PHYSICAL COMPOSITIONS AND CHARACTERISTICS OF MUNICIPAL SOLID WASTE: A CASE STUDY OF IMPHAL CITY, MANIPUR

Wangkhem Chaoton Meetei[*], Saikhom Suma[*], Lairenmayum Surajkumar Singh[**]

[*] Dhanamanjuri University, Dhanamanjuri College of Science (D.M. College of Science), Department of Environmental Science, Imphal, Manipur, India
[**] Kha Manipur College, Department of Zoology, Kakching, Manipur, India

corresponding author: Wangkhem Chaoton Meetei, email: wcm01051974@gmail.com

Professional paper
Received: March 11th, 2024
Accepted: July 11th, 2024
HAE-2425
https://doi.org/10.33765/thate.15.2.4

ABSTRACT

Municipal solid waste management (MSWM) is becoming one of the most challenging tasks for today's policy makers, environmental scientists, sanitation engineers, and many others working on it. Understanding the physical compositions and characteristics of municipal solid waste (MSW) is one of the keys to successful waste management, as the data obtained will provide management options that help develop an effective management strategy. The objectives of the study are to determine the physical compositions and characteristics of MSW of the city of Imphal and to offer management options for a successful waste management. The MSW generated in the main market of Imphal City is temporarily dumped on any available free space in and around the crowded market before being transported to a permanent dumpsite. Waste samples were collected from these temporary dumpsites during two seasons, i.e. summer and winter, and the components were observed according to their physical appearance and grouped into three important categories. The results showed that the percentage of organic biodegradable waste was the highest for both observed seasons. The high content of organic waste requires frequent collection and removal. There is a need for a segregation facility to explore the potential of MSW recovery and recycling along with a composting plant that is currently operating to manage MSW in the study area in a sustainable manner.

***Keywords*:** *physical compositions, municipal solid waste, transfer station, segregation facility, Imphal City*

INTRODUCTION

Solid waste is defined as the waste generated by human and animal activities that is otherwise solid and is discarded as useless or unwanted [1]. It can be categorized according to where the waste is generated, for example as municipal solid waste, health waste and e-waste [2]. Municipal solid waste includes commercial and residential waste generated in a municipal or notified area in solid or semi-solid form, excluding industrial hazardous

wastes, but including treated biomedical waste [3]. It includes wastes such as durable goods, non-durable goods, containers and packaging, food waste, yard wastes, and various inorganic waste from residential, commercial, institutional, and industrial sources [4].

Since the beginning, human beings have been generating waste, but the generation of waste increases with the progress of civilization and becomes more complex in nature [5]. The management of solid waste has become a major cause of concern in recent years in both developed and developing countries [6]. The collection and disposal of MSW is one of the major problems of urban environment in most countries of the world today [7]. With the increase in urban population, changing lifestyle and eating habits, the amount of waste has been increasing on a yearly basis, which poses a challenge for the authorities to manage it properly. This problem is one of the primary urban environmental problems [8]. MSWM, a largely urban phenomenon, is undoubtedly an important issue of global concern today that attracts the attention of engineers, activists, academics, researchers, students and citizens interested in and working on the environment. Disposal of waste in an eco-friendly and sustainable way is a big problem even in small towns nowadays [9]. At both the policy and practical levels, urban local bodies (ULBs) are crucial in developing and implementing waste management strategies in cities to achieve the sustainable development goals (SDGs) [10]. Solid waste management is one of the essential services for environmental protection, public health protection and productivity improvement. For a clean and sustainable country, proper management of solid waste is very important [11]. Research conducted by Carmen-Niño et al [12] in Mexico also showed that MSWM is a complex topic, with multiple operational, environmental, social, cultural, legal, institutional and economic aspects that need to be considered for the system to work. The implementation of waste hierarchy (WH) concepts in solid waste management (SWM) can be observed to some extent in most countries of the Global North, with many countries of the Global South predominantly applying the concept of reuse and other aspects of the WH to varying extents. Some countries have successfully achieved zero waste, zero landfill, and other sustainable SWM strategies; they can, with the appropriate policy, funding, infrastructure, and stakeholder awareness, be applied globally. However, at the global level, both Global North and South implementation of the WH leaves much to be desired, given several global and regionally specific SWM challenges [13].

