Inventory of Greenhouse Gas Emissions (Methane) During 2023 from Market Solid Waste in Kendari City to Support Green City Development

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Abstract. Greenhouse gas emissions from market waste can be an environmental problem that comes from methane (CH_4), which is a powerful greenhouse gas that contributes to climate change. This research aims to find out what types of solid waste are produced from market activities in Kendari City and how much market solid waste can produce greenhouse gas emissions (CH_4) in Kendari City markets within a period of one year (2023). This research was carried out in three market locations, namely Sentral Kota Market, Mandonga Market, and Baruga Market. This research uses direct observation methods in the field in the 3 markets that are the research sample by calculating solid waste generation and solid waste emissions. The large number of community activities in the market will create a larger volume of waste. The research results show that the types of solid waste in the Kendari City market are dominated by organic waste, namely vegetable/fruit waste and food waste, then there is plastic, paper/carton, glass, cloth, rubber, wood, metal, and others. The total concentration of CH_4 gas emissions at Mandonga Market is 1419.1 Gg/year, Baruga Market produces 2128.7 Gg/year of CH_4 gas, Sentral Kota Market produces 709.5 Gg/year of CH_4 gas, so the total CH_4 emissions produced from the 3 markets in Kendari City reached 4257.3 Gg/year. So by converting the CH_4 produced from market waste, it can become a useful energy source, such as electricity or biogas.

Keywords: Greenhouse Gas Emissions, Methane, Market Solid Waste, Kendari City.

ICESDM 2023, November 02, Banjarmasin, Indonesia

DOI 10.4108/eai.2-11-2023.2347952

1 Introduction

Greenhouse gases (GHGs) are gases found in the atmosphere that absorb and emit infrared radiation from sunlight. GHGs are formed naturally or formed due to human activity (anthropogenic). The heat contained in infrared and trapped in GHGs results in an increase in the Earth's surface temperature and further causes climate change [1]. Climate change is the condition of some climate elements whose magnitude and or intensity tend to change or deviate from the dynamics and average conditions. The main cause of climate change is human activities (anthropogenic) related to increased GHG emissions [2].

GHGs are potentially emitted from various stages in waste management, including waste handling at source, transportation, and landfilling. In many countries, the IPCC 2006 method is chosen to predict GHG emissions from various sectors, including waste management. In the IPCC 2006 method, there are database levels based on the data sources used in calculating GHG emissions [3].

One of the GHG emissions that cause global warming is methane gas (CH_4) emissions. Market waste, mostly vegetable and food waste, has the potential to contribute to CH_4 emissions [4]. CH_4 gas emissions can come from market solid waste, especially from the decomposition process of organic matter in waste piles. When organic waste such as food waste decomposes in landfills, anaerobic processes (without oxygen) produce CH_4 as a by-product. This often happens in landfills that are not equipped with CH_4 gas management facilities [5].

The problem of waste will not be separated from the problem of human behavior and lifestyle. Increased activity in the market greatly affects the quantity of waste piles in the market environment [6]. Kendari City, which is the capital city of Southeast Sulawesi Province, consists of 11 districts and 61 sub-districts with an area of 297 km^2, and a total population of 490 thousand people. Based on the standard waste disposal per capita of 2.5/kilogram/person/day, the total waste production generated in Kendari City is approximately 180 tons/day in the landfill [7]. The increase in population in Kendari City resulted in waste generation per person of 0.69 kg/day or 247.96 tons/day, the largest source of waste comes from several markets and household waste [8].

The activities in the market will generate solid waste and the market also does not have a place to manage solid waste directly or only collect it in Temporary Waste Disposal Sites which are then transported to the landfill, so that market solid waste is also the largest contributor to solid waste generation in landfills which can cause GHG emissions, especially decreased air quality due to increased GHG, so research related to GHG emissions from market solid waste in Kendari City is considered important to conduct research, because in the Kendari City market there has been no research related to the contribution of solid waste that can produce GHG emissions. The implementation of this research will be a measure of regional air quality in terms of GHG emissions generated from market solid waste, therefore, there needs to be an effort from the Kendari City Government to support the development of a green city.

Green city development is an urban planning and development approach that aims to create more environmentally, economically, and socially sustainable cities. The concept involves a wide range of measures to reduce negative urban impacts on the environment and improve the quality of life of city dwellers [9].

Research on GHG emissions from CH_4 gas emissions in market solid waste is very important in supporting green city development because (1) CH_4 emissions are one of the main GHGs that have a much higher global warming potential than carbon dioxide (CO_2). Understanding the sources of these emissions and finding ways to reduce them is a key step in managing urban environmental impacts. (2) CH_4 emissions also impact urban air quality, so this research contributes to efforts to improve air quality and the health of city residents. (3) this research encourages better waste management practices, such as recycling, composting, or more efficient waste processing, which are in line with the principles of green city development.

Thus, research on CH_4 emissions from market solid waste is not only important but also one of the key components in the effort to build a sustainable and environmentally friendly green city. Therefore, the objectives of this research are: (1) to know what types of solid waste are generated from market activities in Kendari City, and (2) to determine the amount of market solid waste that can produce GHG emissions (CH_4) in Kendari City markets within one year (Year 2023).

