SOLID WASTE GENERATION, COMPOSITION AND MANAGEMENT SYSTEM IN POKHARA METROPOLITAN CITY, NEPAL

Project Report I submitted in partial fulfilment of the requirements of Pokhara University for the degree of the Bachelor of Engineering

Advisor

ER. RAJIB POKHREL

By

SANTONA BARAL (2021-1-51-0081)
BISHNU SUBEDI (2021-1-51-0053)
SANDHYA THAPA (2021-1-51-0079)
SANCHITA ACHARYA (2021-1-51-0076)
NIRUTA KC (2021-1-51-0068)
KRITI KUMARI SAPKOTA (2021-1-48-0069)

School of Engineering
Faculty of Science and Technology
Pokhara University

Date 2081/3/24

BONAFIDE CERTIFICATE/APPROVAL SHEET

It is certified that this project I, titled **"SOLID WASTE GENERATION, COMPOSITION AND MANAGEMENT SYSTEM IN POKHARA METROPOLITAN CITY, NEPAL"** is the bonafide work of **Miss Santona Baral, Miss Bishnu Subedi, Miss Sandhya Thapa, Miss Sanchita Acharya, Miss Niruta KC, and Miss Kriti Kumari Sapkota, -**who carried out the project work under my supervision. According to the reported information the work reported herein doesn't form part of any other thesis or dissertation or project on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

Dr./Er.

External Examiners
Affiliation

Dr. Rajib Pokhrel

Supervisor
Assoc. Prof. SOE

Er. Om Prakash Giri
Director, SOE

ACKNOWLEDGEMENT

Completing this project has been a wonderful experience. The success of this project required a lot of guidance and assistance from many people, and we would like to express our deep gratitude to every individual for their support and coordination.

We would like to express our deep sense of gratitude to Assoc. Professor **Dr. Rajib Pokhrel** of School of Engineering, Faculty of Science and Technology, Pokhara University, Lekhnath, Kaski for his continuous guidance and encouragement. It would have been impossible to accomplish this project without his valuable suggestion.

We would like to express deepest thanks to Dean, Professor Dr/Er. Rajesh Thagurathi Faculty of Science and Technology, Professor Er. Om Prakash Giri, Director of School of Engineering and Professor Er. Sanjay Baral, Program Co-Ordinator of Civil and Rural Engineering of Pokhara University for giving us this opportunity.

We would like to express thanks to Professor **Er. Saugat Tiwari**, Faculty of Science and Technology for providing support during the dissertation period.

Santona Baral (2021-1-51-0081)
Bishnu Subedi (2021-1-51-0053)
Sandhya Thapa (2021-1-51-0079)
Sanchita Acharya (2021-1-51-0076)
Niruta KC (2021-1-51-0068)
Kriti Kumari Sapkota (2021-1-48-0069)

ABSTRACT

The study explores the current practices of waste collection, transportation, treatment, and disposal in Pokhara. It evaluates the effectiveness of the existing waste management system in Pokhara based on published information

Solid waste management in Pokhara valley of Nepal, especially concerning the siting of landfills, has been a challenge for over a decade. The current practice of the illegal dumping of solid waste on the riverbanks has created a serious environmental and public health problem. The data showed that ⩾70% of the solid wastes generated in Pokhara are of organic origin. As such, composting of the solid waste and using it on the land is the best way of solid waste disposal. This will reduce the waste volume transported to the dumping site.

At present solid waste is handled by the Municipal Waste Management Service in Pokhara. There are several acts and legal provisions for proper and effective solid waste management in Nepal. But, they are not implemented well resulting in improper management system. Pokhara needs to encourage sustainable waste management such as composting, recycling, minimizing waste generation and maximize resource recovery. Also, The current solid management system should be improved by continuous monitoring and evaluation ensuring community engagement, technological integration, and policy frameworks.

Thus, this report outlines the current situation and process of solid waste management in Pokhara Valley, the challenges in waste management process along with the solutions and recommendations. This project group is sure that this report will be beneficial for the general study of the current status of solid waste and its management. The group will also be delighted for any feedback and suggestion to upgrade this report.

