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Study On The Characteristics Of Household Waste In Bojongloa Kaler District, Bandung City, Indonesia

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Abstract
*The complex issues faced by developing countries, including Indonesia, are related to waste management. The waste problem is no longer just an environmental sanitation issue, but has become a social issue that has the potential to lead to conflict. The purpose of this study is to examine the characteristics of household waste in Bojongloa Kaler District as a first step to provide comprehensive data in designing an appropriate waste processing system. Considering the high population density, this location was chosen as the initial research site. The research method began with the selection of the district for the study area, conducted through weighting 30 districts in Bandung City using parameters on the scale of determining the importance of the service area found in SNI 8632:2018. To obtain data on the generation, composition, and characteristics of household waste, waste sampling was conducted for 8 consecutive days. based on SNI 19-3964 1994. Sampling was carried out based on high, middle, and low economic income levels. The sampling results showed that the household waste generation in the Kopo, Jamika, and Babakan Tarogong subdistricts were 0.2 kg/person/day, 0.3 kg/person/day, and 0.3 kg/person/day, respectively. The most dominant composition of household waste in the Kopo, Jamika, and Babakan Tarogong subdistricts was kitchen waste (food waste), which accounted for 49.26%, 45.07%, and 44.35%, respectively. The second most common type of waste in Kopo and Babakan Tarogong subdistricts was plastic, at 28.57% and 32.44%, respectively. Conversely, in Jamika subdistrict, the second most waste was classified as others, while plastic ranked third with a generation of 16.10%. The moisture content in Jamika Subdistrict is 56.56%, Kopo 76.81%, and Babakan Tarogong 64.85%. The analysis results of volatile matter are as follows: Jamika Subdistrict 64.33%, Kopo 31.27%, Babakan Tarogong 40.30%. The ash content analysis shows Jamika Subdistrict at 16.06% dry basis, Kopo 7.84%, and Babakan Tarogong 14.06%. Fixed carbon in Jamika Subdistrict is 4.05%, Kopo 2.41%, and Babakan Tarogong 3.81%. The highest carbon level observed is 52.29% in Babakan Tarogong Subdistrict.***

Keywords: *Characteristics, composition, household waste, kitchen waste, plastic waste, waste generation.*

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I. Background

The complex problems faced by developing countries, including Indonesia, are related to waste management. Waste issues are no longer just a matter of environmental sanitation, but have become a social issue that has the potential to cause conflicts. (Damanhuri & Padmi, 2015). The amount of waste generated from an activity will determine the volume of waste that needs to be managed. The amount of waste that needs to be managed is very important to know and record (Damanhuri, 2018).

Based on Government Regulation No. 81 of 2012 concerning Household Waste Management and Similar Household Waste, waste management is a systematic, comprehensive, and continuous activity that includes waste reduction and handling. Waste is generated from various human activities. As the population grows, the variety of life needs will also increase, which will lead to more and diverse waste being produced. In the waste management system, the design of the waste processing system requires accurate data on waste characteristics.

Based on the National Waste Management Information System (SIPSN) for the year 2024, West Java is the province with the highest waste production, amounting to 6,153,346.94 tons, and the city of Bandung produces 546,151.49 tons of waste, which ranks 4th in waste generation in West Java, after Bogor Regency, Bekasi Regency, and Bekasi City. According to Damanhuri & Padmi, 2015, this is can be caused to several factors including the standard of living of the community, mobility, seasons, lifestyle, and others.

Based on the SIPSN of Bandung City in 2024, the composition of waste by source shows that 60% comes from households, 13.3% from public facilities, 10% from markets, and other sources account for 1.7% to 6%, varying from offices, businesses, areas, and others. The composition of waste by type indicates that the largest portion comes from food waste, which is 44.52%, followed by plastic at 16.7%, paper at 13.12%, other waste at

11.68%, and the remaining types of waste are metals, rubber/leather, cloth, wood/branches varying between 0.9% and 4.745%.