Therefore, solid waste management becomes one of the challenging tasks for today's policy makers, decision makers, environmental scientists and those working in this field. Analysis of the composition of municipal waste is a crucial aspect of waste management, as it provides a database on the types of the waste collected throughout the year, including their quantity and quality [14]. Also, the characterization of the generation of urban solid waste is fundamental for making adequate decision in the strategy of urban solid waste management in the city [15]. As rightly pointed out by Audu et al [16], the importance of understanding waste composition cannot be overemphasized as it is the first step towards sustainable solid waste management. This information is necessary for planning, designing, and establishing appropriate and more sustainable strategies for the collection, transport and final disposal of waste. The waste produced, if not properly managed, will end up on the streets and pose serious health and environmental problems in the area. Information on the characteristics of solid waste is important in assessing the need for alternative equipment, systems, management programs and plans, particularly with regard to the implementation of disposal, resource and energy recovery options. Katiyar et al [17] also pointed out that the characteristics of MSW are the main factor considered as the basis for the design of an efficient, cost-effective, and environmentally friendly waste management system. For effective and successful planning of solid waste management, appropriate quantification and characterization is necessary [18]. Such characterization studies in cities help align waste management strategies, as well as identify links to unused resources. Further, it helps the city to channel

materials back into circular economy loops [19].

The importance of waste composition assessment and characterization can be summarized as follows:

- data generated will provide an estimate of the amount of recyclable and compostable materials,
- it provides knowledge about the physical, chemical and thermal properties of MSW,
- it leads to the knowledge about the potential of MSW recovery,
- it provides data for the creation of a solid waste management plan.

Therefore, understanding the physical compositions and characteristics of MSW is one of the key steps for a successful management of the waste.

MATERIALS AND METHODS

Imphal Municipal Corporation covers an area of 30.75 km^2, has a total population of 277196 (according to 2011 census), and comprises the municipal area in East and West Imphal. It extends between 24° 33′ N to 25° 55′ N latitudes and 93° 42′ E to 94° 7′ E longitudes. There are no large or medium industries in Imphal [20]. Imphal Municipality generated 48 tonnes per day (TPD) of MSW in 2001, which increased to 72 TPD in 2011. The production of MSW per capita also increased from 0.190 kg/day in 2001 to 0.217 kg/day in 2011 [21]. The city records an increase in the amount of MSW by an average of 50 % per day and 14.2 % per capita in a decade.

Following the recommendation of the National Environmental Engineering Research Institute (NEERI) [22], a 100 kg thoroughly mixed sample was made by mixing waste samples collected from ten different locations selected randomly from the temporary disposal sites in and around the main market in Imphal City to obtain a representative sample. The sample was reduced to about 10 kg by the process of repeated mixing and quartering. Then the components were observed according to their physical appearance and grouped into three categories: organic and biodegradable, inorganic and non-biodegradable and inert, and their percentages were calculated after drying. Manual sorting using proper protective equipment (PPEs), such as mask, gloves, goggles was used to classify the collected waste into different types such as plastic, glass, metal, textile, paper etc. The same procedure was conducted for two different seasons, i.e. summer and winter, and the findings were subsequently tabulated and discussed. Necessary recommendations for better management of municipal solid waste in the research area were also given.