TABLE OF CONTENTS

LIST OF FIGURES, TABLES AND PHOTOS

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOS

LIST OF SYMBOLS AND ABBREVIATIONS

Symbol and abbreviation	Meaning
SWM	Solid waste management
PMC	Pokhara Metropolitan City
CBOs	Community-based organizations
MSW	Municipal solid waste
GoN	Government of Nepal
SDGs	Sustainable Development Goals
NGO	Non-government organization
Sq m	Square meter
SWMTSC	Solid Waste Management Technical Support Center
TLO	Tole Lane Organization
AEPC	Alternative Energy Production Council
MSW	Municipal Solid Waste

SOLID WASTE GENERATION, COMPOSITION AND MANAGEMENT SYSTEM IN POKHARA METROPOLITAN CITY, NEPAL

1. Introduction

1.1 Background

Solid-waste management is the process of collecting, treating, and disposing of solid material that is discarded because of it being no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of various harmful disease. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved.

Solid waste management (SWM) is one of the major environmental issues in cities of many developing countries, including Nepal. Urban population growth and economic development lead to increasing generation of municipal solid waste (MSW). The use of products that generate hazardous waste is another concern. Unmanaged disposal of medical wastes from hospitals and clinics also contribute to pollution and public health hazards in the localities. Therefore, SWM has become a major concern for the municipalities of Nepal.

Photo 1: Suspended solid wastes in Phewa lake

Photo 2: Solid wastes at the side of road

(Source: Nepali times)

The Government of Nepal enacted the Solid Waste Management Act of 2011 effective from 15 June 2011. The objectives of the act include maintaining a clean and healthy environment by minimizing the adverse effects of solid waste on public health and the environment. The local bodies, such as municipalities, have been made responsible for the construction, operation, and management of infrastructure for collection, treatment, and final disposal of MSW. The act mandates local bodies to take the necessary steps to promote reduce, reuse, and recycle (3R), including segregation of MSW at source. It also provides for the involvement of the private sector, community-based organizations (CBOs), and non-government organizations (NGOs) in SWM through competitive bidding. In addition, the act authorizes the imposition and collection of service fees against SWM services, and prescribes the basis for fixing such fees and procedures for their collection and usage. It also authorizes the local bodies to formulate rules, by-laws, and guidelines, with the approval of the

municipal board. As provisioned in the act, the SWM Technical Support Center (SWMTSC) under the Ministry of Urban Development shall provide technical support to all local bodies for effective and sustainable SWM and advance research and development in this sector.

Pokhara is the second largest metropolitan city in Nepal after Kathmandu. It is the largest metropolitan area in Gandaki Province (Pradesh) spread over 424 km2 and housing approximately 400,000 people (as of Census 2011). The current estimated population (2019) of Pokhara is 515,000. Pokhara Sub-Metropolitan City was merged with Lekhnath Municipality and some village development committees in fiscal 2016 to create Pokhara Metropolitan City (PMC). PMC has 33 administrative wards. All things considered, ecological weight has expanded in Pokhara particularly along the developed destinations, stream banks, eastern bank of Phewa Lake, and primary market zone between Bagar to Mahendra pool, Mahendra pool to Prithivi Chowk, Lake Side region and old Bus Park region, also the emerging local markets around the city with easy access for locals.

According to the report of Ministry of Local Development, Pokhara Metropolitan City produces strong misuse of 123.45 tons every day and the complete civil waste assortment is 28.39 tons every day, which depends on the assessed populace of 2008 (214,226). Normal waste age of the city is 0.42 kg per individual every day.

1.2.Objective of the study

The general objective of this study is to identify the status of municipal solid waste generation, composition and its management practice in PMC.

The specific objectives of this study are as follows

a. To find the amount of solid waste generation in PMC,
b. To categorize municipal solid waste,
c. To assess solid waste management practice in PMC.

1.3. Significance of the study

This study has two main significances. Firstly, it may give some guideline information to policy makers, solid waste managers and environmental protection agencies about existing situation of municipal solid waste management of the city. Secondly, this study may also be important in putting baseline information to the next work who would like to conduct detailed and comprehensive studies in Pokhara valley.

1.4. Scope of the study

The scope of the study for solid waste management includes various aspects related to generation, handling, treatment and disposal of solid waste.

Following are the components that are included in the scope of study: -

a. Waste generation assessment
    i. Analyzing the types, quantities and characteristics of solid waste generated in Pokhara valley.
    ii. To understand the composition of solid waste and its changes over time.

b. Waste collection system
    i. Evaluate the performance of existing waste collection systems through survey and data analysis.
    ii. Check out the coverage, frequency and reliability of collection services in Pokhara.
c. Waste treatment technologies
    i. To recommend the environment friendly waste management technologies.

