

Generation Assessment of Organic Waste with Correlation and Forecasting Models

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Abstract: This research objection on The data collection of the organic waste amount were produced in 2016 until 2019 through 4 years , the unit is in kilogram. The organic waste divided into 2 categories which are fruit peel and food waste on center of organic management generating the bio fermented water to supply for garden of KU campus and green schools with Vertical Recycle Box (VRB) on Bangkok city. The organic waste data analyzed on statistics of correlation and forecasting with statistic numerical modelling. Pearson's correlation of this research is technique to measure correlation between interested data, but not causation. The forecasting techniques of this research are the Moving average, the Weight moving average, the Simple exponential smoothing, the Holt's exponential smoothing. The amount of organic waste that produced in 2016 until 2019. Calculating Pearson's Correlation Coefficient., the correlation between fruit peel and food waste is 0.2853 which has weak correlation between those two ingredients for producing bio fermented water. And the correlations between bio fermented water and both fruit peel and food waste are 0.2518 and 0.0877 respectively, which mean bio fermented water and fruit peel have a weak correlation, but bio fermented water and food waste have no correlation. There are 4 forecasting techniques which are 1) Moving Average k=3, 2) Weight Moving Average k=3, 3) Simple Exponential Smoothing, and 4) Holt's Exponential Smoothing. All of techniques seem to be similar in March until December of 2020 due to the amount of food waste in year 2018 until early of 2019 is stable. But in January and February of 2020, Moving Average was calculated from past 3 years data and in January of 2016 the amount of food waste was extremely high at almost 1,200 kilograms which make an effect to the forecasting value in January of 2020. The research result benefits from Pearson's correlation and The forecasting techniques of this research with the Moving average, the Weight moving average, the Simple exponential smoothing, the Holt's exponential smoothing can be used to prepare for what will happen in the future, gain the valuable in insight, and thee result from prediction methods could decrease cost for the environmental management on the organic waste.

Keywords: Organicwaste, Correlation, Statistic, Forecasting, Numerical modelling

1. Introduction

The accumulation of critical levels of solid organic waste reach in almost all regions of the world. The organic waste must be operated in a sustainable way to avoid depletion of natural resources, minimize risk to human health, reduce environmental burdens and maintain an overall balance in the ecosystem. The different management strategies for organic waste, as well as its environmental impact and regulations that have emerged (MarkCollins, 2017). Industry of Biogas is an important to Polish bioeconomy. Process of anaerobic digestion of sewage sludges enables new added-value bioproducts to be obtained. Eco-innovative fertilizers developed and produced from valorized sludges. Optimized bio-treatment of eutrophic digester liquors is necessary and advantageous. Elaborated novel biotechnologies ensure closing the organic waste management cycles (PawełKaszycki, 2021). The sustainable products and technologies arises from the enormous negative consequences that anthropogenic activity has on the present and future habitability of Earth. The industrial revolution being a significant contributor to crossing planetary boundaries, it becomes important to re-design and design technology to continue to satisfy needs that humans self-determine and value for their sustenance. The modelling of technical nutrient along the lines of biological nutrient cycles is an example of biological analogy seeking to re-design vicious cycles of industry and the economy along virtuous cycles of nature. Virtuosity of these cycles is qualified by features like closing-the-nutrient-loop, equating waste with food, cascading nutrients within multiple lifecycles etc. Replicating and reaping off such cycles is presumed to preserve the means even when scaled up to meet the requirements of an increasing number of people(Suman Devadulaet al, 2015).The organic and plant growth period as variables based on the number of households, and their expected quantity of waste generation within the neighbourhood premises. The land with disposing waste is one of the major effects of urbanization and has adversely affected the urban landscape quality of the cities especially in developing countries. The quality of the wastes which has the potential for reuse in productive landscape purposes is not tapped(Amritha and Kumar, 2019).Organic waste disposal in landfills has created various environmental issues, such as greenhouse gas emissions and leachate. Awareness of this issue has resulted in diverting landfill to compost. Thus, there is a need to develop an analytical tool to select the best composting technology. The assessment steps designed to evaluate specific sustainability criteria of environmental, social, economic, and technical for organic waste management to select the most suitable composting technology (Shukoret et al 2019).Evaluatingthe management of organic waste policy and to predict the trend of organic waste generation in Albania. The appropriate Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) determine the

