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Investigation on Municipal Solid Waste Composition and Feasible Energy Potential in Mandalay City, Myanmar

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Content

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Abstract

Municipal solid waste (MSW) is one of the global environmental issue. In least developing country, information of waste composition is difficult to obtain due to resources and knowledge limitation. However, this data is necessary to plan policy and action on waste management, particularly on waste to energy aspect. The aim of this study is to investigate the current Municipal solid waste (MSW) composition of Mandalay municipality and estimate the energy potential. Waste sampling was performed in 2019 over two transfer stations, Kyar Ni Kan (Northern transfer point) and Pyi Gyi Tagon (Southern transfer point). Manual sorting was used for classifying waste categories followed the IPCC guideline. Questionnaire survey was also used in this study to investigate the current waste management system. It was suggested that there is a need that government support budget for waste management activities and encourage local people to organize community groups and volunteer to join waste management activities. It is noted that the category of garden waste represented the highest fraction in both stations of 45% in average while plastic, food waste, and textile were 15%,14% and 11% respectively. Small parts of wood, rubber and leather, paper, nappies, metal, glass, etc. were also in waste composition. Based on this composition, the annual energy potential of Mandalay Municipality was in the range 13MW to 60MW by assuming power plant efficiency of 15% - 30% with 300 days for working days and the other days for maintenance days in one year.

Key words: Physical waste composition, municipal solid waste, energy potential, Mandalay city

မန္တလေးစည်ပင်သာယာနယ်နိမိတ်အတွင်းရှိ နေအိမ်သုံးအစိုင်အခဲစွန့်ပစ်ပစ္စည်းများ တွင်ပါဝင်သော ပါဝင်မှုအမျိုးအစားများကို လေ့လာခြင်းနှင့် ၎င်းမှထွက်ရှိနိုင်သည့် စွမ်းအင်ပမာဏအားခန့်မှန်းတွက်ချက်ခြင်း

ထက်သီရိ၊ ဦးစီးအရာရှိ
ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဦးစီးဌာန

စာတမ်းအကျဉ်း

နေအိမ်သုံးအစိုင်အခဲစွန့်ပစ်ပစ္စည်းများ (MSW)ကို စနစ်တကျစွန့်ပစ်ခြင်း နည်းစနစ် မရှိသောကြောင့် ၎င်းနှင့် သက်ဆိုင်သည့် ပြဿနာများကို ကမ္ဘာတစ်ဝှမ်းတွင် သဘာဝ ပတ်ဝန်းကျင်ဆိုင်ရာ ပြဿနာ တစ်ခုအဖြစ် ရင်ဆိုင်ကြုံတွေ့နေရပါသည်။ ဖွံ့ဖြိုးဆဲနိုင်ငံများ တွင် သတင်း အချက်အလက် ဖြန့်ဝေသည့် အရင်းအမြစ်များအားနည်းခြင်း၊ စွန့်ပစ်ပစ္စည်းများ ကို စနစ် တကျစွန့်ပစ်သည့် နည်းစနစ် အားနည်းခြင်းတို့ကြောင့် အစိုင်အခဲစွန့်ပစ်ပစ္စည်းနှင့် သက်ဆိုင်သည့် သတင်းအချက်အလက်များကို ရရှိရန် ခက်ခဲသည်။ သို့ရာတွင်စွန့်ပစ် ပစ္စည်း စီမံခန့်ခွဲမှုနှင့် ပတ်သက်၍ အထူးသဖြင့်စွမ်းအင်ပြန်လည်ထုတ်ယူနိုင်သည့် စွန့်ပစ်ပစ္စည်း ဆိုင်ရာစီမံခန့်ခွဲမှု အတွက်မူဝါဒနှင့် လုပ်ဆောင်ရန် အချက်အလက်များ လိုအပ်ပါသည်။ ယခု လေ့လာမှု၏ ရည်ရွယ်ချက်မှာ မန္တလေးစည်ပင်သာယာနယ်နမိတ်အတွင်းရှိ လက်ရှိ အစိုင် အခဲ စွန့်ပစ် ပစ္စည်း များ၏ ပါဝင်မှုအမျိုးအစားများ(MSW) ကိုလေ့လာရန်နှင့် ၎င်းမှထွက်ရှိနိုင်သည့် စွမ်းအင် ပမာဏ အလားအလာကို ခန့်မှန်းရန်ဖြစ်သည်။ ပါဝင်မှုအမျိုးအစားသိရှိနိုင်ရန်အတွက် စွန့်ပစ်ပစ္စည်း နမူနာ ကောက်ယူခြင်းကို ၂၀၁၁ ခုနှစ်တွင် စွန့်ပစ်ပစ္စည်းလွှဲပြောင်း နေရာ နှစ်ခု ဖြစ်သော ကြာနီကန်(မြောက်ပိုင်း ပို့ဆောင်ရေးစခန်း) နှင့်ပြည်ကြီးတံခွန် (တောင်ပိုင်း ပို့ဆောင် ရာနေရာ) တွင် ပြုလုပ် ခဲ့သည်။ စွန့်ပစ်ပစ္စည်း အမျိုးအစားများကို ခွဲခြား သတ်မှတ်ရာတွင် ပါဝင်မှု အမျိုး အစား ခွဲခြင်းကို IPCC လမ်းညွှန်ချက် အတိုင်းလိုက်နာ ဆောင်ရွက်ခဲ့ပါသည်။ ထို့အပြင် မန္တလေးစည်ပင်၏ လက်ရှိစွန့်ပစ်ပစ္စည်း စီမံခန့်ခွဲမှုစနစ် အားစုံစမ်းစစ်ဆေးရန် မေးခွန်း လွှာ စစ်တမ်းကိုလည်း ဤလေ့လာမှု တွင် အသုံးပြုခဲ့ပါသည်။ လေ့လာမှုအရ စွန့်ပစ် ပစ္စည်း စီမံခန့်ခွဲမှုလုပ်ငန်းများအတွက် ရင်းနှီး မြှုပ်နှံမှုများ ပိုမိုဆောင် ရွက်ရန်နှင့် ဒေသခံ လူထု အားစုစည်းပြီး စွန့်ပစ်ပစ္စည်း စီမံခန့်ခွဲမှု လုပ်ငန်း များတွင်တက်ကြွစွာ ပူးပေါင်းပါဝင်ကြရန် လိုအပ်ကြောင်းအကြံပြုခဲ့သည်။ စွန့်ပစ်ပစ္စည်း လွှဲပြောင်း နေရာနှစ်ခုတွင် နမူနာ စာရင်း

ကောက်ခြင်း ရလဒ်များအရပျမ်းမျှအားဖြင့် ၄၅%ရှိသည့် အိမ်ခြံဝန်းဥယျာဉ်မှ ထွက်သော စွန့်ပစ်ပစ္စည်း အမျိုးအစားသည် အမြင့်ဆုံး ပါဝင်မှု ရှိပြီး ပလတ်စတစ်၊ အစားအစာနှင့် ချည်ထည် စွန့်ပစ်ပစ္စည်းများသည် ၁၅%[iii] ...။ သစ်သား၊ ရော်ဘာ နှင့်သားရေ၊ စက္ကူ၊ Nappies၊ ... ပါဝင်မှုသာရှိသည်။ ဤပါဝင်မှုအမျိုးအစားအပေါ် အခြေခံ၍ မန္တလေး စည်ပင်သာယာနယ်နမိတ်အတွင်းရှိ စွန့်ပစ် အစိုင်အခဲပစ္စည်းများမှ နှစ်စဉ် ထွက်ရှိနိုင်သည့် စွမ်းအင် ပမာဏမှာ တစ်နှစ်အတွင်း လုပ်ငန်း လည်ပတ်ရက် ၃၀၀ ရက် (ကျန်ရက်များအား ပြုပြင်ထိန်း သိမ်းရန် နေ့ရက် များဟုယူဆ) နှင့် စက်လည်ပတ်အား ၁၅% မှ ၃၀% ထိ ဟုယူဆချက်အရ ၁၃ မဂ္ဂါဝပ်မှ ၆၀ မဂ္ဂါဝပ်အထိထွက်ရှိ နိုင်စွမ်းရှိသည်။