2 Research Methods

2.1 Time and Research Location

This research took place in 2023. This research was conducted in 3 market locations that will be the object of research, namely the Kendari Sentral Kota Market located in Jalan Katambak, Dapu-Dapura Sub-district, West Kendari District, Kendari City, Southeast Sulawesi Province, the second point, namely in Mandonga Market located in Jalan Lasandara, Korumba Sub-district, Mandonga District, Kendari City, Southeast Sulawesi Province, and in Baruga Market located on Jalan Kapten Pierre Tendean (Baruga Market Street) Kendari City, Southeast Sulawesi Province. The reason why the researcher determined the sample size to be these three markets (see Fig. 1) is because they are the main markets in Kendari City that are considered to have the most visitors and are also considered to produce the most waste compared to other markets.

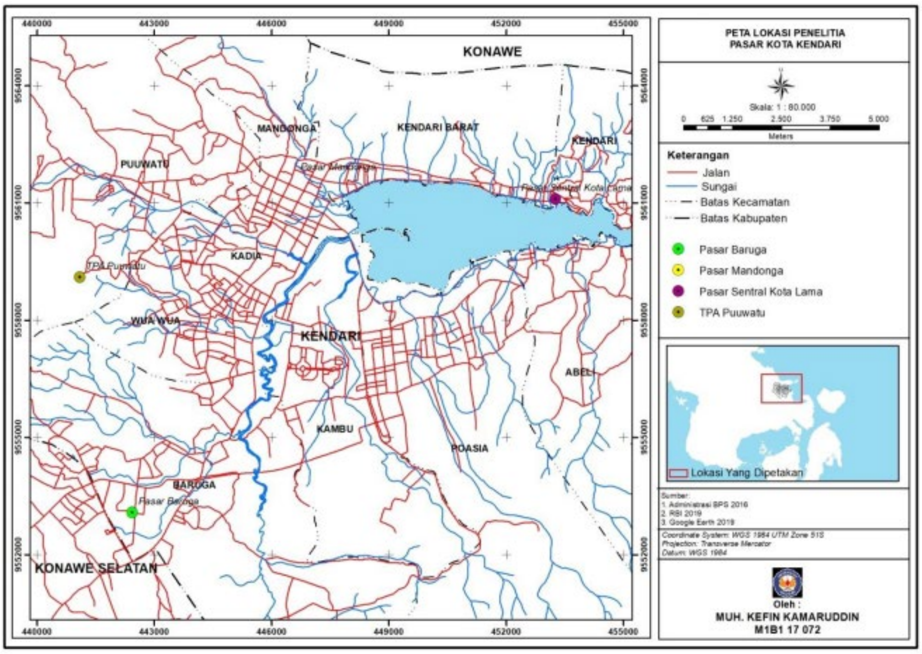

Fig. 1. Map of the research location.

2.2 Tools and Materials

This research uses tools and materials that can support the sampling process in the Kendari City market which can be seen in Table 1.

Table 1. Tools and materials used in the research and their uses.

Tool name	Usability
Plastic bags with a capacity of 50 kg	Receptacle for market solid waste
Small basket	Receptacle for market solid waste sorting
Scales	Weighing the weight of market solid waste
Shovel	Taking samples of market solid waste
Gloves	Protect hands when sorting market solid waste samples
Boots	Protect feet when sampling market solid waste
Masks	Protect nose when collecting and sorting market solid waste samples
Camera	Retrieve research documentation
Writing tools	Recording the data obtained
Laptop	Processing data and writing research reports
Material name	**Usability**
Market organic solid waste in Kendari City	Being a research sample
Market inorganic solid waste in Kendari City	Being a research sample

2.3 Population and Sample

The population in this research is all markets in Kendari City which includes 11 public markets in 10 districts [10]. This research used purposive sampling to determine the sample size in this research, namely among the 11 markets, researchers chose 3 markets that were considered the most crowded with visitors and also considered to produce the most waste, so that the 3 market locations that became the object of the research sample were Sentral Kota Market, Mandonga Market, and Baruga Market.

2.4 Types of Data

The types of data generated in this research include (1) data on the types of solid waste generated in Kendari City Market, (2) data on the generation of types of market solid waste in Kendari City per year, (3) data on the percentage composition of types of market solid waste in Kendari City, (4) data on the amount of solid waste from 3 Kendari City markets per year, and (5) GHG emission concentration data for CH_4 emission from solid waste in Kendari City Market per year.

