be contaminated with these toxic metals. Third, it would also be preferable if other heavy metals such as nickel, chromium and arsenic could likewise be studied since these are also contributors to metal toxicity in fishes and impose human health risks.

Fourth, other public markets aside from Calinan public market like that of Bangkerohan can also be studied and assessed for heavy metals. Fifth, other part such as the head of fish samples can also be assessed since it is part of the fish and can affect other parts. Lastly, the local government and other health related organizations are also advised to utilize this study as guidelines to ensure the safety of the public given the adverse effects

from toxicants of the fish sample. Studying the root cause of these heavy metals in the aquatic environment and its effects to being exposed to fish would be essential to further track the processes beyond assessment. Heavy metals are naturally occurring but efforts in preventing its detrimental effects to the human body and the environment would be of great help in both maintaining a healthy diet and balancing systems of these earthly metals.

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THE EFFECTIVENESS OF QUICKEST FLOW MODEL IN LESSENING THE EVACUATION TIME IN HOLY CROSS COLLEGE OF CALINAN

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ABSTRACT

In this research study, an earthquake evacuation strategy was developed through mathematical and strategic approaches using a network model: the Quickest Flow Model. Its purpose is to find the most time-efficient evacuation routing system for the PM building in Holy Cross College of Calinan. This is to lessen the overall evacuation time, as well as the possible number of casualties whenever an earthquake disaster occurs.

All nodes, arcs and sinks in the school were identified and translated into a network model. Through Djkistra's algorithm, the shortest path each source may take to evacuate among the given set of paths were identified, considering the arc costs, arc and sink capacities, traffic

congestion and availability of arcs at each time interval. To test the model, two sets of drills were conducted using the non-model-based evacuation plan and the model-based evacuation plan. The statistical tool – independent t-test, was then used to test if there is a significant difference between the time of evacuation with and without the model. Compared to the non-model-based evacuation plan, the total evacuation time spent by the evacuees is significantly lower by up to 45 seconds when the model-based evacuation plan was used. Therefore, it was concluded that the proposed model-based evacuation plan improved the time spent during evacuation. Thus, it is recommended that the proposed strategy be employed as the school's new evacuation plan.

Keywords*: time-efficient evacuation, Quickest Flow Model, routing strategy, shortest path algorithm, non-model-based evacuation plan*

INTRODUCTION

In the past decades, disasters have perceptibly increased in number. In the years 1994-2003, Asia was greatly affected by natural disasters in which approximately 70 out of the 650 natural catastrophes recorded in 2004 were damaging earthquakes, 10 were volcanic eruptions, and the rest were strong weather conditions. The 1990s and beyond proved to be much calamitous, as global natural disaster trends rose with increasing rapidity (Sena & Woldemichael, 2006). Hence, strategic evacuation response is necessary to reduce the immediate and potential life-threatening dangers posed by such disasters (Peeta, Sharma, & Hsu, 2011). Although many evacuation models have been proposed, accepted, and simulated in the past years, Ronchi and Nilsson (2013) noticed that in most cases, buildings targeting a safe evacuation often never go beyond the simplified approach. This, however, should not be the case as preparedness is a key component of a major incident management, which actually plays a significant role in the emergency response (Castle, 2006). In designing an evacuation plan, the travel time movement becomes the greatest factor. Thus, a good routing strategy will evacuate as many

evacuees as possible within a limited time (Ng & Chow, 2006; Qui & Jin, 2008). There are many reasons that cause emergency people movement in a building such as fire, earthquake, typhoons and civil disobedience. Traditionally, dealing with emergency evacuation is by code compliance. Codes consider availability of egress routes but do not consider the effects of potential blockage of ways out on time evacuation. Even though various egress designs can be code compliance, they will still perform differently in emergency evacuations. Some lead to a shorter evacuation time while others prevent occupants to escape efficiently. Therefore, different kinds of layouts can be compared in their evacuation performance. But regardless of the layout, an appropriate configuration of plan design can provide a better evacuation result. According to Gwynne and Galea (1998) as cited by Castle (2006), to perfectly assess the potential evacuation efficiency of a building or an enclosure, it is necessary to consider four aspects, which are configuration, environment, behavior and procedures.