Investigation on Municipal Solid Waste Composition and Feasible Energy Potential in Mandalay City, Myanmar

1. Introduction

Waste is the most visible environmental problem not only for the developing countries but also for developed countries. The global solid waste volume was estimated to be about 2.01 billion tons in 2016, and global per capita solid waste generation was approximately 0.74 kg per day [1]. Together with the large solid waste generation, a huge amount of natural resources were consumed every year [2]. Furthermore, the impacts of improper disposed waste affect to (i) the contamination of surface and groundwater through leachate; (ii) soil contamination through direct waste contact or leachate; (iii) air pollution through burning of wastes; (iv) spreading of diseases by different vectors like birds, insects, and rodents; (v) odor in landfills, and (vi) uncontrolled release of methane by anaerobic decomposition of waste [3]. Increasing population, changing consumption patterns, economic development, urbanization, industrialization and rising community living standard are resulted in the increasing generation of solid waste and with a diversification of the types of solid waste generated [4].

In Mandalay, the existing method for disposing waste is landfill system which is not properly engineered and managed. Consequently, the solid waste management system (SWMS) needs to be updated to suit the waste quality, quantity and composition [4]. Therefore, the composition of waste materials is of fundamental importance for many reasons, including the need to estimate material recovery potential, to identify sources of component generation, to facilitate design of processing equipment, to estimate physical, chemical, and thermal properties of the waste. Moreover, it will be the first step to implement a waste management plan as a consequence for energy potential.

According to the Myanmar Energy Master Plan [7], current energy use in Myanmar mostly relies on hydropower, gas, coal, petroleum product and biomass. Energy demand is growing year by year with increasing population and urbanization. However, there was no practice for waste to energy because of capital investment, weak of scientific data and technology. For a modern waste management system, energy recovery from waste is one of the essential parts [8, 9]. Recycling, landfill, mechanical biological treatment and incineration are common methods used for municipal solid waste (MSW) treatment. Among them, a widely applied treatment operation is incineration. It is thermal treatment process to recover the energy content from residual waste.

So, the objectives of this study are to investigate current waste composition of Mandalay city and to estimate its energy potential.

2. Objectives

To investigate current waste composition of Mandalay municipality

To estimate energy potential of waste and its suitability for incineration

3. Materials and Methods

3.1 Location and Sample

The present study is based on the MSW of Mandalay Municipal area. Administratively, it is comprised of 6 townships namely, Aung Myay Tharzan, Chan Aye Tharzan, Mahar Aung Myay, Chan Maya Tharsi, Pyigyi Tagon and Amarapura. The first 3 townships are included in the Northern part and the others are in the Southern part as Mandalay Municipal area is further subdivided into two parts. Therefore, all collected waste from the Northern parts go to Northern disposal site (Kyar Ni Kan) and the others go to Southern disposal site (Taung inn-Myauk inn). It has also two secondary collection points for each. The daily waste collection system was practice and all the municipal solid waste are disposed of first in these two secondary points and finally disposed to the dumping site Figure 1.