quantification of organic waste to be generated. The decision-making process in the planning, change and short-term implementation of organic waste management, and the information provided is very useful in collecting, transporting, storing and managing waste in Albanian cities. Furthermore, the high percentage of the organic waste generation until 2025 constitutes good premises to raising public awareness related to their energy recovery (Ionica Oncioiu et al, 2020). Landfilling is one of the easiest methods to be applied in the management of municipal solid waste (MSW). In its development, bioreactor landfill methods that have various advantages over conventional landfill emerge. The use of bioreactor landfills for the management of organic waste in Jatibarang Landfill, Semarang-Indonesia. There are 4 bioreactor landfills operated: 2 anaerobic bioreactors with leachate recirculation and addition of water, and 2 aerobic bioreactors (Oktiawan Wiharyanto et al, 2019). Management and recycling of organic waste materials such as agricultural crops and animal manure is becoming an important issue in rapidly growing population. Vermicomposting by earthworms (*Eisenia fetida*) is useful technique to recover nutrients of plants such as nitrogen, phosphorus, calcium. A vermicomposting system using the earthworm species (*Eisenia fetida*) and treating it with cattle dung, pig manure and biochar with crop as wheat straw and rapeseed. The waste was established in upland areas of China. It was monitored for two months. Maximum increasing in soil fertility with maximum decrease (39.63%) in C:N ratio. Significant increase of N content in nutrients and reduction in C: N ratios during this process shows conversion of harmful wastes into useful fertilizer (Syed Turab Raza et al, 2019). A comparative analysis of the environmental and economic performances of four integrated waste and wastewater management scenarios in the city of Aarhus in Denmark. The purpose of this analysis is to deliver decision support regarding the installation of food waste disposers in private homes, separate collection and transport of organic waste to biogas plants is a more viable environmental and economic solution. Higher environmental benefits in case of mitigation of human health impacts and climate change, are obtained by transforming the existing waste combustion system into scenario. The waste hierarchy from waste incineration to biogas product at wastewater treatment plants with anaerobic sludge digestion. Considering the uncertainty in the extra damage cost to the sewer system may be associated to the installation of food waste disposers, scenario is the most flexible, robust, and less risky economic solution. An economic, environmental, and resource efficiency point of view, separate collection and transport of biowaste to biogas plants is the most sustainable solution (Marianne Thomsen et al, 2018).

The present statistical Analysis from the data collection case to forecasting with statistic numerical modelling. The analysis have Pearson's correlation measure correlation between interested data, but not causation and the forecasting techniques in the present are Moving average, Weight moving average, Simple exponential smoothing, Holt's exponential smoothing. The Pearson's correlation in this research is Technique to measure correlation between interested data, but not causation. The Purpose of the Correlation used to measure how linearly related between two random variables or interested data. The result is in range of -1 to 1, -1 mean the variables have negative relationship and correlation value equal to 1 mean both of variables have position relationship. The value of correlation equal 0 means both of interested data have no relationship between them. Generally, if the values of correlation lay on -0.1 to 0.1, the researchers can assume that there is no relationship and if the values of correlation have values greater than 0.7 or less than -0.7, the researchers can assume that there is strong relationship between those interested data. The benefits of Pearson's correlation are measure the relationship between interested data, the correlation offers a starting position for research, easy to interpret, the related data would have relationship, can be applied to several forecasting method, non-relationship could lead to irrelevant between interested data, ignore these data or manipulate to do the forecasting techniques. The forecasting technique of the Moving average as one of the simplest forecasting techniques have the benefits on the prediction values are stable and The simplest forecasting technique. The forecasting technique of the Weight moving average as more advanced by adding a weight as coefficient in the equation. The set of coefficients that will be assigned a greater weight to newer data point, while past data points are assigned to be less weight, have the benefits on adding the Weight parameter though time, the present data has more value than older data, and may capture present's event that affect the raw data. The forecasting technique of the Simple exponential smoothing as one of the techniques in exponential smoothing forecasting. The simple exponential smoothing technique is weighting between the observed data and the forecasting data, have the benefits on the easiest in exponential smoothing technique, and weight between past forecasting value and actual value could perform better than moving average. The forecasting technique of the Holt's exponential smoothing as the concept is to introduce a term of capturing the trend from the data. This research has done the exponential smoothing by using Python's library called statsmodel, have the benefits on Holt's exponential smoothing technique can capture trend in raw data, and more accurate than simple exponential smoothing in general.

The data collection of this research on the organic waste amount were produced in 2016 until

2019 through 4 years. The statistical analysis from the data collection case to forecasting with statistic numerical modelling. Pearson's correlation of this research is technique to measure correlation between interested data, but not causation. The forecasting techniques of this research are the Moving average, the Weight moving average, the Simple exponential smoothing, the Holt's exponential smoothing. All of the result benefits from the

prediction methods can be used to prepare for what will happen in the future, gain the valuable in insight, and the result from prediction methods could decrease cost for the environmental management on the organic waste.

2. Materials and Methods

The data collection of the organic waste amount were produced in 2016 until 2019 through 4

years, the unit is in kilogram. The organic waste divided into 2 categories which are fruit peel and food waste on center of organic management generating the bio fermented water to supply for garden of KU campus and green schools with Vertical Recycle Box (VRB) on Bangkok city. The organic waste data analyzed on statistics of correlation and forecasting with statistic numerical modelling follow as;

1. Pearson's correlation: Technique to measure correlation between interested data, but not causation (Kirch, 2008).

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Parameter:

r_{xy} correlation between x and y

x_t value of x at time t

\bar{x} average of x

y_t value of y at time t

\bar{y} average of y

2. Moving average: This technique is one of the simplest forecasting techniques. The formula is as follow:

$$\hat{y}_{t+1} = MA(k)_t$$

Parameter:

\hat{y}_{t+1} forecasting value at t+1 period

k number of time periods

3. Weight moving average: This technique is more advanced by adding a

weight as coefficient in the equation. The set of coefficients that will be assigned a greater weight to newer data point, while past data points are assigned to be less weight. The formula is as follow:

$$\hat{y}_{t+1} = WMA(k)_t$$

Parameter:

W coefficient value as weight

4. Simple exponential smoothing: This is one of the techniques in exponential smoothing forecasting. The simple exponential smoothing technique is weighting between the observed data and the forecasting data (Brown, 1963; Billahet al, 1985).

$$\hat{y}_{t+1} = \alpha y_t + (1 - \alpha) \hat{y}_t$$

Parameter:

\hat{y}_t forecasting value at t period

y_t actual data at t period

α the smoothing factor, $0 \leq \alpha \leq 1$

5. Holt's exponential smoothing: The concept is to introduce a term of capturing the trend from the data (Holt, 1957). This research has done the exponential smoothing by using Python's library called statsmodel (Seabold and Perktold, 2010).

$$L_t = \alpha y_t + (1 - \alpha)(L_{t-1} + T_{t-1})$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1}$$

$$\hat{y}_{t+p} = L_t + pT_t$$

Parameter:

α the smoothing factor for level, $0 \leq \alpha \leq 1$

β the smoothing factor for trend, $0 \leq \beta \leq 1$

3. Results

The amount of organic waste that produced in 2016 until 2019, the unit is in kilogram. We can divide organic waste into 2 categories which are fruit peel and food waste. In the first year, the amount of organic waste is moving around 1,200 – 1,900 kilograms. Then in the year of 2017, the trend seems to be negative which mean the organic waste is reducing among time and stay below 1,000 kilograms in January and February of 2018. After March of 2018, the organic waste start to increase up to around 1,300 kilograms and stay around 1,100 – 1,300 kilograms until December of 2018 then the graph is dropping to below 1,000 kilograms and reach the smallest amount of organic waste in June of 2019 then increasing and stay to around 2,200 – 2,800 in the last 4 months of 2019 (Table 1 and Figure 1).

Table 1 The amount of organic waste in range of 6 months.

| Date | Organic waste (kilograms) |
|----------------------|---------------------------|
| Jan 2016 to Jun 2016 | 9,840 |
| Jul 2016 to Dec 2016 | 9,803 |
| Jan 2017 to Jun 2017 | 9,257 |
| Jul 2017 to Dec 2017 | 6,563 |
| Jan 2018 to Jun 2018 | 6,914 |
| Jul 2018 to Dec 2018 | 7,563 |
| Jan 2019 to Jun 2019 | 4,521 |
| Jul 2019 to Dec 2019 | 11,930 |

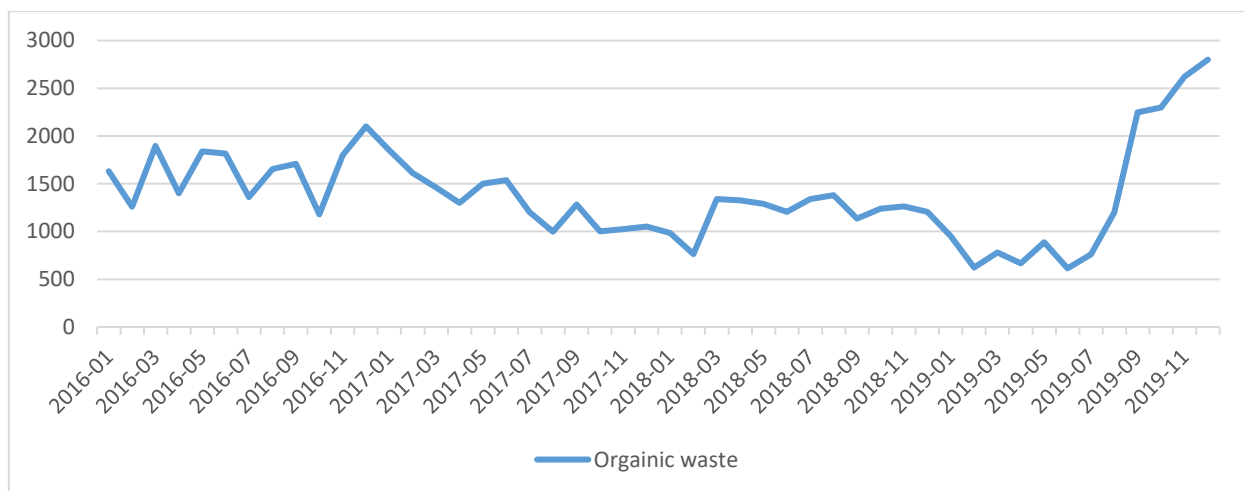


Figure1 The amount of organic waste from the beginning of 2016 until the end of year 2019.

Since organic waste here is fruit peel and food waste, The line graph of amount of fruit peel and amount of food waste in 2016 until 2019. The fruit peel line is moving around 500 – 1,600 kilograms from the January of 2016 until June of 2019 then the waste in fruit peel appears to be large after July of 2019. In January of 2016, there are amount of food waste occurring to be large number then the food waste is dropped in February of 2016 and then line is slightly reduced almost reach to 0 kilogram at around January of 2018 and remain almost zero-food waste until the line slightly increasing again in November of 2018 and remain at low amount of food waste until around September of 2019 then the amount of food waste occurring to be large (Table 2 and Figure 2).