2.5 Data Analysis

The data analysis used in this research includes:

1. Data on the types of solid waste generated in Kendari City Market is analyzed by identifying the types of waste generated from activities in the market through observation in several market landfills. These market solid wastes can come from various sources, such as traders, visitors, and market operational staff.
2. Data on the generation of types of market solid waste in Kendari City per year, which is analyzed by calculating the amount of waste generated from activities in the market through observation of the weight of solid waste scales obtained, starting from the weight of waste generated on average per day, then converted to an average per month, to an average per year.
3. Data on the percentage composition of the types of market solid waste in Kendari City, which is analyzed by calculating the percentage composition of each type of waste generated from activities in the market through observation of the weight of the solid waste scales obtained, starting from the highest average percentage composition of solid waste to the lowest average percentage composition of solid waste.
4. Data on the amount of solid waste from 3 markets in Kendari City per year, which is analyzed by calculating the amount of all waste generated from each activity of the 3 markets obtained, starting from the amount of all waste generated per day, then converted to per month to per year.
5. Data on the total concentration of GHG emissions for CH_4 emissions from solid waste in Kendari City market per year, which is analyzed by calculating GHG emissions for CH_4 emissions from solid waste can use the following Equation (1).

CH_4 emissions = (MSWT x MSWF x MCF x DOC x DOCF x F x 16/12 x R) x (1-0X) (1)

Information:
CH_4 = Solid waste emissions
MSWT = Market solid waste generation (Gg/year)
MSWF = Percentage of solid waste in Kendari City market (%)
MCF = CH_4 correction factor
DOC = Organic carbon degradation for each solid waste composition (Gg C/G waste)
DOCF = DOC fraction of 0.5 based on IPCC 2006
F = CH_4 fraction for a volume of 0.5 based on IPCC 2006
R = C to CH_4 conversion factor
R = CH_4 oxidation recovery has a value of 0 based on IPCC 2006
1-0X = Factor.

Calculating market solid waste generation can use the following Equation (2) [38].

MSWT = Number of Sellers x Solid Waste Generation Rate (2)

Information:
MSWT = Market solid waste generation (Gg/year).

Calculating the percentage of solid waste entering the landfill can use the following Equation (3) [38].

MSWF = Total Market Solid Waste / Total Weight of Market Solid Waste Generated x 100 % (3)

Information:
MSWF = Percentage of solid waste in Kendari City markets that goes to landfill (%).

While calculating organic degradation in solid waste can use the following Equation (4).

DOC = Wi x DOCi (4)

Information:
DOC = Degradation of organic carbon in solid waste
Wi = Composition of solid waste
DOCi = Percentage of DOC in accordance with IPCC 2006.

3 Results and Discussion

3.1 Types of Solid Waste Generated in Kendari City Market

Market solid waste is a type of waste generated from activities in markets, such as traditional markets or modern markets. These wastes can come from various sources such as traders, visitors, and market operational officers. The types of waste generated from the activities of the three markets in Kendari City can be seen in Table 2.

Table 2. Types of solid waste generated from 3 markets in Kendari City.

Type of waste	Mandonga Market	Baruga Market	Sentral Kota Market
Paper/carton	√	√	√
Cloth	√	√	√
Food waste	√	√	√
Wood	√	√	√
Vegetable/fruit	√	√	√
Rubber	√	√	√
Plastic	√	√	√
Metal	√	√	√
Glass	√	√	√
Others	√	√	√

Source: Primary data, 2023

Table 2 shows that overall the average Kendari City market produces solid waste such as paper/carton, cloth, food waste, wood, vegetable/fruit, rubber, plastic, metal, glass, and others. Waste collection and sorting activities were conducted for 8 consecutive days in each of the 3 markets in Kendari City.

The types of waste in the 3 markets of Kendari City are divided into 2 categories, namely organic solid waste, and inorganic solid waste, this is to the research of Abidin et al., [11] organic waste is a type of waste that has a composition of carbon, oxygen, nitrogen, phosphorus, to hydrogen, this waste is very identical to food waste, vegetable, and other types that are easily decomposed due to the help of microorganisms. Furthermore, inorganic waste is paper/carton, cloth, wood, rubber, plastic, metal, glass, and others.

Vegetable waste in the form of rotten cabbage, watermelon skin, corn skin, toge skin, spinach vegetable waste, sweet potato leaves, rotten mustard greens, rotten papaya, skin or seeds, and others that come from vegetable and fruit sellers. According to the results of research by Dikta et al., [12] that organic waste, namely vegetables, fruits, and leaves because they have a high water content, these wastes tends to rot quickly, if not managed properly. This can cause environmental problems such as unpleasant odors, the spread of disease, or even water pollution. When such wastes decompose under anaerobic conditions (without oxygen), such as in closed landfills, they can produce CH_4 gas during the decomposition process. Improper management of organic wastes, such as piling up in uncovered landfills can lead to the emission of CH_4 gas into the atmosphere. Utilization of these wastes can be done for biogas production and animal feed which is in line with the results of Rahayu and Perdana's research [13] that vegetable, fruit, and leaf wastes are wastes that can be used as animal feed. This utilization is very good for reducing GHG emissions.

Food waste is also known as organic waste, which is a type of waste that comes from the remains of uneaten food or foodstuffs that have expired. The characteristics of food waste can vary depending on the type of food, environment, and waste management practices in a region. The types of food waste that are commonly found in Kendari City markets are coffee or tea grounds, stale rice from food stalls, and coconut pulp. Due to its high organic content, food waste has the potential to decompose quickly, cause unpleasant odors, and attract insects or decomposing animals. The decomposition process of organic waste in landfills usually produces CH_4 gas. Food waste has the potential to be utilized as an energy source through the process of making biogas or biomass energy production. Food waste management through recycling or composting methods can be an economic opportunity [14].