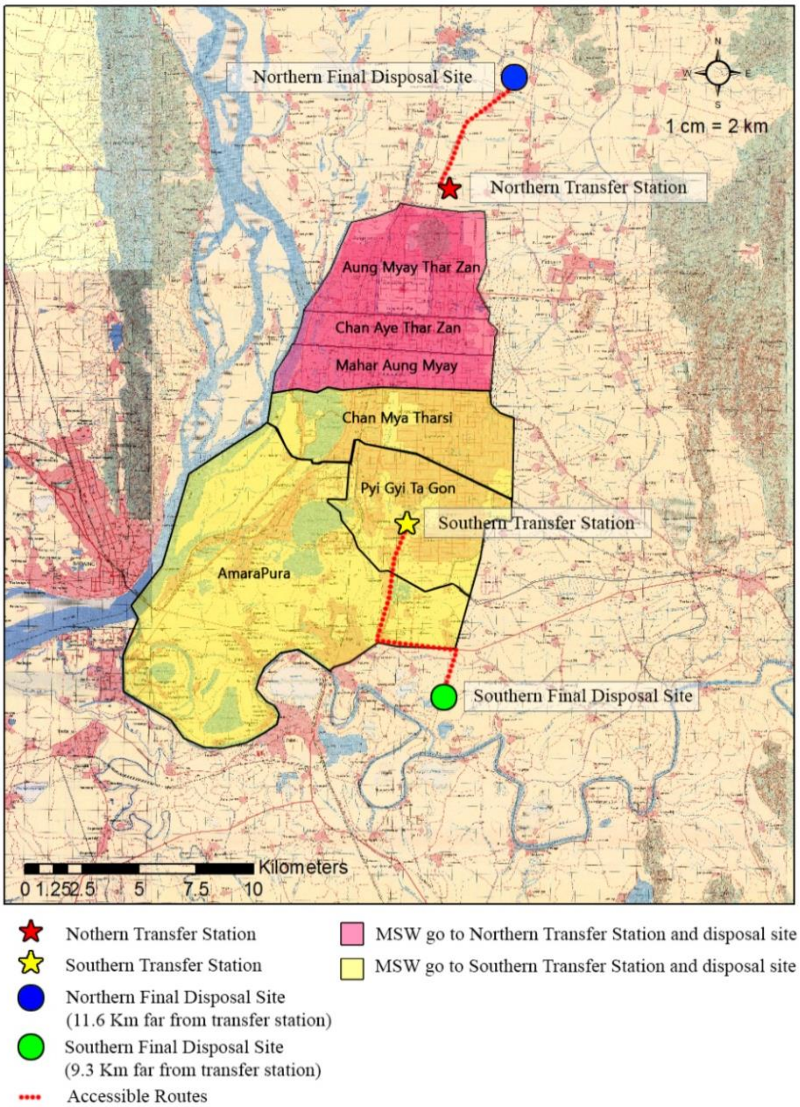


Figure 1. Location map of the study area

3.2 Waste composition Analysis

Waste component analysis was followed by the American Society for Testing and Materials standard (ASTM), D 5231. A primary sample of solid waste was collected by a collection truck from the street containers around the study area. It was done for 3 days (one weekend days and two weekdays) at two transfer station points where MSW comes from 6 different sources to make sure that the sample represents correctly. Moreover, it was considered a day with stable weather settings during the spring season. According to the ASTM, the quartering method was applied in the sampling process. The sample was divided into four sub-samples by the aid of the machine and removes two opposite sides and mixed the remaining parts thoroughly to represent the waste originally gathered. Repeat this sequence until the subsample (91 to 136 kg) was reached. After that, it was manually sorted to estimate waste composition while the representative samples of waste components were shipped to the laboratory for checking moisture content density by following ASTM D 3173. There are 11 categories for manual sorting by following IPCC guidelines [13].

3.3 Estimation of Energy potential of MSW for Mandalay City

The method applied for energy potential calculation was referred to relevant available literatures and previous researches. The knowledge of the calorific value of MSW is important when it is used to design MSW incinerators for energy recovery purposes [16]. Therefore, determination of the heating value of MSW samples was done by using lowest and highest value. In addition, it was calculated by using IPCC default value. Table 1. provides literature values for calorific values with dry basis.