When it comes to emergency preparedness, Japan has greatly progressed. The country's disaster management system has undergone tremendous advancement throughout the past 5-6 decades (Nazarov, 2011). According to Yamada (1996) as cited by Xie, Lin and Waller (2010), under the Natural Disaster Prevention and Relief Law, every Japanese city has its own emergency evacuation plan in preparation for such major disasters as earthquakes, tidal waves, etc. The plan includes places of refuge and the allocation of all the residents to the refuge areas. In spite of this, the magnitude 9.0 earthquake incident at the coast of North-eastern Japan on March 11, 2011 showed the devastating effect of the disaster destroying majority of high-rise buildings killing about 15, 891 people with 2,500 missing cases. The ground displacement during the earthquake almost instantly moved the lower levels of the high-rise buildings in Japan, but it takes a moment for the shaking to reach the upper floors. This created a dangerous seismic echo in the structures, wherein the upper stories rushed to catch up with the motion of the floors below. In just moments of severe shaking, it resulted to structural failure and complete collapse of the high-rise buildings.

Being in the Pacific Ring of Fire just like Japan, the Philippine islands have experienced up to twenty earthquakes a day (Group, 2012), although most are too deep or too small to be felt. In 2008, the area around Ta'al volcano alone recorded ten volcanic earthquakes in just one day. According to Sieh (2007), Asia has a geological record that goes back 1,000 years. It shows the region (South-East Asia) being hit by major earthquakes every 200 - 300 years. The last cluster of powerful quakes happened about 200 years ago which statistically means that South-East Asia is entering a new cluster or new set of powerful earthquakes. In connection, in the year 1990, a 7.8 magnitude earthquake shook Northern and Central Luzon with its epicenter recorded in Nueva Ecija which lasted for about a minute as recorded by Rappler Philippines. Among the hardest hit areas was Baguio City in which several structures collapsed, burying people alive. Some establishments were completely destroyed including hotels like the 12-storey Hyatt Terraces Plaza, 5-storey Nevada Hotel, 6-storey Baguio Hilltop Hotel, 4-storey Baguio Park Hotel and FRB hotel which mainly suggests the susceptibility of high-rise buildings to severe ground shaking. Because of this, building evacuation becomes a critical factor in emergency preparedness (Lu, 2011). Since then, public and private sector planners take very different approaches to planning for catastrophic events, so it will be instructive to examine earthquake risk as an emergency manager would through the four phases of emergency management - mitigation, preparedness, response and recovery.

Experts suggest that many schools fail to formulate policies and guidelines regarding preparedness in terms of evacuation plans, designated evacuation area, and safety awareness. According to UNESCO (2012), school safety is highly necessary as children are among the most vulnerable group. In fact, educational places such as schools are among the most important buildings exposed to serious damage and loss of life from earthquakes (Hosseini & Izadkhah, 2006). When the 7.2 earthquake hit Sulu on January 10, 2017, the tremors were felt even in Davao City. Students and employees from different establishments evacuated to open grounds (Revita, 2017). Because of the earthquake disaster risk

management planning, a "safety culture" was developed in which people became aware of the hazards that may confront them and the knowledge with which they can protect themselves (Hosseini & Izadkhah, 2006). The recent earthquake in Davao has shown that the knowledge from regular drills helped people in reacting during a disaster.

At present, the Holy Cross College of Calinan (HCCC) has 3 high-rise buildings which include a 5-storey college building, 4-storey PM building and 2-storey OLSW building that require an efficient evacuation plan considering their susceptibility to severe ground shakings. Although the institution periodically conducts evacuation drills, the egress system used was not based upon a model. To address such problem, this study aims to provide a mathematical model-based evacuation plan to decrease the overall evacuation time by lessening the congestion occurring along the arcs and by proper route assignment. By using a model-based plan, it will give better insights and orientations for solving real-life complex systems such as the maximization of flows and minimization of time for evacuation (Amirgaliyeva, 2012) which would in turn lessen the possibility of having casualties whenever an earthquake may occur.

Statement of the Problem

The purpose of this study is to develop a new strategic evacuation plan in Holy Cross College of Calinan using a mathematical model, the Quickest Flow. Specifically, it aims to answer the following questions:

Phase 1: Before the Implementation of the Quickest Flow Model

1. What is the present egress system of Holy Cross College of Calinan?

2. What is the average time spent during evacuation using the non-model-based evacuation plan?

3. Is the Quickest Flow Model applicable for planning an evacuation strategy in Holy Cross College of Calinan?

4.What procedures should be employed to improve egress efficiency?

Phase 2: After the Implementation of the Quickest Flow Model

1. What is the average time spent during evacuation using the model-based evacuation plan?

2. Is there a significant difference in the time spent between the non-model and model-based evacuation plan?

METHODS

This chapter presents the design, respondents, locale, and the methods of the study. It considers the nature of the study and discusses the procedures the researchers were conducting. Lastly, it explains how the data collected were analyzed.