Based on the data sources mentioned above, waste management, especially for households, needs to be planned starting from the source. The community should begin sorting their waste, at least into two categories: organic and inorganic waste. Household organic waste consists of kitchen waste, which, according to the SIPSN data from Bandung City in 2024, is quite significant compared to other types of waste. If the community can process organic waste themselves, this will have a significant impact on reducing waste at the source and making it easier for officers to manage the waste. The purpose of this study is to identify the characteristics of waste in Bojongloa Kaler District as an initial step to provide comprehensive data in designing an appropriate waste management system. This study will influence the waste management system in a planned area, particularly in Bojongloa Kaler District, Bandung City, so that problems in waste management can be minimized from the source.

II. Methodology

Selection of Sampling Location Alternatives

The selection of Districts for the study area was carried out by weighting 30 Districts in the City of Bandung using parameters on the Scale for Determining the Importance of Service Areas found in SNI 8632:2018 regarding the operational management techniques for Municipal Solid Waste.

On that scale, there are several criteria that determine the importance of service areas based on sanitation vulnerability and economic potential. The sanitation vulnerability score indicates that the environmental conditions in the area are susceptible to health issues due to poor sanitation, especially waste management. Economic potential refers to the economic value that can be generated from waste management if the area is chosen to be served.

The Regional Service Importance Determination Scale has 6 parameters with sub-parameters that have their respective scores/weights. After consideration, it was decided that only a few parameters would be used in determining the candidate area of study, namely the function and value of the area parameter, the population density parameter, and the topography parameter. The reason is that apart from the 3 (three) selected parameters, the other parameters do not have clear and measurable limits and conditions, and are not supported by secondary data that can be obtained in the preliminary survey before collecting field data. Based on the sum of the sanitation vulnerability scores and the economic potential scores, Bojongloa Kaler District was chosen with a total score of 110.241 to be the study area of this research.

Waste Sampling

Research was conducted in 3 subdistrict of Bojongloa Kaler District, which are the subdistrict with the largest population in Bojongloa Kaler, namely Jamika, Babakan Tarogong, and Kopo. Primary sampling was carried out for 8 consecutive days based on SNI 19-3964 1994. This sampling aimed to obtain data on waste generation, composition, and characteristics of household waste. Moreover, the selection of households for sampling was based on high, medium, and low economic income levels.

Sampling for collecting waste generation data was conducted in the yard of the Integrated Waste Processing Place (TPST) Nyengseret at Jln. Bojongloa No. 65, Panjunan, Astanaanyar District for 8 consecutive days from October 24 to October 31, 2024. To determine number of samples, calculations were performed using the Yamane method (1967) with the formula:

$$n = \frac{N}{1 + N(E^2)}$$

Where n is the number of samples, N is the total population, and E is the error rate. Assuming an error rate of 5% and an average of 5 people per household, the number of houses to be sampled is 82 houses.

Next, an approach to dividing the population based on strata/economic levels is carried out. This method uses data on the Percentage of Households by District/City and the Main Roof Material of the Largest House in 2023.

The characterization test of waste was conducted at the Hazardous Waste Laboratory of the Faculty of Civil Engineering and Environmental Technology Institute of Technology Bandung (ITB). The characteristic analysis consists of two; Proximate analysis using ASTM D2216-80 and ASTM D3172 – ASTM D3175 methods, and Ultimate analysis using ASTM 3172 - 3175 methods.

III. Results And Discussion

Waste Generation

According to SNI 8632:2018, the amount of waste generation based on the components of waste sources, the weight of permanent household waste is 0.65 – 0.7 kg per person per day for Large and Metropolitan Cities. From the sampling results that have been carried out, the average waste weight in Kopo, Jamika, and Babakan Tarogong is below the waste weight in SNI 8632:2018, as can be seen in **Table 1**.

Table 1. Results of Waste Generation Measurements in Bojongloa Kaler District Based on Economic Level

Subdistrict	Kg/person/day				Liter/person/day			
	Low Income	Middle Income	High Income	Rata-Rata	Low Income	Middle Income	High Income	Average
Kopo	0,114	0,222	0,300	0,212	1,425	1,487	2,295	1,736
Babakan Tarogong	0,312	0,177	0,406	0,298	0,483	2,114	3,078	1,892
Jamika	0,433	0,204	0,302	0,313	3,675	2,515	3,090	3,093