Plastic waste is a type of solid waste made from synthetic polymer materials that are difficult to decompose naturally. Plastic has a high resistance to natural decomposition. This means that discarded plastic will remain in the environment for years or even centuries. Examples of plastic waste include plastic bottles, plastic bags, plastic food containers, plastic electronic equipment, and many other consumer products made of plastic. Plastic discarded in landfills has the potential to cause CH_4 gas emissions. Research from the University of Hawaii at Manoa found that plastic will release greenhouse gases once exposed to light. The researchers found that light not only breaks down the plastic but also makes the plastic release methane and ethylene, 2 greenhouse gases that are a problem for the environment [15]. Therefore, it is important to reduce the use of single-use plastics, encourage recycling, and develop more environmentally friendly plastic materials [16].

Waste paper refers to paper materials that are no longer used or needed, and are usually discarded or recycled. Paper waste includes newspapers, paper, carton, and other paper in the form of rice wrappers. Paper is easily degraded naturally by microorganisms. Paper-type waste, such as paper contaminated with food waste or other organic matter, can be a potential source of CH_4 gas when decomposed in an environment that favors anaerobic conditions. For example, in landfills buried in the ground, organic waste, including paper, can produce CH_4 gas during the decomposition process. One way to reduce the environmental impact of paper waste is to recycle it. The paper recycling process involves collecting, processing, and making new paper from existing cellulose fibers. Paper recycling can reduce excessive tree cutting and reduce the need for new raw materials. Paper recycling can reduce the cost of producing new raw materials and reduce pressure on forests and the environment [17].

Cloth waste is a type of solid waste that comes from scraps or items made from cloth or textiles. Cloth waste can consist of various types of cloths, such as cotton, silk, rayon, polyester, wool, and others. Cloth waste can be contaminated by chemicals such as detergents, dyes, and other addictive materials used during production, wearing, or washing that can potentially harm the environment. Cloth and textile recycling can create business opportunities in the recycling industry and manufacturing of products made from cloth waste. Cloth-type waste does not directly produce CH_4 gas, as cloths are generally made of synthetic or natural fibers that do not decompose like organic waste. However, in certain situations in the market, if cloth waste is mixed with organic waste such as food waste or other organic materials, and if this waste is buried in soil or an environment that supports anaerobic conditions, then the organic waste may produce CH_4 gas during the decomposition process. Therefore, if decomposing waste cloth produces CH_4, it may contribute to climate change by increasing the greenhouse effect [18].

Wood waste refers to material resulting from the process of felling, processing, or using wood that no longer has economic value or is no longer used for its primary purpose. Wood waste can be in the form of chips, small pieces, sawdust, or even large pieces. Wood waste can also contain contaminants such as paints, adhesives, or other chemicals used in the wood processing process. Wood waste can have a significant economic impact. Traditionally, wood waste can be utilized as fuel, and raw material for other wood products. In some contexts, wood waste such as sawdust or wood chips disposed in landfills suitable for anaerobic conditions can lead to the production of CH_4 gas. Therefore, efficient utilization of wood waste and proper treatment can help reduce CH_4 gas emissions, as well as its negative impact on the environment and global climate, and can increase economic value if properly utilized [19].

Waste rubber refers to various types of waste derived from rubber or natural rubber products, such as old tires, recycled rubber products, rubber industry production waste, and so on [20]. Some rubber products contain harmful chemicals such as fillers, adhesives, and other additives that can contaminate soil and water, if not managed properly. Waste rubber, such as piles of old tires or other rubber goods, can be a source of CH_4 gas when decomposed in landfills or environments that are not sufficiently oxidized. The decomposition process of rubber waste by microorganisms under anaerobic conditions produces CH_4 gas as one of its products. Therefore, rubber waste that is not properly managed and disposed of in unsuitable landfills, can lead to the production of CH_4 gas which is a potentially harmful GHG to the environment.

Glass waste is a type of solid waste formed from glass materials that no longer have economic value or function. Glass is a durable material and does not biodegrade easily. This makes glass waste have a very long degradation period in the environment. Glass cannot be decomposed by decomposing organisms such as bacteria or fungi. Therefore, glass waste tends to accumulate in landfills. Examples of glass waste include broken glass bottles, pieces of glass from windows, or broken mirrors. Waste glass has economic potential if recycled or reused in manufacturing processes, such as reusing recycled glass to make new products [21]. Glass-type waste has no relationship with CH_4 gas generation. Therefore, glass waste, such as glass bottles or broken glass, cannot produce methane gas because their chemical composition does not support the formation of CH_4 gas.