Research Design

The study utilizes the operational method of research or systemic operational design (SOD) which is an application of system theory to operational art. It attempts to rationalize complexity through systemic logic and translates strategic direction and policy into operational level designs. Moreover, it focuses upon the relationships between entities within a system to develop a rationale for systemic behaviors that accounts for the logic of the system thus, facilitates a cycle of design and planning (Schmitt, n.d.).

Relatively, the design is appropriate in the study because it allows the conception and construction of a framework that can underpin a major operation such as evacuation operation and its subsequent execution to the institution under study. The operational design deals with the method by which the procedure is specified in the sample thus observational and statistical designs can be conducted. Since the study focused on linear programming, network flow programming and formulation of optimization model, then the operational design is the most suitable to use.

The purpose of employing the operational method in the study is to come up with a time-efficient evacuation strategy for earthquake emergencies that can be applied in the current building floor plan of Holy Cross College of Calinan. Finding a solution for time minimization involves operational design since the method attempts to apply mathematical, logical and analytical techniques to the solution of cost minimization or of profit maximization problems (Kothari, 2004).The study also utilizes Quasi- Experimental research design in comparing the time of the evacuation with and without the model. Like any other experimental designs, it tests causal hypothesis but does not randomly assigns respondents into groups. It is designed around an intervention which estimates the size of intervention effect on some outcome and to test whether it differs significantly from no effect (Wiley & Sons, 2005). The subjects are exposed to the intervention of interest then measures the outcomes from the subjects observed. Moreover, it ascertains the effects of the independent variable through observed changes in the dependent variable. Thus, the design is appropriate in the study since it aims to measure whether there is a significant difference before and after the implementation of the model-based plan. Also, it does not randomly assign the respondents into groups.

Research Respondents

The study focused on the population occupying the college, high school and grade school building of Holy Cross College of Calinan. Further, it utilized multistage sampling technique to determine the average speed of the respondents during evacuation. Multistage sampling refers to the method in which the population is divided into stages using smaller and smaller sampling units at each stage. In a two-stage sampling design, a sample of primary units is selected and then a sample of secondary units is selected within each primary unit (Sedgwick, 2015). This technique is applicable in the study considering that the students belong to different sex and year levels, who are also within the same age group that could affect the accuracy of the data collected. According to Kothari (2004), multistage

sampling is easier to administer and can sample a large number of units through clustering whereas this is not possible in most simple designs. Also, the majority of the large probability samples selected from school-based to national surveys use multistage sampling technique that includes stratification at each stage of selection (Gilbert, 2001).

Consequently, the sample in this study was clustered by department – grade school, junior high school, senior high school and college. Through stratified sampling, the sample was then divided according to their grade level and sex to address the fact that there is a wide variance in the age and ability of the respondents. A total of 125 respondents was needed in the study consisting of 45 respondents from the high school, 40 from the grade school, and another 40 from the college. This is to simulate the students' evacuation activity as a class. The qualified respondents were the grade 3 to 4th year college students occupying the PM building including the 2 computer laboratories. All respondents were physically capable and did not have any health problems.

Research Locale

The study was conducted at Holy Cross College of Calinan, a level II PAASCU accredited Catholic school. It is located at the Davao-Bukidnon Road, Calinan, Davao City which is the home of the Philippine Eagle and the king of the fruits, durian. The school was founded by the PME Fathers in 1948. This is the only private sectarian school in Calinan which has been administered by the Presentation of Mary Sisters. It envisions its students to be Christ-centered, intellectually proficient, and responsive. It has four educational buildings and it offers primary, secondary, and college education. Among the many services, it also provides a safety plan which includes evacuation drills and safety training.