Table 1. literature values for calorific values

References	Country	Calorific values (KJ/kg dry weight)						
		Biodegradable waste				Non-Biodegradable waste		
		food waste	garden waste	paper&cardboard waste	fwood waste	plastic waste	rubber &leather waste	textile waste
S.N.M. Menikpura et al. (2007)	Srilankan	18,400	15,800	15,000	14,200	33,300	23,000	17,000
K.Dimitrios et al. (2011)	Greece	20,933	17208	15,931		39350		
T. Rand et al. (2000)	World bank	17,000		16,000	17,000	33,000	23,000	20,000
F.F Carlos et al. (2008)	spain			16024 ± 194		32037 ± 397		23160 ± 185
IPCC guideline		11,600				1,000		

Samples were analysed for dry weight followed equation, Then the Energy Potential (EP) was analysed by following the equation [21]

$$\text{Dry weight} = \text{wet weight} - (\text{wet weight x Percentage of Moisture content})$$

$$\boldsymbol{EP_{msw}} = \boldsymbol{W_{msw}} \text{ x } \boldsymbol{CV_{msw}} \text{ x } 3.6 \tag{10}$$

where EP_{msw} is the energy potential from MSW, W_{msw} (kg) is the weight of MSW, CV_{msw} is the net Calorific value of the MSW (MJ/kg). Converting ratio (1 kWh = 3.6 MJ) (Anshar et al., 2014)

3.4 Questionnaire

During the investigation, 126 people were interviewed from 6 townships, these are the same of 6 different sources which is making for waste composition analysis in transfer stations. For local community interview, random sampling method was use and number of households was selected proportionally depending on the population and total number of households. The respondents were asked about demographic information (age, religion, marital status, education, occupation, etc.), and their awareness in deal with waste management system and their opinion on current city waste management system. Questionnaire composes close-ended, open-ended and semi-structured questions. In order to obtain the general information, interview of local community leader was performed before. Questionnaires were completed face to face interviews according to the suggestions of the quarter head.

4. Results and discussion

The study results are presented in the following order: 1- Physical component of current waste composition, 2- Possible Energy potential for the year 2018 and 3- Point of view from local community to current waste management system.

4.1 Municipal solid waste composition (physical component)

Table 2. describes the solid waste composition of Mandalay municipal area which includes 6 townships and can be seen in Figure 2. The results show that the solid waste composition in the dumpsite was mainly consisted of garden waste, second is food waste and plastic materials. Small fractions of textiles, wood, rubber and leather, paper, nappies, metal, glass, etc. are also contained in the waste. Furthermore, the hazardous waste components in the dumpsite could not be detected based on this classification. According to the result, a high fraction of garden waste can be found in all communities. Similarly, the other studies in 2012, 2014 and 2015 showed the results with the highest component of garden waste as well [22]. This is due to the largest amount of waste comes from leaves, vegetable markets, small branches and flowers. The reason is the culture and habitat of local people as some vegetables were wrapped with leaves for refreshing and sometimes used for food packaging. In addition, 80% of people in the city believe in Buddha and offered flowers for Buddha. The Northern site received a little higher percentage of food waste, than the Southern site because some households from southern part recover a significant percentage of this waste for animal food. In additions textile waste fraction is significantly higher in Northern site rather than the southern site. The possible explanation for that difference can be in terms of high socio-economic status in Northern site can afford to throw away more textiles than the Southern site. As in opposite garden waste, wood, paper and cardboard waste is a little high percentage in Southern site. For the others, rubber and leather, nappies, glass, metal and other wastes are not significantly difference between these two sites.