By studying these various components, we can develop broad strategies and solutions to address the challenges associated with solid waste generation and disposal.

1.5. Study limitations

The limitations of the study are as follows:

a) Although the study covered MSW quantity and quality, including commercial and institutional wastes, industrial wastes, waste generated from parks and gardens, street sweeping, and treated hospital waste, which fall under MSW, were not accounted for.
b) The small sample size and one-time sampling of waste generation may provide an inaccurate average value.
c) The study falls short of analyzing technological solutions for improving the solid waste management system- this would require a technical analysis by a specialist.

2. Literature Review

2.1 Solid Wastes and their types

2.1.1 Solid Waste

In simple words, solid wastes are any discarded (abandoned or considered waste-like) materials. Solid wastes include household refuse, agricultural remnants, food leftovers, plastic bags, tin cans ash and packaging, such as cartons. They become waste once they have been discarded because they are no longer needed in their present form. Refuse, garbage, litter and street sweepings are all terms used to describe solid wastes in various situations.

Resource Conservation and Recovery Act *(RCRA,1976)* defines solid waste to include garbage, refuse, sludge or other discarded materials from industrial, commercial, mining, agriculture or community activities *(UNEP,2005)*. Solid waste is an inevitable byproduct of human activities *(HMG/N & et.al.2000)*

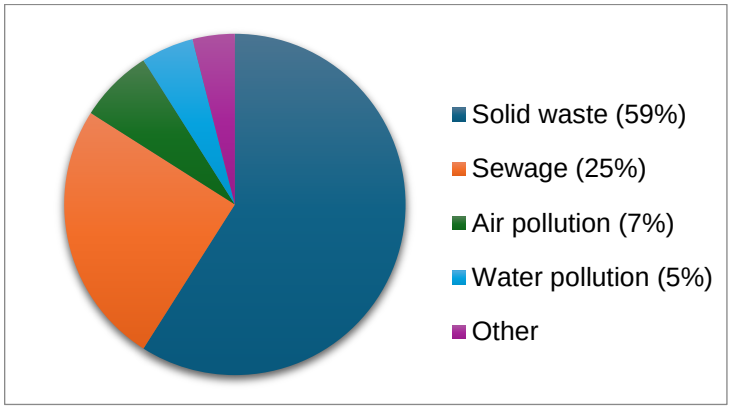

Figure 2: Public Opinion on Main Environmental Problems in Urban Areas
(Source: CBS Report,1997)

The public opinion on main environmental problems that are in urban areas is shown in the fig 2, according to which 59% people believe that solid waste is the main cause *(CBS Report,1997)*.

2.1.2. Municipal Solid Waste

Municipal solid waste (MSW), commonly known as trash or garbage, refuse or rubbish is a waste type consisting of everyday items that are discarded by the public *(CIUD,2006).* Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.

Table 1: Categories of Garbage

Organic waste	kitchen waste, vegetables, flowers, leaves, fruits
Toxic waste	old medicines, paints, chemicals, bulbs, spray cans, fertilizers, and pesticides containers, batteries, shoe polish
Recyclable	paper, glass, metals, plastics
Soiled	hospital waste such as cloth soiled with blood and other body fluids

(Source: http://edugreen.teri.res.in/explore/solwaste/types.htm)

Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminum foils, plastics, and other such non-biodegradable items that cause incalculable harm to the environment.

2.1.3 Classification of Municipal solid waste

Municipal Solid Waste can be classified as hazardous or non -hazardous and also as biodegradable or non-biodegradable. Waste can also be described as combustible or non-combustible depending on whether it will burn or not. Table 2.3 classifies waste using these different properties.

Table 2: Classification of Solid Waste

S. N	Main Classification	Type	Short Description	Examples
1	Hazardous waste	Solid or semisolid	Substances that are ignitable, corrosive, react infectious or explosive	Some obsolete pesticides such as DDT, dihedron etc.
2	Non-Hazardous	Biodegradable	Easily decomposable/biodegradable solid waste	Food wastes

(Source: http://labspace.open.ac.uk/mod/oucontent/view.php?Id=453833& section=1.3)

2.2. City's institutional arrangement for SWM

Environment and disaster management is one of the fifteen main divisions of PMC, with the waste management branch under it. The waste management branch has four sub-branches.