Similarly, compared to PERMENLHK no 6 of 2022 concerning the National Waste Management Information System, the waste generation at all sampling locations is below the estimated waste generation factor per capita based on city classification, which is Metropolitan City of 0.7 kg/person/day. According to Asase 2011 in Miezah et al., 2015 who conducted research in Ghana which is a developing country based on its socio-economic conditions, it is stated that areas with high socio-economic classes generate the highest amount of waste in the study area; 0.56 kg/person/day followed by middle-class areas at 0.49 kg/person/day and low-class areas at 0.47 kg/person/day for the capital city. Similar findings regarding the differences in waste generation among socio-economic regions where higher socio-economic classes generate higher waste. The amount of waste generation is influenced by several factors including the standard of living of the community, mobility, seasons, lifestyle, and others (Damanhuri & Padmi, 2015).

The projection of waste generation in 3 Subdistrict in Bojongloa Kaler District can be seen in figure 1. The growth rate calculation follows the growth of Bojongloa Kaler District with the reference data of Bandung City.

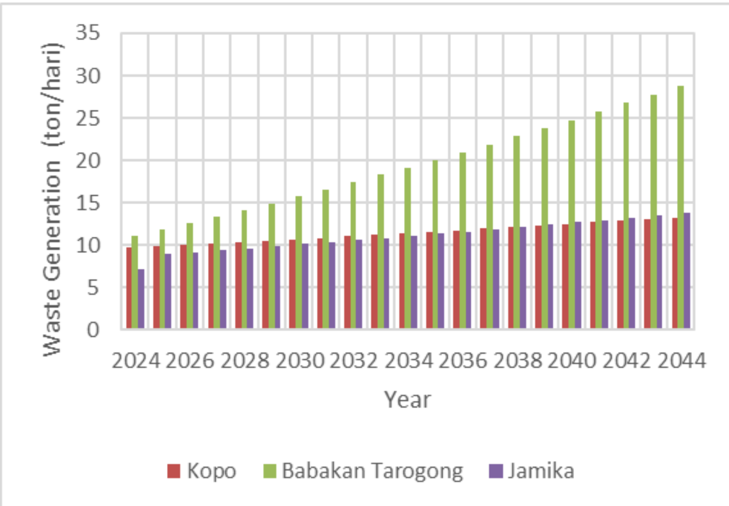

Figure 1. Projection graph of waste generation in Kopo, Jamika, and Babakan Tarogong Subdistricts.

Based on the projection results of waste generation in Kopo, Jamika, and Babakan Tarogong, the waste generation in Babakan Tarogong is expected to rise dramatically until 2044 compared to the other two Subdistrict. This is due to the projected population of Babakan Tarogong increasing much higher than that of the other Subdistrict, as the population data in certain years shows a drastic rise. The increase in waste generation is caused by population growth, rapid economic development, urbanization, and lifestyle changes (Huseein et al., 2018).

Waste Composition

The composition of waste in Kopo, Jamika, and Babakan Tarogong subdistricts is predominantly organic waste (kitchen waste). The composition of kitchen waste in Jamika, Babakan Tarogong, and Kopo subdistricts is 49.26%, 45.07%, and 44.35% respectively. This figure is not far off from the SIPSN data for Bandung City in

2024, which is 44.52%. The second highest type of waste in Kopo and Babakan Tarogong subdistricts is plastic, accounting for 28.57% and 32.44% respectively. In contrast, in Jamika subdistrict, the second highest type of waste is categorized as 'other waste', while plastic contributes 16.10%. The composition of plastic in Kopo and Babakan Tarogong is higher than the SIPSN data for Bandung City in 2024, which is 16.7%, while Jamika subdistrict is close to this figure. The waste composition chart for the three subdistricts in Bojongloa Kaler can be seen in the following figure 2:

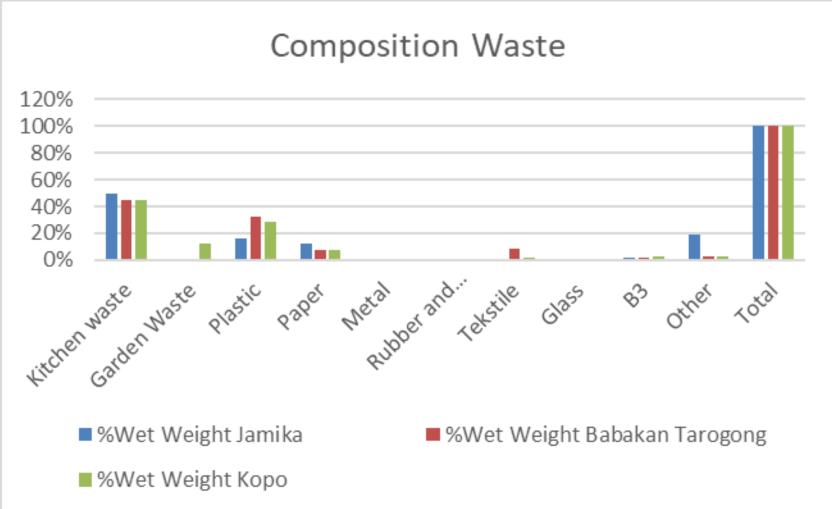

Figure 2. Waste Composition of 3 Subdistrict in Bojongloa Kaler District

In general, the national waste composition trend is dominated by food waste, accounting for 37-49% (Ministry of National Development Planning/Bappenas, 2023). The organic fraction of waste is the highest in Ghana, ranging from 48% to 69% (Miezah et al., 2015). Residents with a higher economic level tend to be more consumptive, which can influence the increase in the amount of food waste generated; this is likely the basis for the higher composition of food waste in cities compared to rural areas (Ministry of National Development Planning/Bappenas, 2023).

Characteristics of Waste

The characteristics of the waste in a city need to be understood in order to estimate its management, utilization of materials and energy contained, suitable processing methods, and potential impacts. These characteristics vary significantly depending on the components of the waste. Municipal waste in developing countries will differ in composition from municipal waste in developed countries (Damanhuri, 2018).

The characteristics of waste in 3 Subdistrict in Bojongloa Kaler District based on proximate analysis, which includes moisture content, volatile matter, ash content, and fixed carbon, can be seen in Table 2 and Figure 3. The percentage of moisture content in the samples indicates the level of waste humidity. This can affect the subsequent processing (Damanhuri Padmi, 2015).

Table 2. Results of proximate analysis of waste characteristics in 3 (Three) Subdistrict

No	Paramater	Unit	Analysis Results		
			Kopo	Babakan Tarogong	Jamika
1.	Moisture content (*as received*)	% BK	76,81	64,85	56,56
2.	Moisture content (*air dried*)	% BK	58,49	41,83	25,56
3.	Volatile content (*air dried*)	% BK	31,27	40,30	64,33
4.	Ash content (*air dried*)	% BK	7,84	14,06	16,06
5.	Fixed Carbon (*air dried*)	% BK	2,41	3,81	4,05

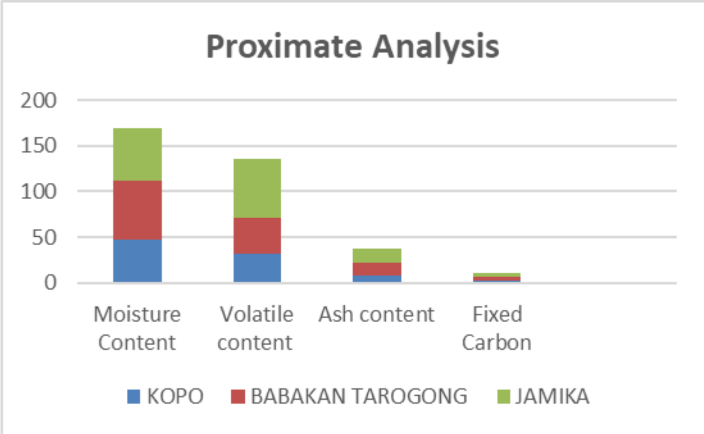

Figure 3. Proximate analysis graph of waste characteristics in 3 (Three) Subdistrict

The Jamika subdistrict has a moisture content (as received) of 56.56%, indicating that the waste is in a wet or damp condition, while the moisture content (air dried) shows that after the waste sample is dried, there is still 25.56% moisture content remaining. The measured moisture content at the study location is lower than the moisture content of household waste analyzed by Arsyandi et al., 2018 in Bandung City, which is 69.47%, and is almost close to the moisture content of household waste analyzed by Maulana et al., 2019 at 57.46% in the Babakan Sari and Babakan Surabaya subdistricts of Bandung City. The Kopo subdistrict has a very high water content (76.81% as received), which indicates that the waste is in a very wet condition and can affect further processing such as drying and transportation. After drying, the waste is still wet as it still contains 58.49% water. The percentage of water content in the Babakan Tarogong subdistrict is 64.85% (as received) indicating that the waste is wet, and the air dried water content at 41.83% shows that the drying process only reduced the initial water content by 23.03%.