Metal waste is a type of waste consisting of metallic materials or metallic compounds that no longer have economic value or are no longer used, and tend to be considered as waste. Some metals such as iron and steel are subject to corrosion, which is a reaction with oxygen or water that causes deterioration of the material. Although waste metals are often considered as waste, some metals still have economic value if recycled. Examples are waste metals from manufacturing industries such as aluminum, steel, and copper. There is no connection between waste metal types and the occurrence of CH_4 gas. Metals, such as iron, aluminum, or copper are materials that do not decompose like organic matter. Thus, metal waste will not produce CH_4 gas. Therefore, good and efficient management of metal waste involves proper recycling practices, toxicity management, GHG emission reduction, as well as utilization of the economic potential associated with metal waste [22].

3.2 Generated Types of Market Solid Waste in Kendari City per Year

The generation of types of market solid waste is the amount of waste generated by one trader per day in units of waste volume or weight of waste generated from the type of waste source in a certain area at unity time. Based on the results of the research conducted, the amount of generation of each type of solid waste from 3 market locations in Kendari City can be seen in Table 3.

Table 3. Solid waste generation of each type from 3 markets in Kendari City.

Type of waste	Mandonga Market (kg)	Sentral Kota Market (kg)	Baruga Market (kg)	Amount (kg)	Average/ day (kg)	Average/ month (kg)	Average/ year (kg)
Paper/carton	23	20	21	64	21	640	7,680
Cloth	3	3	4	10	3	100	3,000
Food waste	119	126	145	390	130	3.900	117,000
Wood	2	2	2	6	2	60	1,800
Vegetable/fruit	156	149	170	475	158	4.750	142,500
Rubber	3	3	3	9	3	90	2,700
Plastic	46	45	49	140	47	1.400	42,000
Metal	1	1	1	3	1	30	900
Glass	5	4	3	12	4	120	3,600
Others	3	2	3	8	3	80	2,400
Total	361	355	401	1,117	372	11,170	323,580

Source: Primary data, 2023

Based on Table 3 above, the generation of each type of solid waste in the Kendari City market produces an average paper/carton waste of 21 kg/day. The most dominant waste is vegetable/fruit waste which produces an average of 158 kg/day and food waste which produces an average of 130 kg/day, while the least waste is the type of metal which produces an average of 1 kg/day. If multiplied by a year, it can produce an average of 7,680 kg/year for paper/carton waste and produce an average of 142,500 kg/year for vegetable/fruit waste.

Waste generation is the volume of waste or weight of waste generated from a type of waste source in a given area over time [23]. Urban markets are often the main source of solid waste in developing cities. One of the waste generators is market activity. Dense market activities also generate waste. Lizayana et al., [24] suggested that buying and selling activities are one of the causes of market waste. The waste generated can be in the form of solid waste. Market solid waste management is a complex challenge because it involves environmental, health, and social aspects. The data collection method is carried out by taking direct measurements of solid waste generated in each market during a certain period. The data was analyzed to obtain information on the daily, monthly, and annual amount of waste from each market. Based on the results of the data analysis obtained, Table 3 shows that Baruga Market generates the most waste, the results of this research indicate that Baruga Market has the largest contribution to the total amount of solid waste in the market area of Kendari City. This could be due to factors such as market size, number of traders, as well as consumer habits in disposing of waste. In addition, Baruga Market is a market that sells various types of vegetables and fruits on a large scale.

Pasar Mandonga also has a significant contribution to solid waste, while Pasar Sentral Kota has a lower amount of waste compared to the other 2 markets. Therefore, the local government should design an effective and sustainable waste management program, especially for Baruga Market and Mandonga Market. Measures such as waste reduction, recycling, and composition should be considered to reduce the environmental impact of market solid waste.

Population growth has an influence on the increase in waste generation. Tampuyak et al., [25] argued that increasing population and community activities will also lead to an increase in waste generation. The more people in an area, the more waste is generated. Rapid population growth without adequate waste management infrastructure can lead to an increase in solid waste generation. Increased purchasing power and changes in people's consumption patterns can generate more waste. The demand for consumer goods, packaging, and single-use products can contribute significantly to waste generation. The existence of inadequate or inefficient waste management systems can result in uncontrolled accumulation of waste. The lack of effective recycling practices results in more materials ending up as solid waste rather than being reused. In an effort to reduce waste, traders can also pay attention to merchandise so that it is not easily damaged which then becomes waste, especially organic waste. Merchants can use appropriate packaging materials for product types such as protectors to prevent damage during shipping or storage, and keep merchandise clean against dust or dirt with covers or additional packaging [26].

3.3 Percentage Composition of Market Solid Waste Types in Kendari City

The percentage of waste type composition is how much solid waste is produced by Kendari City markets with various compositions. Based on the results of the research, the percentage composition of solid waste types from 3 Kendari City markets can be seen in Table 4.

Table 4. Percentage composition of solid waste types from 3 markets in Kendari City.