RESULTS AND DISCUSSION

More than 92 % of the MSW generated in India is directly disposed of in open landfills in an unsafe and unplanned manner [23]. During the investigation, it was revealed that municipal solid waste was temporarily dumped before being transported to the permanent dumpsite randomly in all available vacant spaces in and around the crowded market without any environmental considerations. Sometimes the waste stayed in those places for more than a week. Such a type of temporary dumping can promote the growth of microorganisms and other disease-causing vectors and can spread many diseases, which can ultimately affect daily life of the city residents. There may also be possibility of release of gas hazardous to health from the temporary disposal site and may cause adverse effects on the surrounding area including accidental fire. The stench from these temporary dumping sites bothers city dwellers and affects their daily lives. People living in and around the main market have been complaining about pollution and bad smell for a long time. If such temporary dumping continues for years, it will not only pollute the soil, but there are chances of polluting the nearby water bodies, and this condition might cause frequent malaria, hepatitis, dysentery, diarrhoea, skin infections etc. in the surrounding community. Therefore, it is

necessary to stop the temporary disposal of MSW in all available free spaces in and around the main market. A transfer station or some public bins at suitable locations in and around the main market can be constructed for temporary storage of MSW before it is transported to a permanent disposal site.

Currently, management of MSW in and around the main market of Imphal City is done by Imphal Municipal Corporation which is ill-equipped to tackle the problem. Lack of dedicated manpower, lack of garbage collection and transport vehicles and acute shortage of funds have made it difficult for the corporation to deal with the problem. In this regard, financial support through adequate funding from state government seems necessary.

The various components present in MSW from two different seasons are shown in Table 1. During summer season, MSW in and around the main market of Imphal City consisted of compostable organic material (46.25 %), paper (12.80 %), textile (4.45 %), plastic (10.10 %), rubber (1.80 %), leather (2.00 %), glass (4.45 %), metal (1.15 %), ceramic (1.10 %), e-waste (3.65 %), fine earth and ash (6.95 %), gravel, stone and pebble (4.25 %) and brick (1.05 %). During winter season, it consisted of compostable organic material (50.15 %), paper (11.80 %), textile (6.80 %), plastic (9.15 %), rubber (1.30 %), leather (1.10 %), glass (3.85 %), metal (1.45 %), ceramic (0.70 %), e-waste (2.55 %), fine earth and ash (5.50 %), gravel, stone and pebble (4.75 %) and brick (0.90 %).

Table 1. Physical composition of MSW of Imphal City during summer and winter 2023

No.	Items	Percentage in dry weight (summer season)	Percentage in dry weight (winter season)
A) Organic and biodegradable			
1.	Paper	12.80	11.80
2.	Textile	4.45	6.80
3.	Compostable organic material (food, fruit, vegetable, animal waste, leaves, grasses, wood etc.)	46.25	50.15
Total		63.50	68.75
B) Inorganic and non-biodegradable			
4.	Plastic	10.10	9.15
5.	Rubber*	1.80	1.30
6.	Leather*	2.00	1.10
7.	Glass	4.45	3.85
8.	Metal	1.15	1.45
9.	Ceramic	1.10	0.70
10.	e-waste	3.65	2.55
Total		24.25	20.10
C) Inert			
11	Fine earth and ash	6.95	5.50
12	Gravel, stone and pebble	4.25	4.75
13	Brick	1.05	0.90
14	Hair	negligible	negligible
Total		12.25	11.15
Grand total		100	100

* they are considered non-biodegradable as they take many years to break down

The results of the research showed that the percentages of paper, plastic, rubber, leather, glass, ceramic, e-waste, fine earth and ash and brick were higher in the summer season compared to the winter season, while the percentages of textile, compostable organic materials, metal and gravel, stone and pebble were higher during the winter season than in the summer season. It was found that the municipal solid waste in and around the main market of Imphal City was highly heterogeneous with a high percentage of organic and biodegradable fraction.

Since the MSW of the research area contains a high percentage of organic and biodegradable fraction, the frequency of collection and removal of MSW must be increased. Moreover, the collection and transportation method used is outdated and needs to be upgraded according to the current trend. Currently, the permanent disposal of MSW of Imphal City is done at permanent landfill at Lamdeng Khunou, Imphal West with an additional solid waste treatment and management facility constructed under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) funded project of the Ministry of Urban Development, Government of India. The plant has already started converting the compostable organic fraction of MSW of the city into organic manure. Non-biodegradable materials are dumped into a large pit near the crushing unit of the plant.