The moisture content of waste varies greatly depending on the composition of the waste (Damanhuri and Padmi, 2018). According to research by Zhen et al., 2019 in Indonesia, the moisture content of each type of urban waste is over 30% and can reach up to 70% for food waste, while the mixed waste has a moisture content of 50.74%, resulting in an average moisture content in Indonesia of 48.49%, which is nearly comparable to the moisture content in Shenzen at 48.17% and higher than Taiwan at 36.69%. The average moisture content of urban waste in China is 50.3%, while the moisture content of urban waste in Malaysian landfills is between 50-58%, with food waste making up 39% (Kalanatarifard et al., 2012). Climate, particularly rainfall, can affect moisture levels. The moisture content of domestic waste is also influenced by the ratio of food waste, as the moisture content of food waste can reach 60-70% (Zhu et al., 2021).

The volatile content refers to materials that evaporate easily at a temperature of 550°C. The higher the organic content of a material, the easier it burns, and the higher its calorific value, which is directly proportional to the increase in flame height (Damanhuri and Padmi, 2018). The analysis results for the volatile content in Jamika Subdistrict show a value of 64.33%, indicating that most organic components in the waste easily volatilize when heated, meaning the waste has the potential to be processed into fuel or biogas production. The volatile content of waste from Kopo subdistrict is quite low, at 31.27, which means the energy potential of the waste sample is lower compared to samples with higher volatile contents. The volatile content of Babakan Tarogong Subdistrict is 40.30%, indicating potential for waste processing using composting methods. The volatile content of waste at Bakri Landfill, Malaysia is 80% (Kalanatarifard et al., 2012). The volatile content at the research site is still lower compared to waste in Malaysia. Volatile can be used to estimate the organic content in urban waste samples (M Baawain et al., 2017 in Zhen et al., 2019). The highest volatile content is found in plastic waste, approaching 90%, thus containing the most organic material, whereas the organic material content of mixed waste is the lowest. The average volatile value of MSW in Indonesia is close to 70%, indicating that the MSW contains relatively more organic matter. (Zhen et al., 2019).

Kadar Abu merupakan bagian sampah yang tidak tervolatilisasikan, atau bagian sampah yang tidak terbakar. Abu mengurangi kapasitas pembakaran, meningkatkan biaya penanganan, dan mempengaruhi efisiensi pembakaran/efisiensi boiler pada incinerator, serta menyebabkan penggumpalan dan penyumbatan. Biasanya yang menjadi abu setelah proses pembakaran adalah mineral yang ada di dalam bahan bakar atau sampah. (Damanhuri dan Padmi, 2018). Hasil analisis kadar abu Kelurahan Jamika senilai 16,06% BK, Kelurahan Kopo 7,84%,, Kelurahan Babakan Tarogong 14,06% menunjukkan kandungan anorganik dalam sampel sampah sedikit hal ini menunjukkan sampel sampah didominasi oleh bahan organik. nilai ini relatif rendah bila dibandingkan dengan hasil analisis Maulana dkk.,2019 di Permukiman Bantaran Sungai Cidurian Kota Bandung yaitu sebesar 24,52% dan lebih tinggi bila dibandingkan dengan hasil analisis Arsyandi dkk.,2019 dari sampah Rumah Tangga

Bantaran Sungai Ckapundung Kota Bandung sebesar 2,78%,. Untuk Kelurahan Jamika dan Babakan Tarogong mempunyai nilai lebih tinggi dibandingkan dengan hasil penelitian Raharjo, dkk.,2017 di Kota Padang yaitu sebesar 10%. Kadar Abu rata rata dari sampah perkotaan di Kota Mexico adalah 13% (Moreno et al.,2013). Kadar Abu dari sampah di Barkri Landfill Malaysia adalah 14%. Nilai kadar abu hasil analisis di 3 Kelurahan Kecamatan Bojongloa Kaler adalah typical range 10 – 20-% dari sampah (Tchobanoglous 2002).