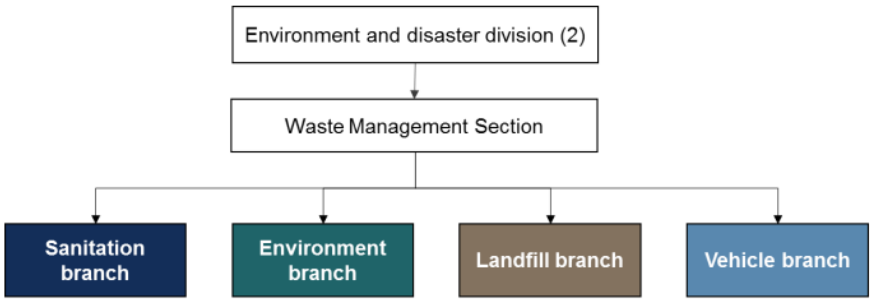

Figure 3: Waste Management Branches at PMC

The waste management section has 90 personnel to undertake management and on-ground operations. The responsibilities and strengths of the sub-branch are described below:

1. Sanitation branch: Sanitation branch is the key branch looking after solid waste operations and management. It is manned by one management staff, one office helper, four drivers, one guard and 59 sweepers. About 32 of 59 sweepers are female. The sweepers are responsible for sweeping about 8 km of roads, including market areas, every day.
2. Environment branch: The responsibility of this branch includes tree plantation and conservation, conducting training and awareness programs. This sub-branch has three personnel—two management staff and one office helper.
3. Landfill branch: The branch has 18 personnel—one for management, five drivers, eight helpers and four guards. All are associated with landfill operations.
4. Vehicle branch: The branch is manned by three personnel—two management staff and one office helper. They operate and manage the vehicles utilized for SWM operations

After the merger of Lekhnath and other rural areas, the institutional structure is under evaluation and revision. SWM operations are managed by PMC and seven private operators appointed by PMC for collection and transportation of waste. Further, PMC has engaged separate private operators for biomedical waste handling, landfill and septage management. PMC has four vehicles which they operate to collect and transport waste from six wards of the city. The ULL has four drivers in the sanitation sub-branch and five drivers in the landfill division to run these vehicles. They are supported by eight helpers. PMC has 59 sweepers to sweep the main commercial streets, market areas, temples and other public spaces. Sweeping does not come under the scope of the private contractors. The private contractors appoint drivers and helpers for collection and transportation of waste. Also, they have a team of management staff and personnel to collect sanitation charges.

3. Data and Methodology

Pokhara Metropolitan City was chosen as the study area because the generation of municipal solid waste is being observed to be increased day by day and with together migration and floating population is very high and rapid. Pokhara Metropolitan City is located in the Kaski district of Gandaki Province, Nepal. The city is nestled in a bowl-shaped valley, cradled by the Annapurna Himalayan Range. Its unique geographical features include a rapid rise in altitude within a short distance. The elevation ranges from 505m (Kotre) to 2650m (Armala) above sea level. The total area of Pokhara Metropolitian city is 464.94 sq km which represents 23.01% area of the Kaski district and 0.31% area of the country, Nepal. This metropolitan has 81456 households and 402995 populations (CBS, 2011). Pokhara Sub-Metropolitan City was merged with Lekhnath Municipality and a few surrounding villages in 2016 to create PMC. PMC has 33 administrative wards.