Table2 The amount of fruit peel and food waste in range of 6 months.

| Date | Fruit peel (kilograms) | Food waste (kilograms) |
|----------------------|------------------------|------------------------|
| Jan 2016 to Jun 2016 | 7,434 | 2,404 |
| Jul 2016 to Dec 2016 | 8,083 | 1,720 |
| Jan 2017 to Jun 2017 | 7,540 | 1,717 |
| Jul 2017 to Dec 2017 | 5,629 | 934 |
| Jan 2018 to Jun 2018 | 6,794 | 120 |
| Jul 2018 to Dec 2018 | 7,332 | 231 |
| Jan 2019 to Jun 2019 | 4,141 | 380 |
| Jul 2019 to Dec 2019 | 9,910 | 2,020 |

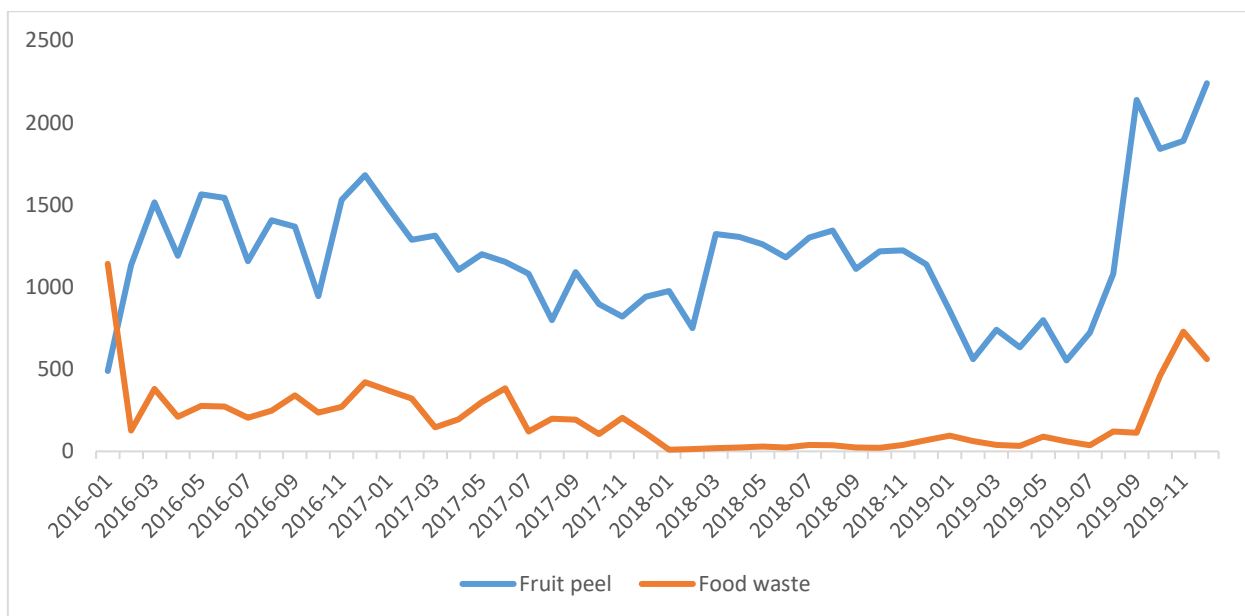


Figure 2 Amount of fruit peel and food waste that were using for fermentation from the beginning of 2016 until the end of year 2019.

The bio fermented water was produced from organic waste by transforming. One of benefit of bio fermented water is for planting plants. The amount of bio fermented water that were produced, the amount of bio fermented water that were produced moving around 150 – 800 liters. Only in July of 2569 that was produced more than 1,300 liters (Table 3 and Figure 3)

Table 3 The amount of bio fermented waste in range of 6 months.

| Date | Bio fermented waste (kilograms) |
|----------------------|---------------------------------|
| Jan 2016 to Jun 2016 | 2,140 |
| Jul 2016 to Dec 2016 | 4,300 |
| Jan 2017 to Jun 2017 | 2,700 |
| Jul 2017 to Dec 2017 | 2,600 |
| Jan 2018 to Jun 2018 | 2,700 |
| Jul 2018 to Dec 2018 | 2,600 |
| Jan 2019 to Jun 2019 | 1,300 |
| Jul 2019 to Dec 2019 | 1,990 |