Type of waste	Waste composition (%)			Amount (%)	Average (%)
	Mandonga Market (%)	Sentral Kota Market (%)	Baruga Market (%)		
Paper/carton	6.2	5.4	5.6	17.2	5.7
Cloth	0.8	0.8	1.1	2.7	0.9
Food waste	32	33.9	39	104.9	35
Wood	0.5	0.5	0.5	1.5	0.5
Vegetable/fruit	41.9	40.1	45.7	127.7	42.6
Rubber	0.8	0.8	0.8	2.4	0.8
Plastic	12.4	12.1	13.2	37.7	12.6
Metal	0.3	0.3	0.3	0.9	0.3
Glass	1.3	1.1	0.8	3.2	1.1
Others	0.8	0.5	0.8	2.1	0.7

Source: Primary data, 2023

Based on Table 4, the highest average percentage of market solid waste composition is vegetable/fruit waste, which is 42.6%. The average percentage in the composition of the lowest market solid waste is metal waste, which is 0.3%. The average percentage of paper/carton type waste is 5.7%, the average percentage of cloth type waste is 0.9%, the average percentage of food waste is 35%, the average percentage of wood type waste is 0.5%, the average percentage of plastic-type waste is 12.6%, the average percentage of rubber type waste is 0.8%, the average percentage of glass type waste is 1.1% and the average percentage of others is 0.7%.

Markets are one of the major sources of solid waste in a city. To manage solid waste effectively, it is necessary to understand the composition of waste types generated by the market, as well as the total amount of waste generated. In this context, research was conducted in Kendari City to analyze the percentage composition of market waste types and the total amount of solid waste generated. Based on Table 4, the waste type composition is expressed in percentage and calculated based on 3 main markets, namely Mandonga Market, Sentral Kota Market, and Baruga Market. Vegetable/fruit waste has the highest average percentage at 42.6%. This indicates that vegetable/fruit waste is a major contributor to the total market waste. The average percentage of plastic waste and paper/carton waste is quite significant with around 12.6% and 5.7% respectively. Recycling, incineration, and burial are some of the ways that can be done to deal with plastic waste. However, burning plastic waste is harmful to living things, as it produces toxic substances, while burial is ineffective, as plastic is very difficult to degrade. So an effective way to avoid environmental pollution and reduce the volume of plastic waste in landfills can be done by reusing waste materials by recycling [27].

3.4 Total Solid Waste from 3 Markets in Kendari City per Year

From the results of direct surveys in the field at 3 markets in Kendari City, it can be seen that the amount of Kendari City market solid waste generated can be seen in Table 5.

Table 5. Data on the amount of solid waste from 3 markets in Kendari City.

Market name	Ton/day	Ton/month	Ton/year
Mandonga	6	180	2,190
Baruga	9.7	270	3540.5
Sentral Kota	3	90	1,095
Total	18.7	540	6825.5

Source: Primary data, 2023

Based on Table 5, shows that the one that produces the most waste is Baruga Market, which produces 9.7 tons per day. This value is obtained from 9 tons transported to the landfill and 700 kg taken by the community to be used as animal feed. Based on the results of the research survey, the average seller in Baruga Market produces waste of 25 kg/day, then multiplied by the number of sellers, if multiplied for 30 days, it produces waste of 270 tons/month and 3540.5 tons/year. Mandonga Market which produces market solid waste of 6 tons/day, this value is obtained from the average seller who produces waste of 15 kg/day, then multiplied by the number of sellers. If multiplied for 1 month, it produces a total solid waste of 180 tons/month and 2,190 tons per year. And the Sentral Kota Market which produces 3 tons of waste, this value is obtained from the average seller who produces waste of 9 kg/day, then multiplied by the number of sellers, if multiplied for 30 days, it produces waste of 90 tons/month and 1,095 tons/year.

Table 5 presents data on the total amount of solid waste generated by the 3 main markets in Kendari City in various time scales (per day, per month, and per year). Baruga Market generates the largest amount of daily waste, which is 9.7 tons. This indicates that the market has a significant impact on overall waste production. Mandonga Market produces 6 tons of waste per day, while Sentral Kota Market produces 3 tons per day. The total amount of waste from the 3 markets is 18.7 tons per day, 540 tons per month, and 6825.5 tons per year. It can be concluded that markets in Kendari City generate a significant amount of solid waste. Vegetable/fruit type waste is the main contributor to the total waste, while metal waste has the lowest percentage. Baruga Market generates the most waste, followed by Mandonga Market, and Sentral Kota Market. This analysis is important in waste planning and management to ensure the efficiency and sustainability of the waste management system in Kendari City as one of the indicators of green city development. Market solid waste management that can be applied in Kendari City is Organic waste composting [28].

Harjanti and Anggraini [29] mentioned that solid waste management in landfills, especially in Jatibarang Semarang City is quite good with the availability of waste facilities, such as drainage channels in the form of rivers, collection installations, and leachate water treatment in the form of leachate ponds, operational control posts, CH_4 gas controllers in the form of pipes to measure CH_4 gas pressure, and also various heavy equipment used in the waste processing process. In addition, there is also the availability of waste processing that can be directly utilized by the community, such as composting waste that can be used as fertilizer, utilizing CH_4 gas for cooking, reducing waste by grazing waste, and the existence of a CH_4 gas canteen where payment is made using plastic waste. This management is also very good, if applied in Kendari City to reduce GHG emissions from market solid waste in Kendari City.