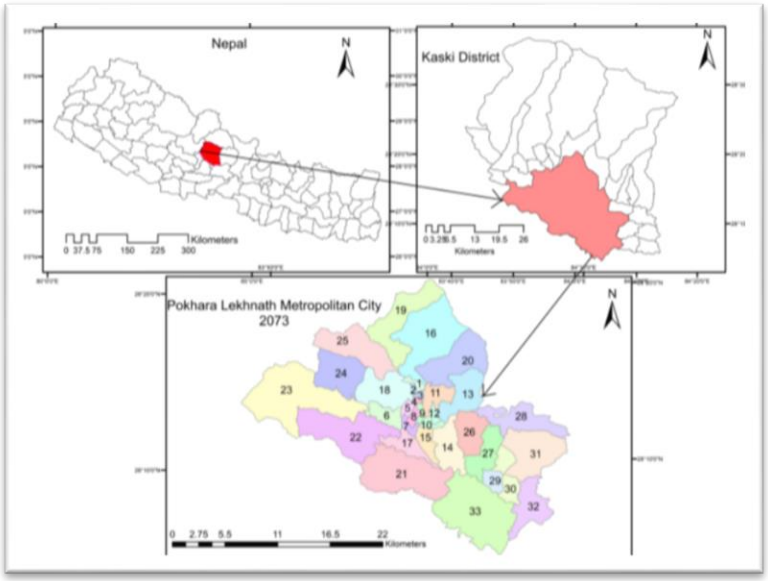

Figure 1: Location of study

This output assesses city-level SWM and provides recommendations for improvement. The assessment of solid waste has been carried out across the SWM activity chain based on:

a) Reconnaissance survey
b) Primary survey
c) Secondary information assessment

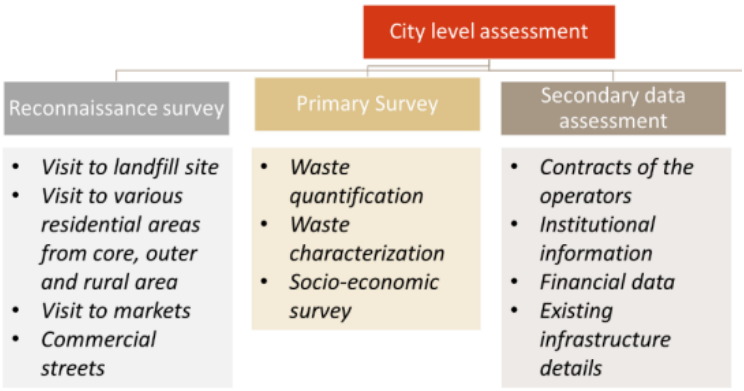

Figure 4: Methodology adopted for city-level assessment

1. Reconnaissance survey
   Reconnaissance visits to various residential and commercial areas to study waste management practices such as storing and disposal mechanism, and cleanliness of the streets and public areas were carried out. Also visits to the existing dumpsite and material recovery and processing facilities to obtain deeper understanding of the actual processes were carried out. Additionally, visits to the markets to understand the waste generation and disposal pattern of bulk generators and tourist areas such as Phewa Lake and Begnas Tal in order to find out about the issues of littering, if any were carried out.
2. Primary survey
   For the primary survey, the authorized solid waste management department in Pokhara Metropolitan City was visited. The recorded data and information regarding the solid waste generation, collection, segregation, treatment and disposal in PMC were accumulated and assessed. The SWM staffs working to collect the solid wastes in the city were also interviewed and the information gathered were included in the report.
3. Secondary survey
   For the secondary survey, the research papers, journals, articles and published reports were studied thoroughly. The internet search was carried out throughout the study process. Every data collected from the study were analyzed in details and improvised to obtain the qualitative result.

4. Result and Discussion

4.1. Pokhara's Solid waste generation and composition

4.1.1. Solid waste generation

Based on the primary survey results, the city generates about 182 MT of solid waste per day. Based on the population estimate of 5,15,000, as of 2019 per capita waste generation in the city is 354 gm per day, 60% more than 220 gm in 2012. About 85 MT solid waste reaches the dumping site daily.

Table 3: Summary of waste quantification for Pokhara

Sl No	Item	Quantity (MT/day)
A	**Primary waste quantification results**	
1	Quantity of waste generated by households	145.55
2	Quantity of waste generated by bulk generators	4.50
3	Quantity of waste generated by commercial establishments	25.53
4	Quantity of waste generated by institutions /offices	7.12
B	**Total waste generated (TPD)**	**182.50**
C	**Estimated current population of PMC**	**5,14, 890**
D	**Estimated generation (gram/capita/day)**	**354**
E	**Average waste quantity received at the dump site (TPD)**	**85**

(Source: CRIS assessment based on primary survey results and projections for 2019)

Per capita waste generation varies across the city. The household waste generation in core, outer and rural areas is 282, 382 and 188 grams per capita per day, respectively. Combining various use categories such as domestic, commercial and institutional, the city-level daily per-capita generation is 354 grams.