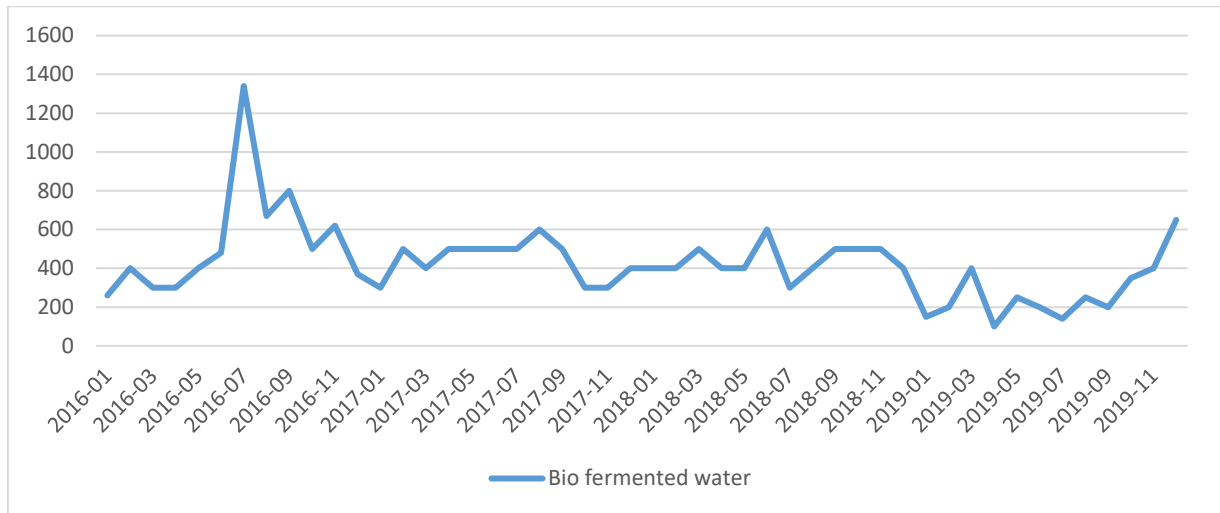


Figure 3 Show the amount of bio fermented water that were produced from year 2016 until year 2019.

Since we know that fruit peel and food waste were used to produce bio fermented water, then the amount of both fruit peel and food waste were used should have relevant with the amount of bio fermented water was produced and we can have the relevant value by calculating Pearson’s Correlation Coefficient., the correlation between fruit peel and food waste is 0.2853 which has weak correlation between those two ingredients for producing bio fermented water. And the correlations between bio fermented water and both fruit peel and food waste are 0.2518 and 0.0877 respectively, which mean bio fermented water and fruit peel have a weak correlation, but bio fermented water and food waste have no correlation (Figure 4 and Table 4).

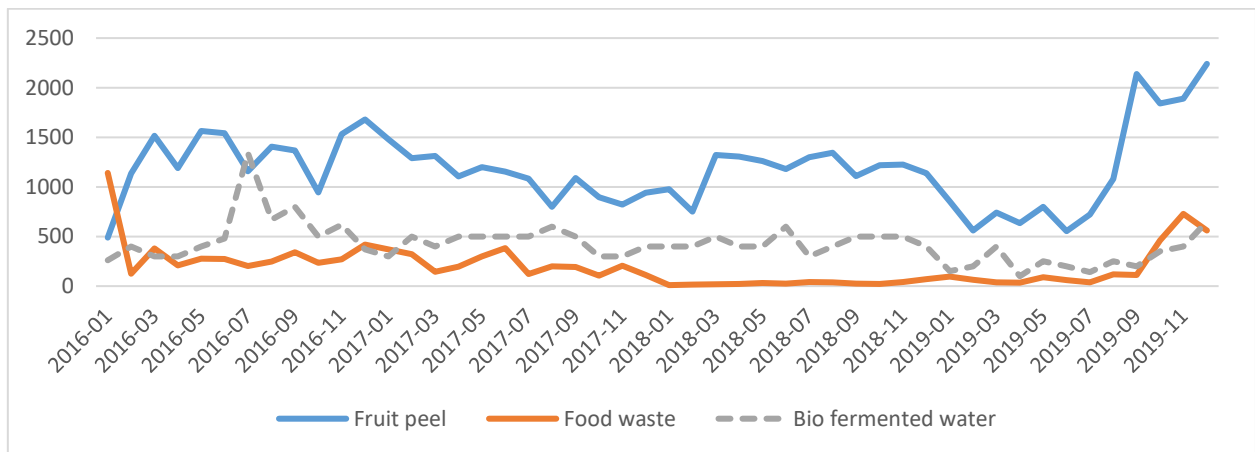


Figure 4 Comparison between fruit peel, food waste, and bio fermented water since 2016 until 2019.

Table 4 Correlation between fruit peel, food waste, and bio fermented water

| Correlation | Fruit peel | Food waste | Bio fermented water |
|-------------|------------|------------|---------------------|
| Fruit peel | 1 | | |
| Food waste | 0.2853 | 1 | |

| | | | |
|---------------------|--------|--------|---|
| Bio fermented water | 0.2518 | 0.0877 | 1 |
|---------------------|--------|--------|---|

There are 4 forecasting techniques which are 1) Moving Average k=3, 2) Weight Moving Average k=3, 3) Simple Exponential Smoothing, and 4) Holt’s Exponential Smoothing. The Simple Exponential Smoothing and Holt’s Exponential Smoothing are calculated in by statsmodels. Since predicting the 12 months forward by using normal time-series data format could have large error, then we use Year-on-Year data format (YoY), The Year-on-Year data format using the previous data from same time in the past year to do forecasting. For example, in Moving Average k=3 mean using 3 past data to calculate the forward data, if we want to forecast the amount of fruit peel will be used in 2020 then the 3 past data will be January of 2017, January of 2018, and January of 2019. Those 3 techniques, Moving Average, Weight Moving Average, and Simple Exponential Smoothing, have remarkably similar value, but Holt’s Exponential Smoothing has a slightly difference (Table 5 and Figure 5).