3.5 Total GHG Emission Concentration for CH_4 Emissions from Solid Waste in Kendari City Market per Year

The amount of CH_4 gas produced depends on the composition of the waste. Theoretically, each kilogram of waste can produce 0.5 m^3 of CH_4 gas. In addition, the CH_4 gas formed from market solid waste spreads in landfills both horizontally and vertically and eventually escapes into the atmosphere. In calculating the amount of CH_4 gas emissions, there are several factors, namely: the amount of market solid waste generation, the percentage of market solid waste, the correction factor, which is a type of management used in managing market solid waste. Market solid waste in Kendari City has a value of 1, because the market solid waste is managed without the help of air. Degradable Organic Carbon (DOC) is the process of degradation or decay of market solid waste that occurs in the organic component. DOC for Kendari City market has a value of 2.16 based on IPCC 2006. The CH_4 fraction (DOCf), which is the estimated fraction of carbon that is degraded and released from market solid waste landfills, has a value of 0.5 based on the IPCC 2006. Recovery (R) to a better previous state has a value of 0, because no recovery has been carried out in the landfill. Furthermore, the oxidation factor (0x) is the response of a substance that binds oxygen has a value of 0.1 sourced from the IPCC 2006.

Based on the results of the research, the total concentration of CH_4 gas from 3 markets in Kendari City can be seen in Table 6.

Table 6. Concentration of CH_4 gas emissions from solid waste in 3 markets in Kendari City.

Market name	MSWt	MSWf	DOC	DOCf	FX		R		0x
Mandonga	2195.5 Ton/Year	99.75 %	2.16	0.5	0.5	16/12	0	1	0.1
Baruga	3485.8 Ton/Year	94.24%	2.16	0.5	0.5	16/12	0	1	0.1
Sentral Kota	1097.9 Ton/Year	99.73%	2.16	0.5	0.5	16/12	0	1	0.1

Source: Primary data, 2023

Based on Table 6 above, solid waste generation in Mandonga Market is 2195.5 tons/year, Baruga Market is 3485.8 tons/year, while Sentral Kota Market is 1097.9 tons/year. The percentage of solid waste from each market can be seen in Table 6 above, the DOC value is 2.16, the DOCf value is 0.5, the FX value is 0.5, and the R value is 0.

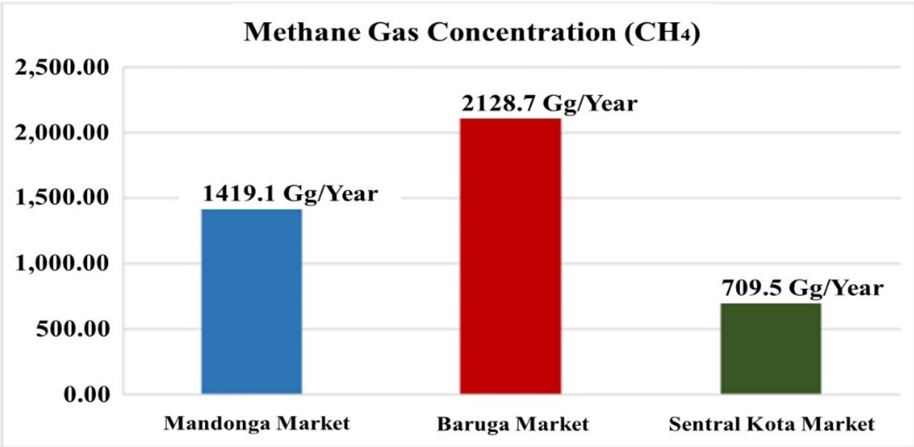

Fig. 2. Histogram graph of CH_4 gas concentration from solid waste in 3 markets of Kendari City.

Based on Figure 2 above, the market that has the highest CH_4 gas emission content is Baruga Market, which is 2128.7 Gg/year, Mandonga Market produces CH_4 gas, which is 1419.1 Gg/year, and Sentral Kota Market produces CH_4 gas, which is 709.5 Gg/year. From the 3 markets in Kendari City that were used as samples, the total CH_4 gas emissions generated from solid waste in Kendari City markets amounted to 4257.3 Gg/year.

The amount of CH_4 produced depends on the composition of the waste [30]. CH_4 contributes 15% to global warming and theoretically every kilogram of waste can produce 0.5 m^3 of CH_4 gas. In addition, the CH_4 gas formed spreads in the waste pile both horizontally and vertically and eventually escapes into the atmosphere [31]. In calculating the amount of CH_4 gas emissions there are several factors, the first, namely the amount of waste generation, the percentage of waste, and the correction factor, which is a type of management used in managing waste. The market in Kendari City has a value of 1.0 because it is managed without the help of air. Degradable organic carbon (DOC), is the process of degradation or decay that occurs in organic components or carbon. DOC for the market in Kendari City is 2.16 based on IPCC 2006. CH_4 fraction (DOCf), the estimated fraction of carbon that is degraded and released from landfills, has a value of 0.5 based on IPCC 2006. Recovery or recovery back to a better previous state, which is worth 0, because no recovery has been carried out. Furthermore, the oxidation factor, which is worth 0.1 sourced from IPCC 2006, the oxidation aspect is the response of a substance that binds oxygen. Based on the research results, market solid waste in Kendari City produces CH_4 emissions, which amounted to 4257.3 Gg/year.