4.1.2. Solid Waste Composition

Physical and chemical characterization of waste was done at the point of generation and downstream at the dumping site as well. At the source, share of organic content is the highest at ~65%, followed by plastic (~19%), paper (~6%) and glass (~4%).

The variation in organic content in the waste is high. Of the waste generated in core and outer areas, about 65% is organic waste and in the rural area, it is 87%. Plastics form 29%, 14% and 10% of the waste generated in core, outer and rural areas, respectively. This clearly shows typical differences in characteristics of waste from rural and urban areas. Paper content is the highest in the waste from outer at 10%, compared with 1-2% in the core and rural areas

Table 4: Summary of waste characterization for Pokhara

SN	Parameter	Unit	Point of waste generation	Downstream sample
		A Physical composition		
1	Organic	%	65%	48%
2	Plastic	%	19%	19%
3	Paper	%	6%	16%
4	Glass	%	4%	8%
5	Rubber	%	0%	0%
6	Textile	%	2%	4%
7	Metal	%	2%	4%
8	Others	%	1%	0%
		B Chemical composition		
1	Moisture content	%	81.73	67.12
2	Bulk density	kg/m^3	149.8	155.62
3	Organic content	%	65.42	48.09
4	Calorific value	Kcal/kg	2532	2961
5	Carbon/nitrogen ratio		43.71	28.87
6	Total solid	%	18.27	32.88
7	Volatile Solids (VS)		62.6	52.91

(Source: Report of solid waste management baseline survey in Pokhara Sub-metropolitan City, Solid Waste Management Technical Support Center (SWMTSC), Ministry of Local Development, July 2012.)

4.2. Existing Solid Waste Management System in Pokhara

At present solid waste is handled by the Municipal Waste Management Service in Pokhara. Existing solid waste management in Pokhara area as follows:

4.2.1. Collection And Segregation

A typical operational system used in Pokhara consists of primary collection such as street cleaning followed by secondary collection including container pickup and door to door service solid waste collection. It is outsourced to seven private contractors who provide service in 25 wards (covering 84% i.e. about 80000 households as per census 2011).Six wards are served by PMC covering about 14% and remaining two wards being rural in nature are not covered with the waste collection service.

Pokhara practices curbside waste collection where the vehicles stop in the main arterial roads, blow their horns and waste generators come to the vehicle to dispose their waste. It was observed from stakeholders' consultations that waste collection vehicles do not follow a fix time schedule. The solid waste management act mandates waste generators to segregate the waste and dispose it in waste collection vehicles. However, this has not been followed in PMC. Mixed waste is collected and transported to dumping site.

4.2.2. Transportation

Waste collection and transportation is outsourced to seven private contractors. Private vehicles deployed by all seven contractors for waste collection have a cumulative capacity of 132 ton, provided the entire fleet is in operation and completely filled with waste. Based on the logbook recorded, these vehicles make around ~50 trips per day, carrying ~85 ton to the dumping site. Thus, vehicle utilization is about 60% provided the vehicles are full on reaching the dumping site.

Table 5: Contractor-wise human resource available for waste collection and transportation activities

Name of the company	Management staff	Operational staff	Others (including collector of sanitation charges)	Total
Pokhara Waste Management Pvt Ltd	NA*	Driver-6 Helper-7	32	45
Batawaraniya Sundar Nepal Pvt Ltd	9	Driver- 7 Helper- 18	NA	34
Nepal Public Health and Environment for Development	NA	Driver-3 Helper- 6	12	21
Waste Management Recycling Pvt Ltd	1	Driver-3 Helper-4	4	12
Pragati Sansar Nepal	NA	Driver-1 Helper-2	4	7
Just in Time	NA	Driver-2 Helper-4	12	20
Pokhara Greenmart	7	Driver- 5 Helper- 10	10	32

(Source: PMC and private operators, November 2019).

Photo 3: Solid waste collection and transportation vehicles in Pokhara

(Source: Bishnu Subedi (2024))

4.2.3. Final Disposal

a. Landfill

PMC has developed a sanitary landfill site of an area covering 10.2 hectares among which 4 hectares has been separated for filling area within total area. It has started functioning since February 2005.Pokhara sanitary landfill site is located at ward no 18 Bacggeduwa of PMC Kaski. The Phusre Khola flowing near the south boundary this landfill. The altitude of landfill site is about 827 m above the sea level. This landfill lies at a distance of 12 km from the core area of Pokhara.