Waste segregation is an important component in the waste management chain because it enables the realization of effective reuse, recycling and recovery (RRR) [24]. It is an essential function in improving waste management. Waste segregation not only facilitates recycling and reduces waste going to landfills, but can benefit our environment and people in various ways [25]. Since there is no proper waste segregation with the current management system, a segregation facility is highly recommended so that the various components of the heterogeneous waste of the study area can be separated, and components such as paper, glass, metals etc. can be recovered and recycled. Hazardous waste, biomedical household waste, e-waste and other harmful waste should also be segregated and disposed of separately. There is a need to adopt a proper scientific method of solid waste disposal in order to minimize public health problems and environmental impacts. It should be noted here that the participation of citizens, policy makers, strategic planners, researchers, and private and municipal agencies is crucial in solving MSWM challenges, such as social, economic, and environmental impacts [26]. Therefore, it is necessary to develop and implement an effective waste management system.

CONCLUSION

A study on the physical compositions and characteristics of MSW in and around main market of Imphal City, Manipur, revealed that the MSW contains a high percentage of biodegradable waste. The percentage of compostable organic materials is the highest among the organic and biodegradable fractions, while the percentages of plastic waste contribute the most among the inorganic and non-biodegradable fractions. A large amount of biodegradable waste requires frequent collection and removal. The waste composting plant at the permanent landfill has already started converting the compostable organic fraction of MSW of the city into organic manure in the amount of 60 TPD. The plant also needs to be upgraded in terms of its capacity since the waste generation rate exceeds the conversion rate. Conversion of compostable organic fraction to manure is currently the best available option, while material recovery and recycling would be preferred option for non-biodegradable and inert fractions after proper and necessary segregation.

REFERENCES

[1] H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental engineering, 1st edition, McGraw-Hill, New York, 1985.

[2] Solid waste, in: Compendium of WHO and other UN guidance on health and environment, Version with International Classification of Health Intervention (ICHI) codes, Geneva, World Health Organization, 2021.

[3] S.K. Senthamil, M. Palanivel, A case study approach on municipal solid waste generation and its impact on the soil environment in Dharapuram Municipality, Tamilnadu, India, International Journal of ChemTech Research 9(2016) 2, 196-204.

[4] G.K. Singh, K. Gupta, S. Chaudhary, Solid waste management: Its sources, collection, transportation and recycling, International Journal of Environmental Science and Development 5(2014) 4, 347-351.

[5] M. Bhakkad, Solid waste management: a case study of Surat City, International Journal of Management and Applied Science 5(2019) 1, 34-36.

[6] R. Rana, R. Ganguly, A.K. Gupta, Solid waste management in Chandigarh - a case study, Journal of Civil Engineering and Environmental Technology 1(2014) 4, 67-70.

[7] H.I. Abdel-Shafy, M.S.M. Mansour, Solid waste issue: sources, composition, disposal, recycling, and valorization, Egyptian Journal of Petroleum 27(2018) 4, 1275-1290. https://doi.org/10.1016/j.ejpe.2018.07.003

[8] A. Dwivedi, R. Dubey, P.K. Singh, A. Ohri, Scientific management of municipal solid waste in an academic campus - a case study of IIT(BHU), Journal of Materials and Environmental Sciences 10(2019) 10, 909-917.

[9] G.M.D. Sarma, M.C. Sarma, Municipal solid waste management (MSWM): a case study of Nagaon Town in Assam, India, International Journal of Science and Research 4(2015) 1, 2806-2809.

[10] D.A. Kiran, S.V. Pushkara, R. Jitvan, S. Darshan, Characterization, quantification and management of municipal solid waste in Shivamogga city, Karnataka, India, Waste Management Bulletin 1(2023) 3, 18-26. https://doi.org/10.1016/j.wmb.2023.06.006

[11] V. Kumar, Solid waste management: a case study of Patiala City, Journal of Emerging Technologies and Innovative Research 8(2021) 7, a584-a589.