The ash content is the non-volatile part of waste, or the part of waste that does not burn. Ash reduces combustion capacity, increases handling costs, and affects combustion efficiency/boiler efficiency in incinerators, as well as causing clumping and blockage. Generally, what becomes ash after the combustion process are minerals present in the fuel or waste. (Damanhuri and Padmi, 2018). The analysis results of the ash content in Jamika were 16.06% dry weight, Kopo Subdistrict 7.84%, and Babakan Tarogong Subdistrict 14.06%, indicating a low inorganic content in the waste samples, which suggests that the waste samples are predominantly organic. This value is relatively low compared to the analysis results by Maulana et al., 2019, in the riverbank settlement of Cidurian City of Bandung, which was 24.52%, and higher compared to the analysis results by Arsyandi et al., 2019, from the household waste of Ckapundung Riverbank in the City of Bandung at 2.78%. For the Jamika and Babakan Tarogong , the value is higher compared to the research results by Raharjo et al., 2017 in the city of Padang, which was 10%. The average ash content of urban waste in Mexico City is 13% (Moreno et al., 2013). The ash content of waste at Barkri Landfill Malaysia is 14%. The ash content value from the analysis in 3 Subdistrict in the Bojongloa Kaler District is a typical range of 10 – 20% of the waste (Tchobanoglous 2002).

Fixed carbon or volatile content at temperatures of 800 - 950°C, when the heating in the analysis of volatile content is continued up to 950°C (Brunner, 1994 in Damanhuri and Padmi, 2018), then the weight loss at that temperature is called fixed carbon (Damanhuri and Padmi, 2018). The fixed carbon in the Jamika Subdistrict is 4.05%, in Kopo Subdistrict 2.41%, and in Babakan Tarogong Subdistrict 3.81%. These values are relatively low compared to the fixed carbon from waste at Bakri Landfill Malaysia which is 6.0% (Kalanatarifard et al., 2012). This indicates that the waste from three subdistricts in the study area has very small energy potential in the form of charcoal. The fixed carbon content means that the lesser the content of carbon that is difficult to decompose in the waste after some burning, the smaller the energy potential in the form of charcoal (Damanhuri and Padmi, 2018).

In this study, an ultimate analysis of waste characteristics was also conducted in 3 (three subdistricts), which can be seen in table 3 and figure 4. Ultimate analysis is an important aspect in the application of theoretical combustion calculations and Heating Value (Akdag et al., 2016 in Khuriati et al., 2017) consisting of Carbon, Hydrogen, Oxygen, Nitrogen, Sulfide, and Chloride. The concentrations of carbon, hydrogen, and oxygen are useful for predicting calorific value (Saidur et al., 2011 in Bounanchar et al., 2018).

Table 3. The results of the ultimate analysis of waste characteristics in 3 Subdistrict of Bojongloa Kaler District

No	Paramater	Unit	Analysis Results		
			Kopo	Babakan Tarogong	Jamika
1.	Carbon	% BK	47,56	52,29	48,59
2.	Hydrogen	% BK	8,29	6,51	8,22
3.	Oxyigen	% BK	21,46	25,44	32,12
4.	Nitrogen	% BK	0,49	2,25	0,51
5.	Sulfida	% BK	0,28	0,21	0,05
6.	Chlorida	% BK	0,69	0,11	0,71