Table 5The prediction values in 4 forecasting techniques in fruit peel in year 2020.

| Date | Moving Average k=3 | Weight Moving Average k=3 | Simple Exponential Smoothing | Holt’s Exponential Smoothing |
|----------|--------------------|---------------------------|------------------------------|------------------------------|
| Jan 2020 | 982 | 507 | 320 | 1,063 |
| Feb 2020 | 1,057 | 154 | 433 | 993 |
| Mar 2020 | 1,384 | 181 | 400 | 1,351 |
| Apr 2020 | 1,200 | 143 | 400 | 1,219 |
| May 2020 | 1,341 | 202 | 433 | 1,291 |
| Jun 2020 | 1,292 | 227 | 527 | 1,232 |
| Jul 2020 | 1,179 | 121 | 713 | 1,203 |
| Aug 2020 | 1,183 | 162 | 557 | 1,172 |
| Sep 2020 | 1,189 | 186 | 600 | 1,146 |
| Oct 2020 | 1,019 | 121 | 433 | 1,065 |
| Nov 2020 | 1,192 | 172 | 473 | 1,141 |
| Dec 2020 | 1,253 | 200 | 390 | 1,163 |

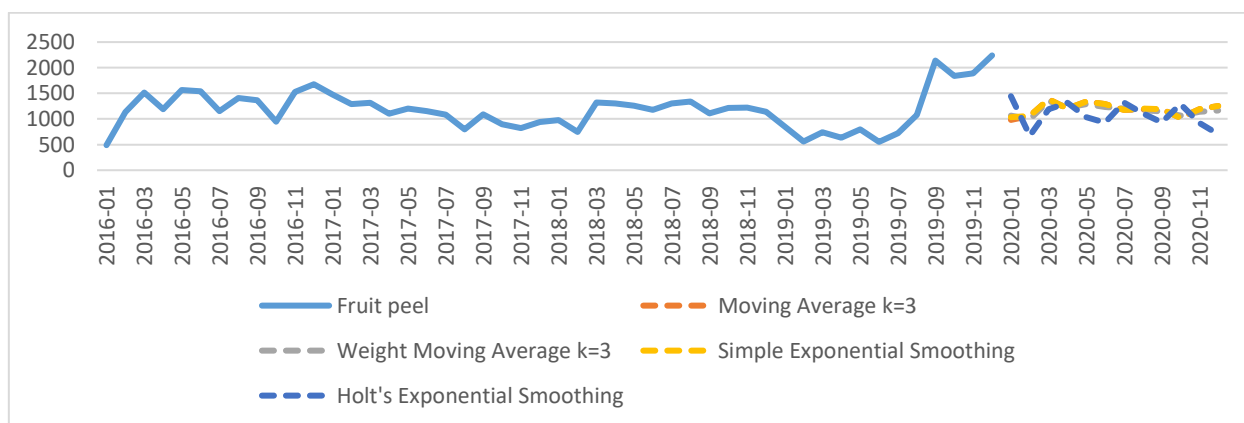


Figure 5 Forecasting techniques in fruit peel in year 2020.

All of techniques seem to be similar in March until December of 2020 due to the amount of food waste in year 2018 until early of 2019 is stable. But in January and February of 2020, Moving Average was calculated from past 3 years data and in January of 2016 the amount of food waste was extremely high at almost 1,200 kilograms which make an effect to the forecasting value in January of 2020. Weight Moving Average also has the

effect of value from January of 2016, but less than Moving Average due to weight parameters. The Simple Exponential Smoothing moving around 20 – 200 kilograms in the first 6 months and stable around 20 – 60 kilograms in the last 6 months. And Holt’s Exponential Smoothing predict around 10 – 100 kilograms in 2020 (Table 6 and Figure 6).

Table6 The prediction values in 4 forecasting techniques in food waste in year 2020.

| Date | Moving Average k=3 | Weight Moving Average k=3 | Simple Exponential Smoothing | Holt’s Exponential Smoothing |
|----------|--------------------|---------------------------|------------------------------|------------------------------|
| Jan 2020 | 507 | 320 | 1,063 | 319 |
| Feb 2020 | 154 | 433 | 993 | 135 |
| Mar 2020 | 181 | 400 | 1,351 | 121 |
| Apr 2020 | 143 | 400 | 1,219 | 112 |
| May 2020 | 202 | 433 | 1,291 | 161 |
| Jun 2020 | 227 | 527 | 1,232 | 186 |
| Jul 2020 | 121 | 713 | 1,203 | 94 |
| Aug 2020 | 162 | 557 | 1,172 | 126 |
| Sep 2020 | 186 | 600 | 1,146 | 133 |
| Oct 2020 | 121 | 433 | 1,065 | 85 |
| Nov 2020 | 172 | 473 | 1,141 | 133 |
| Dec 2020 | 200 | 390 | 1,163 | 141 |