[12] V.D. Carmen-Niño, M.L. Sampedro-Rosas, A.L.R. Herrera, A.L. Juárez-López, M. Reyes-Umaña, S.E. Silva-Gómez, Municipal solid waste management course: a case study in Xaltianguis, Guerrero, México, International Journal of Applied Environmental Sciences 13(2018) 9, 787-800.

[13] F.B. Awino, S.E. Apitz, Solid waste management in the context of the waste hierarchy and circular economy frameworks: an international critical review, Integrated Environmental Assessment and Management 20(2024) 1, 9-35. https://doi.org/10.1002/ieam.4774

[14] M. Musliu, A. Bilalli, H. Ibrahimi, N. Berisha, L. Grapci-Kotori, D. Geci, Analysis of the quantity and composition of waste in the Peja District, Kosovo, Journal of Ecological Engineering 24(2023) 8, 228-235. https://doi.org/10.12911/22998993/166391

[15] G. Gomez, M. Manases, L. Ballinas, F. Castells, Characterization of urban solid waste in Chihuahua, Mexico, Waste Management 28(2008) 12, 2465-2471. https://doi.org/10.1016/j.wasman.2007.10.023

[16] H.A.P. Audu, I.E. Aigwi, M.A. Enaboifo, Solid waste composition analysis for the development of a suitable waste disposal system in Port Harcourt L.G.A of Rivers State, Nigeria, Journal of Emerging Trends in Engineering and Applied Sciences 6(2015) 2, 113- 119.

[17] R.B. Katiyar, S. Suresh, A.K. Sharma, Characterization of municipal solid

waste generated by the City of Bhopal, India, International Journal of ChemTech Research 5(2013) 2, 623-628.

[18] V. Ramakrishna, Municipal solid waste quantification, characterization and management in Rajam, The International Journal of Engineering and Science 5(2016) 2, 40-47.

[19] S. Manuja, Municipal solid waste composition analysis and its importance: a case of Kanpur, International Journal of Engineering Research & Technology 13(2024) 4, Article ID: IJERTV13IS040050.

[20] IMC, City development plan, Imphal (CDP), Imphal Municipal Council, Government of Manipur, India, 2004.

[21] R.K. Annepu, Sustainable solid waste management in India, Waste-to-energy research and technology council (WTERT), Columbia University, 2012.

[22] NEERI Report, Strategy paper on solid waste management in India, NEERI, Nagpur, India, 1997.

[23] B.K. Pandey, S. Vyas, M. Pandey, A. Gaur, Characterization of municipal solid waste generated from Bhopal, India, Current Science Perspectives 2(2016) 3, 52-56.

[24] J.M. Kihila, K. Wernsted, M. Kaseva, Waste segregation and potential for recycling - a case study in Dar es Salaam City, Tanzania, Sustainable Environment 7(2021) 1, Article ID: 1935532. https://doi.org/10.1080/27658511.2021.1935532

[25] M. Kalyanasundaram, K. Krishnan, S, Singh, K.C. Sahoo, R. Soni, V. Parashar, N. Mathankar, A. Pathak, Y. Sabde, C.S. Lundborg, S. Atkins, K. Rousta, V. Diwan, Composition analysis (pick analysis) of waste generated from household: a pilot study in Ujjain city, India, Heliyon 9(2023) 9, Article ID: e19902. https://doi.org/10.1016/j.heliyon.2023.e19902

[26] A.H. Khan, M. Sharholy, P. Alam, A.I. Al-Mansour, K. Ahmad, M.A. Kamal, S. Alam, Md. N. Pervez, V. Naddeo, Evaluation of cost benefit analysis of municipal solid waste management systems, Journal of King Saud University - Science 34(2022) 4, Article ID: 101997. https://doi.org/10.1016/j.jksus.2022.101997