The highest carbon levels observed were 52.29% in Babakan Tarogong subdistrict, with the largest oxygen recorded at 32.12% in Jamika Subdistrict. The highest hydrogen was 8.29% in Kopo subdistrict, the highest nitrogen at 2.25% in Babakan Tarogong Subdistrict, the largest sulfide at 0.28% in Kopo Subdistrict, and the largest chloride at 0.71% in Jamika Subdistrict. The research by Khuriati et al., 2017 has ultimate analysis values that are almost close to the values of this study, including a carbon value of 54%, an oxygen value of 32.05%, a hydrogen value of 6.72-8.25%, and a nitrogen value of 0.33-2.33%. This indicates that the characteristics of waste in the study location of Bandung City have similar characteristics to the waste characteristics in Semarang City based on the research by Khuriati et al., 2017. Sulfur analysis results are also present but in small quantities. The combustion of sulfur will produce SO_2 gas. SO_2 and NOx will contribute to the growth of photochemical smog, increase the greenhouse effect, and deplete ozone in the stratosphere (Akdag et al., 2016, Tang et al., 2012 in Khuriati et al., 2017). SO_2 has also been proven to effectively inhibit the formation of PCDD/F (Aurell et al., 2009 in Khuriati et al., 2017). The small amounts of nitrogen and sulfur will ensure reduced emissions during combustion. The high carbon amount indicates a sufficient heating value for energy generation (Vairam and Ramesh, 2013 in Ibikunlea RA et al., 2019). An increase of about 1% in carbon and nitrogen will enhance the calorific value by 79.08% and 10.83% respectively, while a 1% increase in hydrogen and nitrogen decreases the calorific value by 30.2% and 619.1% respectively (Ibikunlea RA et al., 2019).

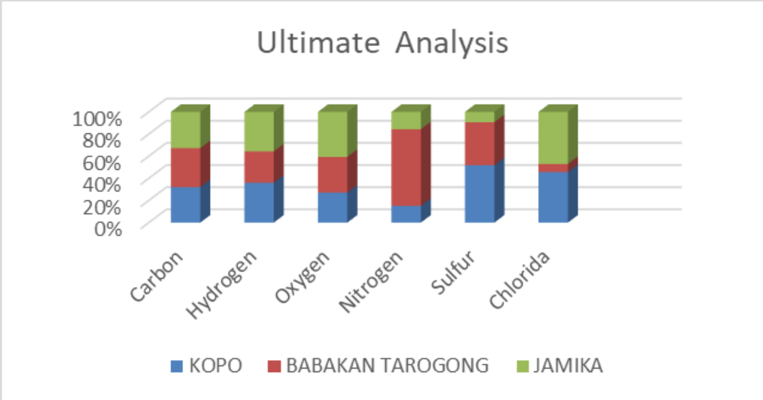

Figure 4. Analysis chart of the Ultimate characteristics of waste in 3 Subdistrict.

Based on the table of proximate and ultimate analysis results from Jamika subdistrict., which can be seen in Table 2 and Table 3, the empirical formula/chemical composition of the waste sample from the study area can be determined as follows.

A sample of waste weighing 100 grams is assumed.
Mass of each element:

- Carbon: 48,59 gram
- Hydrogen: 8,22 gram
- Oxygen: 32,12 gram
- Nitrogen: 0,51 gram

The number of moles of each element:

- Carbon: 48,59 g / 12 g/mol = 4,05 mol
- Hydrogen: 8,22 / 1 g/mol = 8,22 mol
- Oxygen: 32,12 g / 16 g/mol = 2,01 mol
- Nitrogen: 0,51 g / 14 g/mol = 0,04 mol

Mole comparison (divide all mole values by the smallest mole value):

- Carbon: 4,05 mol / 0,04 mol = 101,25 ≈ 101
- Hidrogen: 8,22 mol / 0,04 mol = 205,5 ≈ 206
- Oxygen: 2,01 mol / 0,04 mol = 50,25 ≈ 50
- Nitrogen: 0,04 mol / 0,04 mol = 1

Therefore, the empirical formula of the samples from the Jamika village based on the laboratory results is $\mathbf{C_{101}H_{206}O_{50}N}$.

Based on the table of proximate and ultimate analysis results of Babakan Tarogong subdistrict above, the empirical formula/chemical composition of the waste sample from the study area can be determined as follows.

A sample of waste weighing 100 grams is assumed.
Mass of each element:

- Carbon: 52,29 gram
- Hydrogen: 6,51 gram
- Oxygen 25,44 gram
- Nitrogen: 2,25 gram

The number of moles of each element:

- Carbon: 52,29 g / 12 g/mol = 4,36 mol
- Hydrogen: 6,51 / 1 g/mol = 6,51 mol
- Oxygen: 25,44 g / 16 g/mol = 1,59 mol
- Nitrogen: 2,25 g / 14 g/mol = 0,16 mol

Mole comparison (divide all mole values by the smallest mole value):
- Carbon: 4,36 mol / 0,16 mol = 27,25 ≈ 27
- Hydrogen: 6,51 mol / 0,16 mol = 40,69 ≈ 41
- Oxygen: 1,59 mol / 0,16 mol = 9,94 ≈ 10
- Nitrogen: 0,16 mol / 0,16 mol = 1

Thus, the empirical formula from the samples of Babakan Tarogong subdistrict based on the lab results is $\mathbf{C_{27}H_{41}O_{10}N}$.