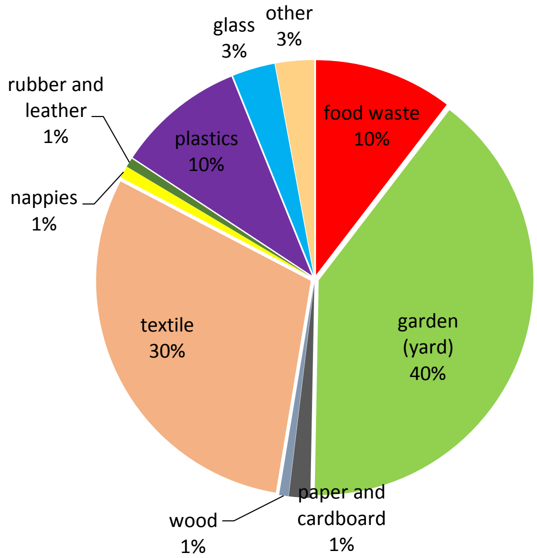
Plastic waste is one of the recyclable materials and it contains a high percentage in waste of fraction. Another well-recycle materials are papers and often do not enter the dumping site because of the scavengers collected on the site. A significant amount of paper came from used tissues as these are very common in restaurants but also home. Rubbers in the dumping site were in the form of motorcycle tyres and fewer car/truck tyres. Only a tiny amount of other materials like construction waste and electronic waste were enter the waste stream.

According to the result of the study, the highest contamination of garden waste means success for composting in the future. The high plastic materials in dumpsite is possible to be recycled as RDF. Moreover, recycling activities for paper and other recyclable plastic are carried out in Mandalay city mostly by the informal sector, which includes scavengers, waste collectors, and waste dealers. These scavengers and waste collectors collect recyclable materials such as newspapers, metal, plastic bottles, tin and glass from households, communal depots, streets, commercial areas and final disposal sites and in turn sell these items to waste dealers who subsequently clean, sort, store and sell them in bulk to the recycling industry both locally and for export.

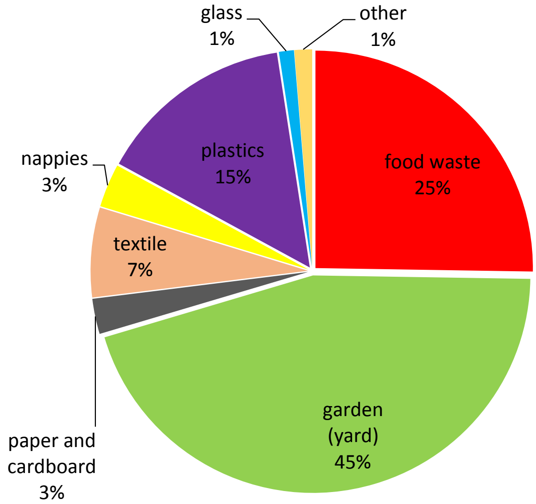
Table 2. Current Solid waste compositions for Mandalay municipal area

Waste composition	Northern transfer point waste composition in average (%)	Southern transfer point waste composition in average (%)	Average waste Composition of Mandalay City (%)
Food waste	18	13	14 ± 6.43
Garden (yard)	42	47	45 ± 4.66
Paper and cardboard	2	5	4 ± 1.38
Wood	1	5	3 ± 2.49
Textile	18	6	11 ± 11.08
nappies	2	1	2 ± 1.07
Rubber and leather	1	1	1 ± 0.60
Plastic	12	18	15 ± 3.13
Metal	0	1	2 ± 0.79
Glass	2	2	2 ± 1.21
Others	2	1	1 ± 1.13

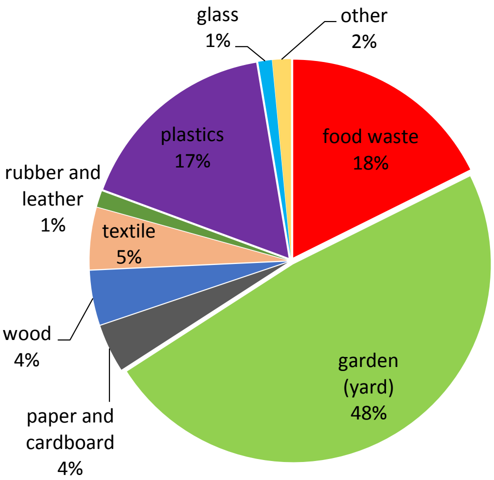
Waste Composition for sample -1 (Northern site at weekend days)