However, this was used as a dumpsite i.e. all the waste collected from the city were dumped here without any segregation and processing. A seepage management system was installed within the dumping but it was not functional.

An international airport has been constructed within the 2km radius of this landfill. Hence this landfill was scientifically closed by December 2020.

b. Dumping

After the landfill site was closed in December 2020. The issues have emerged in the waste management of PMC. After discussion, the plan was proposed to dispose the waste to Lamaehaal 32, Pokhara. After the agreement between the metropolitan city and the locals of Lamaehaal, the plan so developed was imposed to dispose the wastes at Lamaehaal landfill site for about 18 months. At present the wastes are disposed there but this area is used as a dumping site only where the garbage carrying vehicles should reach the site between 6 am to 4pm to dispose the waste. After each disposal, it should be immediately covered from small layer of soil. Likewise, life insurance of the citizens affected from the waste would be covered and the insecticides should be sprayed in the waste management site are the other conditions to be fulfilled for the locals of Lamaehaal

Photo 4: Dumping site in Lamaehaal

(Source: Bishnu Subedi (2024))

4.2.4. Other Management Process

a) Incineration

The process of burning waste to reduce its volume and the risk of disease transmission is called incineration. This method is often used to dispose of hazardous and medical waste, but it comes with some environmental concerns. These can include pollution and release of toxic gases. Incineration is mainly used to reduce hazardous wastes such as oils, chlorinated hydrocarbons, solvents, pesticides, and medical wastes. The combustion produced from the waste generates heat and electricity. So, this method also helps produce energy. The strategy is particularly helpful for those who do not want to store waste at a common location. In context of PMC this practice is used in Hospitals and Community health posts. Some local locals also burn the waste generated in their households which results being hazardous to the environment.

b) Composting

Composting is the process of breaking down organic waste, such as yard and food waste, into a soil amendment rich in nutrition. Composting nullifies the chances of waste sent to landfills. In the core and outer areas, where the frequency of waste collection is more than once a week, residential waste generators tend to segregate their biodegradable waste. In rural areas, organic waste is used as fodder for cattle or used as manure in the kitchen garden or agricultural fields. As per the primary survey results, agricultural waste, mainly generated in outer and rural areas, is used as organic manure and to feed cattle. Some TLOs have provided composting bins to households to store and reduce their organic waste. For example, in ward 10, 76 composting bins of approximately 50-liter capacity each were distributed. Also, small-scale biogas units have been distributed by a private supplier with support from the Alternative Energy Production Council (AEPC) and PMC. Of the units distributed, 42 are for small-scale waste generators in rural areas and 40 are for small-scale waste generators in urban areas (households).

Photo 5: Incineration

Photo 6: Composting

(Source: Google)

4.3. Challenges of the waste management

The challenges faced in waste management include increasing waste generation due to rapid population growth & urbanization, inadequate infrastructure and resources, the high cost of maintenance, political interference. Some challenges of waste management are as follows:

1. Waste is dumped on the streets.
2. Different types of waste are not collected separately.
3. There is no proper waste collection system.
4. Lack of financial resources for advanced waste management solution.
5. Low levels of public awareness and participation in waste segregation & recycling.
6. Challenges in enforcing waste management regulations & policies.
7. Limited adoption of modern waste management technologies and practices.
8. High waste generation from the tourism industry, stressing the existing waste management system.

Also, the tourism center of Nepal, Pokhara, has been influenced by the foreign consumption lifestyle of visitors from different continent. The number of restaurants, hotels & marts is increasing to supply the city dwellers needs. Besides, the packaged food from hotels & restaurants, canned juice, bottles, beverage & party food culture have notably increased, due to which solid waste production is remarkably gaining momentum in Pokhara. It is creating problem in environmental protection.

4.4. Recommendations

4.4.1. Development of policy, strategy and guidelines

While the enactment of the new Solid Waste Management Act in 2011 was a major step toward improving SWM practices in Nepal, it has not been effectively translated into actions and results on the ground. A national SWM policy and strategy that specifies key policy objectives, guiding principles, and an implementation strategy with a timeline and a clear monitoring and evaluation mechanism needs to be developed to provide clear strategic direction to local bodies. Technical guidelines will also need to be developed for issues such as organic composting, resource recovery technologies, and landfill development and operation.