Based on the table of proximate and ultimate analysis results of Kopo subdistrict above, the empirical formula/chemical composition of the waste sample in the study area can be determined as follows.

A sample of waste weighing 100 grams is assumed.
Mass of each element:
- Carbon: 47,56 gram
- Hydrogen: 8,29 gram
- Oxygen: 21,46 gram
- Nitrogen: 0,49 gram

The number of moles of each element:
- Karbon: 47,56 g / 12 g/mol = 3,96 mol
- Hydrogen: 8,29 / 1 g/mol = 8,29 mol
- Oxygen: 21,46 g / 16 g/mol = 1,34 mol
- Nitrogen: 0,49 g / 14 g/mol = 0,04 mol

Mole comparison (divide all mole values by the smallest mole value):
- Carbon: 3,96 mol / 0,04 mol = 99
- Hydrogen: 8,29 mol / 0,04 mol = 207,25 ≈ 207
- Oxygen: 1,34 mol / 0,04 mol = 33,5 ≈ 34
- Nitrogen: 0,04 mol / 0,04 mol = 1

Therefore, the empirical formula from the samples of Kopo Subdistrict based on the lab results is $\mathbf{C_{99}H_{207}O_{34}N}$.

Municipal Solid Waste in Indonesia has a high water content, a high amount of carbon and hydrogen, and a high organic matter content. Water content is the main factor affecting heat. The carbon and hydrogen content in MSW in Indonesia is higher than that of Shenzhen and Taiwan, indicating that Indonesia has good potential for Waste To Energy (WtE) (Zhen et al., 2019). The MSW fraction must undergo pre-treatment before being used for energy production, to reduce the effects of moisture content, hydrogen, and nitrogen elements, which can decrease heating value efficiency (Ibikunlea RA., et al, 2019).

IV. Conclusion

1. The results of the waste generation measurements in Kopo, Jamika, and Babakan Tarogong based on weight units are 0.2 kg/person/day, 0.3 kg/person/day, and 0.3 kg/person/day respectively, while the waste generation in volume units is 1.7 liters/person/day, 1.9 liters/person/day, and 3 liters/person/day. The waste generation in these 3 subdistricts is below the average waste generation according to SNI 8632:2018 and SIPSN Bandung City 2024.
2. The composition of waste in the Kopo, Jamika, and Babakan Tarogong subdistricts is dominated by organic waste (kitchen waste). The composition of kitchen waste in the Jamika, Babakan Tarogong, and Kopo subdistricts is 49.26%, 45.07%, and 44.35% respectively. This is quite similar to the 2024 SIPSN data for the city of Bandung, which is 44.52%.
3. The moisture content in the Jamika subdistrict is 56.56%, Kopo 76.81%, and Babakan Tarogong 64.85%, indicating that the waste is in a wet or damp condition, which can be influenced by the moisture content of food waste.
4. The results of the analysis of volatile content in Jamika subdistricts are 64.33%, Kopo subdistricts 31.27%, and Babakan Tarogong subdistricts 40.30%, indicating potential for waste processing using composting methods. This shows that the MSW content is relatively more organic.
5. The analysis results of the ash content in Jamika subdistricts amounted to 16.06% dry weight, Kopo subdistricts 7.84%, and Babakan Tarogong subdistricts 14.06% indicate the inorganic content in the waste samples.
6. The fixed carbon in Jamika subdistricts is 4.05%, in Kopo subdistricts is 2.41%, and in Babakan Tarogong subdistricts is 3.81%. This indicates that the waste from the 3 (three) subdistricts of the study location has a very small energy potential in the form of charcoal.

7. The highest carbon level observed is 52.29% in Babakan Tarogong Subdistrict**,** the high carbon amount indicates a sufficient heating value for energy generation

Daftar Pustaka

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