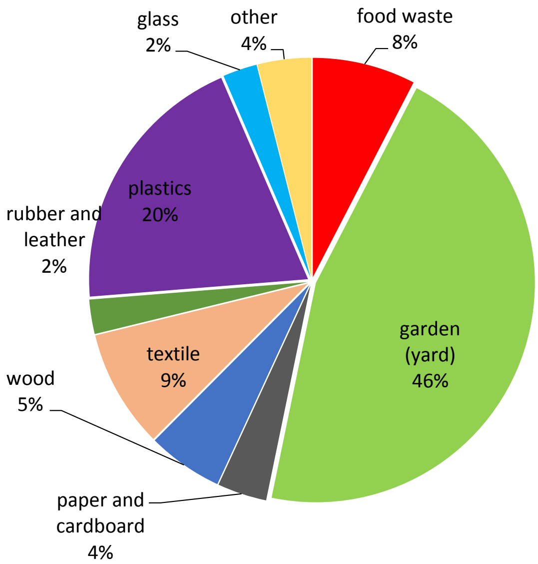
Waste Composition for sample -2 (Northern site at weekend days)

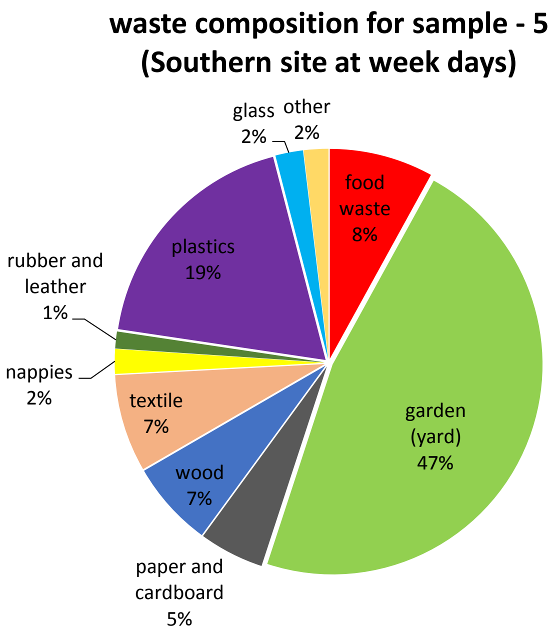


waste composition for sample -3 (Southern site at weekend days)



waste composition for sample -4 (Southern site at weekend days)





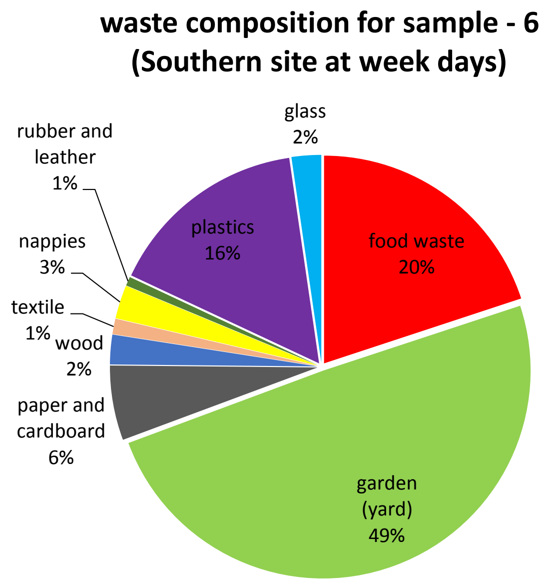


Figure 2. Current Waste composition of Mandalay for 6 samplings

Similar results are showed for waste composition analysis in 6 samplings. This is because of the same region, economic development, weak of suitable waste infrastructure and ineffective separate collection systems.

4.2 Moisture content of waste and its potential energy

With the use of oven, at constant temperature of 105°C, moisture content of 43% was determined. However, it is not the good way to use the same moisture content for all components in calculation. Therefore, IPCC default dry matter content was used to extrapolate the dry weights of total municipal solid waste in this research.