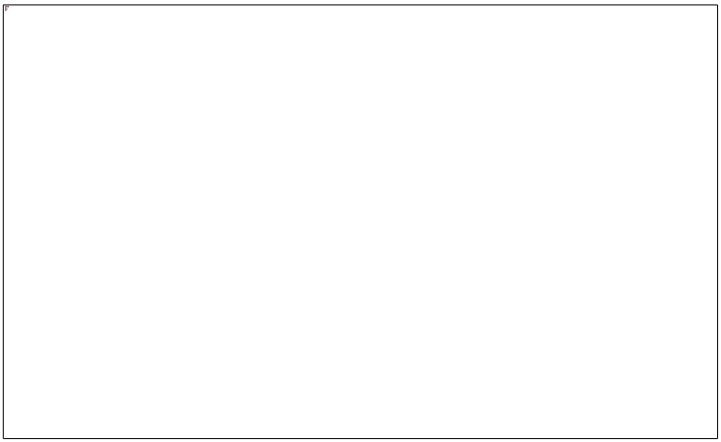
Data Gathering Procedures

Letters of permission were sent to Holy Cross College of Calinan administration before conducting the study. The study needed the current floor plan of the school which was inquired from the Community Engagement and Services Office (CESO). The distance from each source to sink, in this case, from each classroom to the evacuation area was determined using measuring equipment. The nodes, sources, sinks and arcs were then identified from the floor plan by considering necessary criteria as they are important variables in the model. It also needed data on both movement time for each arc and the capacity of each node, arc, and sink through estimation methods. A speed test was conducted to determine the movement time for each arc which included simulation of the evacuation activity then measuring the time it would take for the class to exit the building. The capacities of the sinks were assumed by finding the area of the location and the estimated area of occupancy of each individual, in which according to Bappenas (2005) is 1m2/person. In order to validate the result of the study, simulation of both the present/non-model and proposed/model-based evacuation plan was conducted and compared.

Data Analysis

The gathered data such as the size and measurement of building and corridors using the floor plan, capacities of arc, nodes and sinks, and the previous evacuation time spent using the non-model method were analyzed to get the necessary variables required in the model. The identified arcs, nodes, sources and sinks from the floor plan of the school were translated into a network in which the costs and the capacities of each arc, node and sink were identified. As a prerequisite in getting the costs, the average speed was first identified using a standard formula of speed = mean of total distance/elapsed time. To get the cost or the movement time for each route, the standard formula: time = distance/average speed was used. The cost was used to identify the shortest path a flow may take to reach its sink. On the other hand, the capacities were used to assign the sources into routes avoiding congestion which were identified through the use of the formula: capacity = area/space occupied. The data (movement

time and capacities) were then incorporated in the Quickest Flow Model and were simulated. For validation of results, the statistical computing program, R, was used specifically the t-test function. It was used to compare before-and-after observations on the same subjects (Shier, 2004). The time spent on evacuation both before and after the implementation of the model was tested using the box plot function to identify significant outliers in the data. Then, the total egress time using the non-model-based evacuation plan was compared to the proposed model-based plan to see if there is a significant difference between the two data considering the normality and homoscedasticity of both data sets.



RESULTS AND DISCUSSIONS

This chapter contains the results of the data analysis and the discussion of the problem statements presented in the study. This presents also the interpretation of the results and its analysis together with the references that support the response to each research question.

Figure 2. Present Non-model Based Evacuation Plan of HCCC

Figure 2 shows the present egress system of Holy Cross College of Calinan not based upon a model. This evacuation plan utilizes only one sink which is the Football Field as destination of the evacuees and was long formulated even before the present administration. Based on Figure 2, most of the sources were assigned to sink t1 while only a few were assigned to the other sinks making the Football field sink congested whenever occupants of the other buildings like OLSW and Rivier are present. Also, it is shown that arc (E,G) which is the OLSW arc was not used congesting most of the flows to the stairs of the PM building. Lastly, some of the flows were assigned incorrectly, making them more prone to hazards and could contribute to a longer evacuation time. An example is the route of source 10 in which it is the longest and is very dangerous because it passes below the building itself. Several post-disaster investigations have cited evacuation failures as a major contributor or to the death toll during disasters (Alexander, 2002 as cited by Stepanov & Smith, 2008). One factor is the over-utilization of a particular road link which can block traffic through the link completely, which is in this case, the crowding of evacuees in the stairs. This blocking will affect all upstream links which causes the significant congestion through the evacuation network. Based on the data, the current egress system of the school does not follow any mathematical model for optimization purposes. Also, it is only suitable for a certain number of evacuees making it obsolete with the increased population in the school. According to Xie (2008), many transportation and traffic related efficiency and safety issues would be frequently encountered yet not satisfactorily addressed at the current state of evacuation practice not following a model. In order to manage such emergencies more effectively, decision makers may benefit from having in-place evacuation plans with mathematical approaches for scenarios which are most likely to happen, even though real-time design and re-evaluation of evacuation plans may be required after the disaster strikes (Alexander, 2002 as cited by Stepanov & Smith, 2008).

Table 1. Time spent using the non-model evacuation plan with observations.