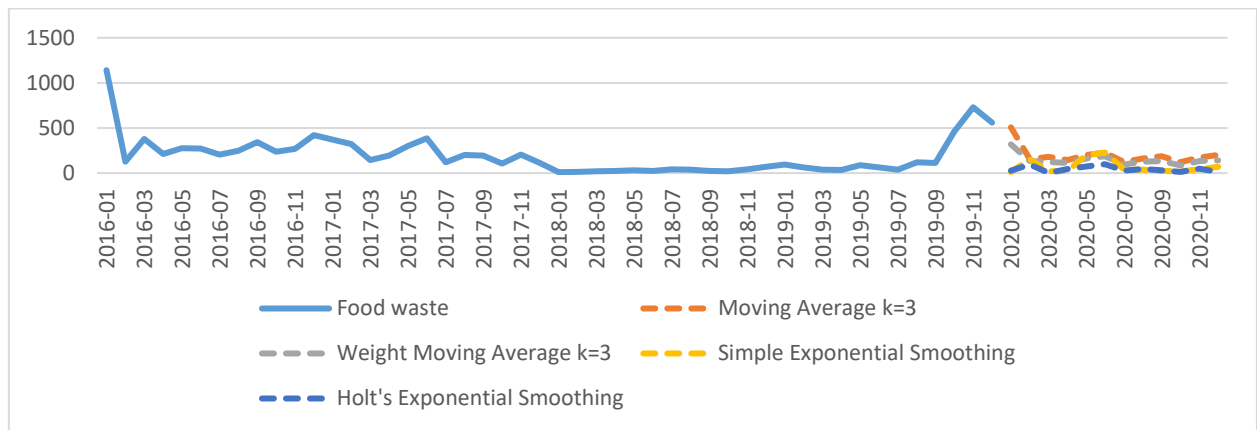


Figure 6 Forecasting techniques in food waste in year 2020.

Moving Average has a bit high value in July of 2020 because of previous years. Weight Moving Average perform similar to Moving Average but not vary as Moving Average, this technique forecast around 300 – 600 kilograms. Simple Exponential Smoothing and Holt’s Exponential Smoothing have similar value, but Holt’s Exponential Smoothing technique forecasted the value slightly lower than Simple Exponential Smoothing (Table 7 and Figure 7).

Table7 The prediction values in 4 forecasting techniques in bio fermented waste in year 2020.

| Date | Moving Average k=3 | Weight Moving Average k=3 | Simple Exponential Smoothing | Holt’s Exponential Smoothing |
|----------|--------------------|---------------------------|------------------------------|------------------------------|
| Jan 2020 | 320 | 1,063 | 319 | 343 |
| Feb 2020 | 433 | 993 | 135 | 433 |

| | | | | |
|----------|-----|-------|-----|-----|
| Mar 2020 | 400 | 1,351 | 121 | 433 |
| Apr 2020 | 400 | 1,219 | 112 | 417 |
| May 2020 | 433 | 1,291 | 161 | 433 |
| Jun 2020 | 527 | 1,232 | 186 | 547 |
| Jul 2020 | 713 | 1,203 | 94 | 540 |
| Aug 2020 | 557 | 1,172 | 126 | 512 |
| Sep 2020 | 600 | 1,146 | 133 | 550 |
| Oct 2020 | 433 | 1,065 | 85 | 433 |
| Nov 2020 | 473 | 1,141 | 133 | 453 |
| Dec 2020 | 390 | 1,163 | 141 | 395 |

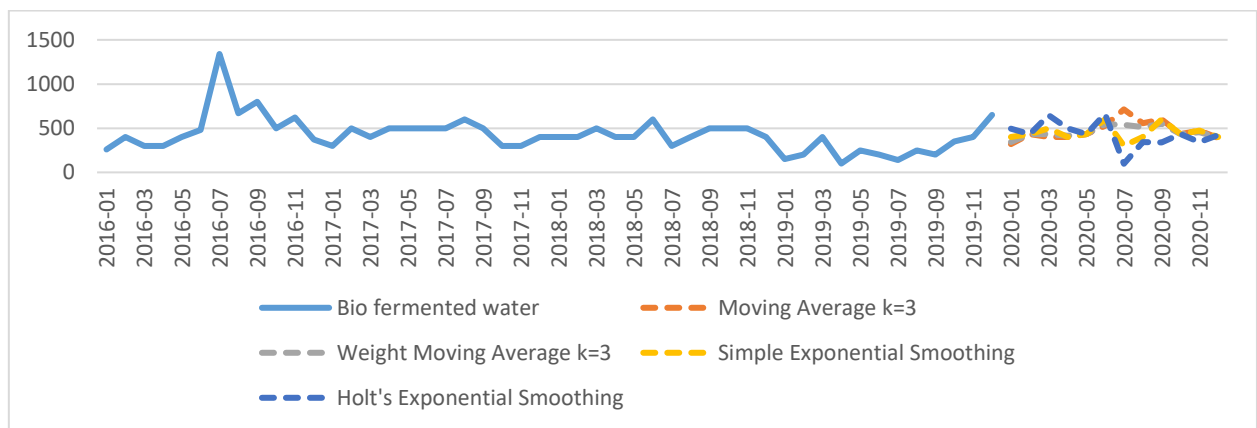


Figure 7 Forecasting techniques in bio fermented water in year 2020.