Dry weight of total Municipal solid waste was found, and this value was used for energy potential calculation by using highest and lowest calorific value on dry basic and IPCC net calorific value as in Table 3 and 4.

Table 3. Energy Potential Result by using lowest CV and highest CV

Type of waste	Dry weight (kg)	Lowest CV (Mj/kg)	Energy potential by using lowest CV (Mj/yr)	highest CV(Mj/kg)	Energy potential by using highest CV(Mj/yr)
Food waste	21646.912	17	367997504.00	20.933	453134808.90
Garden (yard)	69579.36	15.8	1099353888.00	17.208	1197321626.88
Paper and cardboard	13915.872	15	208738080.00	16.218	225687612.10
Wood	9857.076	14.2	139970479.20	17.000	167570292.00
Textile	34016.57	17	578281792.00	23.345	794116966.72
Rubber and leather	3247.036	23	74681846.40	23.000	74681846.40
Plastic	57982.80	31.64	1834575792.00	39.350	2281623180.00
Total			4,303,599,381.60		5,194,136,332.99

Table 4. Energy Potential Result by using IPCC guideline calorific value

Type of waste	Dry weight (kg)	IPCC guideline calorific value (Mj/Gg)	Energy of MSW (Mj/yr)
Bio-degradable waste	114999220.00	10000000	1149992200.00
Non-biodegradable waste	95246412.80	11600000	1104858388.48
Total	210245632.80		2254850588.48

Energy Potential results from Table 3 and 4 were calculated for 100% efficiency but as in real there was no incineration plant or energy plant with 100% output. So, it was assumed power plant efficiency ranging from 15-30% with 300 days for working days and the other days for maintenance days in one year as shown result in Table-5.

Table 5. Energy efficiency Possibility

Energy potential based on lowest CV(MW)		Energy potential based on highest CV(MW)		Energy potential based on IPCC CV(MW)	
15%	30%	15%	30%	15%	30%
25	50	30	60	13	26

According to the results, if the power plant efficiency is 15% it will have the range between 13MW and 30MW. On the other hand, Energy efficiency will range from 26MW to 60MW if the efficiency is very good with the new modern Technology.

4.3 View of waste Management system from Local people

There are 6 regions included within Mandalay Municipal area where community faced some problems in waste collection stage. Firstly, most of the collecting points are far from their house and 80% of household have to dispose their waste when the collecting trucks come. In this regard, due to the narrow street and alley, collection truck cannot go through the confined area. Secondly, collection services are irregular in some area because of insufficient collective vehicles. Then, acting schedule is not appropriate for their lifestyle. In addition, local communities are suffered from the unbalance between the tax they have paid and the services they have received. Some suggestions were raised to improve waste management system to easily reach the responsible organization. Another problem is collective vehicles are not secured and modernized as in consequences uncovered collective can caused bad smells (most of problems causing during bad weather conditions). Moreover, Local people are less experience in solid waste management and some people don't understand even 3R (Reduce, Reuse, Recycle). On the other sides from political point of view, sometimes cultural factors influencing the selection of appropriate management system. Furthermore, there is lack of knowledge and technology to follow up with solid waste management system (Eg- separation, recycling, etc...)

5. Conclusion

There were almost 1.8 million people lived in Mandalay Municipal area and the total Municipal solid waste generated by the municipalities of Mandalay is 1059 tons per day with high components of garden waste. The possible energy potential of Mandalay Municipality was found to be ranging from 13 MW to 60 MW. There are many ways to convert solid waste to energy for example incineration, sanitary landfill, pyrolysis, anaerobic digestions and other types. It is interesting to look into waste to energy as well as composting because there are higher percentages of green waste. These options not only produce energy but also can reduce global warming potential alternatively. Our result suggested that to improve waste management in term of waste to energy, raising local awareness on waste management activity, including create community network voluntary basis to join the climate action are essential. The last but not least is to support more budget on waste management activity.

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