Drill no.	Date	Observations	Elapsed Time
No. 1 (replacement of the outlier)	February 27, 2017 (Afternoon Break)	The guidance sink was not used. There was a heavy congestion in both stairs A and B. The OLSW arc was not used. Most students were just walking.	4 minutes and 1 second
No. 2	July 6, 2017 (Morning Break)	The guidance sink was already used. The students in the football sink were blocking the entry place of emergency vehicle. The OLSW arc was not used resulting in a heavy clogging in both stairs A and B.	4 minutes and 5 seconds
No. 3	July 11, 2017 (Morning Break)	The students in both sinks were not arranged properly. Students from source 10 followed a dangerous route which is across the building. Still the OLSW arc was not used resulting in a heavy clogging in both stairs A and B.	4 minutes
No. 4	July 14, 2017 (Afternoon Break)	Students did not walk faster than normal, instead some just walked towards the evacuation areas.	4 minutes and 6 seconds
No. 5	July 20, 2017 (Morning Break)	The students in both sinks were not arranged properly. Students from source 10 followed a dangerous route which is across the building. Still the OLSW arc was not used resulting in a heavy clogging in both stairs A and B. Some students were not in their rooms. Others	3 minutes and 54 seconds

		were running instead of walking faster than normal.	

Table 1 provides the observations and the time spent to evacuate the building using the non-model based evacuation plan with an average of 4 minutes and 1 second. During the analysis of the data set, it was identified that the fourth drill conducted on July 18, 2017 is a significant outlier using the box plot function which could affect the result of the study. To address such problem, the researchers used the evacuation time conducted last school year on February 27, 2017 since conducting another drill with the non-model based plan is not anymore possible. It is shown that the fourth drill conducted on July 15, 2017 had the longest time which took the evacuees 4 minutes and 6 seconds to evacuate while the fifth drill conducted on July 20, 2017 took the shortest time with only 3 minutes and 54 seconds. Different factors such as the location of the evacuees, congestion along the stairs and the drill behavior affected the overall evacuation time. The problems observed are repetitive; however, they are still not addressed in the non-model based evacuation plan.

Evacuation by nature is a transportation activity involving traffic. The congestion generated along the stairs may be a result of a surge of traffic demand exceeding the capacity of the arc (Kalafatas & Peeta, 2009). The problem involving the exit path of source 10 and the congestion of evacuees needs to be dealt with properly as an evacuation plan must be enacted with the aim of reducing the life-threatening risk of the susceptible population to minimum level (Xie, 2008). Also, the evacuee behavior which is a complex phenomenon should be understood since it causes most of the clogs during evacuations (Stepanov & Smith, 2008). The undesirable behavior of the evacuees like not walking faster than normal, shouting and laughing may contribute to the long evacuation time. That is why by using an evacuation model, though it does not cover the behavior

of evacuees under emergency conditions, it will update the evacuation routes in time periods which will minimize the overall evacuation time (Khadka, 2016) despite the different behaviors that the evacuees are exhibiting.

Conclusion

In this paper, different approaches both mathematical and strategic were considered and eployed to provide an evacuation plan that would lessen the overall evacuation time of the school. Through Djkistra's Algorithm, the shortest paths were determined by comparing the distances of all the possible routes from each source to the nearest evacuation area. The capacities of arcs and sinks were also identified by computations through the use of standard formulas and estimation methods. This would help route flows efficiently using available and uncongested pathways which would lessen the possibility of congestions both in the arcs and in the sinks during real-time evacuation activity. Another factor considered is the supply and demand factors, evacuees were assigned and arranged in specific locations in the evacuation areas which helped in organizing the crowd of evacuees. Lastly, the most important variable which is time expressed in time units was also captured in the model by foreseeing the distribution of evacuees in the different arcs at each time interval and computing the evacuation time through the model's objective formula given the different costs and the speed of the evacuees.

Recommendations

Based on the scope and delimitations of the study, several recommendations were made and should be considered by future researchers.

First, since the newly imposed routing strategy significantly decreased the total time of evacuation, it is recommended that the proposed strategy should be followed as the new school's evacuation plan. Second, given the constant changes in the population in the school, it

would be better to incorporate both previous and forecasted enrollment data as the assume number of evacuees. Third, it is recommended to consider different behaviors of the evacuees under emergency conditions like panic, herding, congestion, counter flows and ignorance of guidance which could greatly affect the evacuation activity despite the presence of an evacuation plan. Fourth, since the study only provides evacuation routing strategy for the PM building, it is advantageous as well for the future related studies to provide evacuation routes for the Rivier, Our Lady Seat of Wisdom and Elementary buildings. Fifth, it is also recommended to increase the number of simulations or evacuation drills to address the possible variance in the data when determining whether the time of evacuation decreased significantly after providing the model-based routing strategy. Sixth, future researchers may also consider the presence of the secondary disasters that may occur like fire which could affect the flow of evacuees if certain arcs and nodes will be affected. This is the same with unavailability of certain routes in the building due to various factors and the possibility of blockage in the exits. Lastly, other researchers may also venture on developing the disaster response strategy as it is also part of the emergency preparedness plan of the school.

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