The market that produces the highest CH_4 emissions is Baruga Market with total emissions of 2128.7 Gg/year, with 382 sellers. Baruga Market is one of the trading centers located in urban areas. The high level of emissions generated by Baruga Market is largely due to various activities that occur in the market, such as transportation in and out of the market, the use of electrical energy, waste management, and so on. These emissions have an impact on air quality and the environment around Baruga Market, as well as potentially impacting the health of people living or doing activities around the market. In addition, Baruga Market also has a large number of sellers, totaling 382 sellers. As Baruga Market has an important economic role, steps need to be taken to reduce the level of emissions produced. This can be done by implementing more environmentally friendly practices, such as optimizing energy use, and considering more efficient waste management. One way that can be done is to utilize vegetable/fruit waste as animal feed. Vegetable/fruit waste will be valuable if utilized as feed through processing [32]. Thus, Baruga Market can remain a trading center that contributes to the economy, while keeping its environmental impact under control.

Mandonga Market produces emissions, which amount to 1419.1 Gg/year. Mandonga Market is one example of a modern market located in Kendari City. This market has various modern facilities and a wide range of vendors selling various types of products, ranging from food, clothing, electronics, and so on. However, this market also contributes to a significant amount of GHG emissions. According to measured and calculated data, Mandonga Market produces CH_4 gas emissions of 1419.1 Gg/year from decomposing organic waste. Waste management by recycling or composting organic waste, the market can reduce CH_4 emissions resulting from waste decomposition. Waste management that can be done on wet waste or organic waste to reduce the amount of waste entering the landfill includes composting. One of the composting methods that can be done is using the Takakura Method which has many advantages including using simple, cheap, easy equipment, and during composting is very aesthetically pleasing does not cause odor, and does not damage the environment [33].

Sentral Kota Market produces CH_4 gas emissions of approximately 709.5 Gg/year. Sentral Kota Market is the main trading center in West Kendari Sub-district where various types of products and commodities are traded every day. However, this market also plays a role in generating CH_4 gas from market solid waste, such as unsold food scraps, fruit peels, vegetables that are no longer fresh, and other organic waste. This waste can be composted. The composting process is a way to recycle organic waste into more useful materials, such as compost. Furthermore, the CH_4 gas produced can then be collected and used for various purposes. Abdullah et al., [34] stated that in their research, one of the common uses of CH_4 gas is as an alternative energy source. Potential content of CH_4 gas in the form of electrical energy and in the form of LPG gas.

The resulting CH_4 gas emissions amounted to 1419.1, if multiplied by the number of markets in Kendari City of 11 markets, it can reach 15,610.21 Gg/year. CH_4 gas will damage the earth's ozone layer because it includes greenhouse gases that cause climate change. The amount of GHG emissions depends on the composition of waste and waste characteristics, as well as the number of waste management activities [35]. The waste fraction that is the largest contributor to emissions is the vegetable/fruit type and the food waste type. Piles of vegetable/fruit waste are rarely used by the community, because they are no longer suitable for consumption as animal food, vegetable/fruit waste is just left alone, causing odors that can interfere with environmental hygiene and health. The existence of abundant types of vegetable/fruit waste has great potential as a source of making compost and biogas, in line with the research of Rasyid et al., [36] who examined the utilization of organic waste as raw material for making compost and biogas. If the amount of market solid waste cannot be avoided, then what needs to be done is to utilize the waste so that it does not accumulate and cause GHG emissions.

Solid wastes generated by markets in Kendari City can be utilized. Organic matter from municipal solid waste can stand as a great potential source of nutrients for plants if used as fertilizer through composting [37]. Organic waste can be converted into organically useful products, organic fertilizers, and animal feed through bioconversion, and has been recognized as a valuable and profitable source of energy. In the research of Indriyanti et al., [28] organic waste at Sampangan Baru Market has been processed into compost and has been sold. This resulted in 3 human resources from the Self-Help Group at Sampangan Market which processed market organic waste into ready-to-sell compost. The same thing is also expected to be applied in the markets of Kendari City.

4 Conclusions

The types of solid waste generated from the 3 markets in Kendari City ranged from the highest value to the lowest value, namely vegetable/fruit, food waste, plastic, paper/carton, glass, cloth, rubber, wood, metal, and others. Solid waste generated from the 3 markets in Kendari City is dominated by organic waste, especially vegetable/fruit waste and food waste.

The total concentration of CH_4 gas emissions at Baruga Market amounted to 2128.7 Gg/year, Mandonga Market produced CH_4 gas emissions, amounted to 1419.1 Gg/year, and Sentral Kota Market produced CH_4 gas emissions, which amounted to

709.5 Gg/year so that the total CH_4 gas emissions generated from 3 markets in Kendari City, which reached 4257.3 Gg/year.

Based on these conclusions, it can be recommended that there is a need for efforts from the Kendari City Government to support green city development, namely by converting CH_4 generated from market waste into useful energy sources, such as electricity or biogas.

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