4. Conclusion

1.The data collection of the organic waste amount were produced in 2016 until 2019 through

4 years , the unit is in kilogram. The organic waste divided into 2 categories which are fruit peel and food waste on center of organic management generating the bio fermented water to supply for garden of KU campus and green schools with Vertical Recycle Box (VRB) on Bangkok city. The organic waste data analyzed on statistics of correlation and forecasting with statistic numerical modelling.

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5.The fruit peel and food waste were used to produce bio fermented water, then the amount of both fruit peel and food waste were used should have relevant with the amount of bio fermented water was produced and we can have the relevant value by calculating Pearson's Correlation Coefficient., the correlation between fruit peel and food waste is 0.2853 which has weak correlation between those two ingredients for producing bio fermented water.And the correlations between bio fermented water and both fruit peel and food waste are 0.2518 and 0.0877 respectively, which mean bio fermented water and fruit peel have a weak correlation, but bio fermented water and food waste have no correlation.

6.There are 4 forecasting techniques which are 1) Moving Average $k=3$, 2) Weight Moving Average $k=3$, 3) Simple Exponential Smoothing, and 4) Holt's Exponential Smoothing. The Simple Exponential Smoothing and Holt's Exponential Smoothing are calculated in by statsmodels. Since predicting the 12 months forward by using normal time-series data format could have large error, then we use Year-on-Year data format (YoY), The Year-on-Year data format using the previous data from same time in the past year to do forecasting. For example, in Moving Average $k=3$ mean using 3 past data to calculate the forward data, if we want to forecast the amount of fruit peel will be used in 2020 then the 3 past data will be January of 2017, January of 2018, and January of 2019. Those 3 techniques, Moving Average, Weight Moving Average, and Simple Exponential Smoothing, have remarkably similar value, but Holt's Exponential Smoothing has a slightly difference.

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5. Acknowledgment

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References

1. Kirchw..2008. Pearson's Correlation Coefficient. (eds) Encyclopedia of Public
2. Health. Springer, Dordrecht.
3. Brown R.G..1963. Smoothing, Forecasting and Prediction of Discrete Time Series.
4. Billah B., King ML., Snyder RD., Koehler AB..1985. Exponential smoothing: The
5. state of the art, Journal of forecasting.
6. Holt, C. C..1957. Forecasting trends and seasonals by ex-potentially weighted
7. averages, O.N.R. Memorandum52/1957, Carnegie Institute of Technology.
8. Seabold S. and PerktoldJ..2010.statsmodels: Econometric and statistical modeling
9. with python. In 9th Python in Science Conference.
10. Ionica Oncioiu, Sorinel Căpușneanu, Dan Ioan Topor, Marius Petrescu, Anca-Gabriela Petrescu, Monica Ioana Toader. (2020). The Effective Management of Organic Waste Policy in Albania. Energies, 13.

11. Junidah Abdul Shukor, Mohd Faizal Omar, Maznah Mat Kasim, Mohd Hafiz Jamaludin, and Mohd Azrul Naim. (2019). Assessment of Composting Technologies for Organic Waste Management. *International Journal of Technology*, 9(8), 1579-1587.
12. Marianne Thomsen, Daina Romeo, Dario Caro, Michele Seghetta, and Rong-Gang Cong. (2018). Environmental-Economic Analysis of Integrated Organic Waste and Wastewater Management Systems: A Case Study from Aarhus City (Denmark). *Sustainability*, 10(10).
13. Mark Collins. (2017). *Organic Waste : Management Strategies, Environmental Impact and Emerging Regulations*. Hauppauge, New York : Nova Science Publishers, Inc.
14. Oktiawan Wiharyanto, Wisnu Wardhana Irawan, Sutrisno Endro, Gorat Domuanri, and Rizky Rizaldianto Alfian. (2019). Municipal Solid Waste Management Using Bioreactor Landfill in the Treatment of Organic Waste from Jatibarang Landfill, Semarang-Indonesia. *E3S Web of Conferences*, 125.
15. P. K. Amritha, and P. P. Anil. Kumar. (2019). Productive landscapes as a sustainable organic waste management option in urban areas. *Development and Sustainability*., 21(2), 709-727.
16. Paweł Kaszycki, Marcin Głodniok, and Przemysław. Petryszak. (2021). Towards a bio-based circular economy in organic waste management and wastewater treatment – The Polish perspective. *New BIOTECHNOLOGY*, 80-89.
17. Suman Devadula, B. Gurumoorthy, and Amaresh Chakrabarti. (2015). Design for sustainability: case of designing an urban household organic waste management system. *Current Science*., 109(9), 1622-1629.
18. Syed Turab Raza, Zulfiqar Ali, and Tang Jia Liang. (2019). Vermicomposting by *Eisenia fetida* is a Sustainable
19. and Eco-Friendly Technology for Better Nutrient Recovery and Organic Waste Management in Upland Areas of China. *Pakistan Journal of Zoology*, 51(3)..