4.4.2. Promotion of reduce, reuse and recycle

3R method (Reduce, Reuse, Recycle) should be promoted significantly to reduce the amount of waste to be disposed at final disposal sites. The wastes should be segregated at the source and 3R method should be applied appropriately. Promoting "Reduce, Reuse, and Recycle" is essential for fostering sustainability and minimizing environmental impact.

Promoting the reduction of waste for solid waste management involves encouraging practices that minimize the generation of waste in the first place. This can be achieved through various strategies such as promoting the use of reusable products instead of disposable ones, advocating for the purchase of products with minimal packaging, and educating the public about mindful consumption habits.

Promoting reuse for solid waste management involves encouraging the extended use of products and materials to minimize waste generation. This approach emphasizes finding creative ways to reuse items instead of discarding them after initial use. Strategies for encouraging reuse involves promoting the use of durable goods and supporting initiatives like repair cafes or thrift stores where items can be reused instead of discarded.

Promoting recycling for solid waste management is essential for reducing environmental impact. It involves the process of collecting, sorting, processing, and converting waste materials into new products or raw materials that can be used again. The promotion of recycling begins with raising awareness about the importance of separating recyclable materials such as paper, plastics, glass, and metals from general waste. Collaborating with local governments, businesses, and community organizations for providing accessible recycling bins in public spaces and implementing curbside recycling programs. The promotion of organic composting would reduce the volume of organic waste sent to dumping site but also produces a valuable soil amendment that improves soil health and fertility.

4.4.3. Public participation

Local bodies alone cannot meet the challenge of keeping city clean and livable. Community participation needs to be ensured through information, education, and communication campaigns to enhance citizens' awareness of 3R and better SWM. Awareness should start from the basic "no littering" in public places to teaching about proper waste management practices, including waste segregation, recycling, and composting. Various channels such as community meetings, schools, media, and local events can be considered to reach a wider audience. Youth groups, local clubs, and organizations can be mobilized to participate in regular clean-up drives and recycling campaigns. Providing incentives or recognition for individuals, households, or businesses that actively participate in waste reduction, recycling, or composting programs might motivate and encourage others to do so too.

4.4.4. Strengthening capacity of local bodies

The SWM Act have mandated municipalities to take charge of collection, transport, treatment, and final disposal of MSW. However, due to continuous unplanned urbanization and increase in population, PMC is facing a shortage of financial and human resources, as well as technical and managerial skills to effectively manage MSW. Developing the in-house capacity in Pokhara is thus essential. The establishment of SWMTSC with suitably qualified individuals is recommended as it is best suited to provide short- and medium-term technical support to local bodies in planning, waste collection, transport, and final disposal. Comprehensive training programs for local government officials, staff, and community members on modern waste management techniques, including waste reduction, segregation, recycling, and composting should be provided. By strengthening the capacity of local bodies, communities can achieve improved waste management outcomes, reduce environmental impacts, promote public health, and contribute to SDGs at the local level.

4.4.5. Public-private participation

In Pokhara, seven private contractors manage collection and transportation of waste in 25 (out of 33) wards of the city. PMC has also appointed one private operator to segregate recyclable waste at the dumpsite. Thus, PMC has eight contracts to supervise regarding SWM. The involvement of the private sector has great potential to improve operational efficiency and cost effectiveness in MSW collection, transport, treatment, and final disposal. Management contracts that tap the experience of qualified private sector partners should be considered as a viable alternative to ensure efficient operation of the dumping sites. PMC need strengthening in the areas of conducting competitive bidding; establishing appropriate scope and performance specifications in contracts; assessing qualification requirements of private sector companies, CBOs, or NGOs; and monitoring performance in accordance with the provisions of the contract.

5. Conclusion

This study summarizes the solid waste generation composition and management system in Pokhara metropolitan city. The study has covered the required data and statistics of the city from several published literatures and field data collected by the locals as well as the authorized personnel in the city.

It was estimated that the total amount of waste generated from the city is approximately 354 grams per capita per day of which 282 grams per capita per day is contributed by households, 50 grams per capita per day by commercial establishments, 14 grams per capita per day by institutions/ offices and 8 grams per capita per day by other sectors.

It was found that, according to existing solid waste data in PMC, the waste management practices followed in the city is having questionable difficulties to have a smooth run. The limited waste handling, collection, transport, resource recovery and safe disposal capacity has been the restraining issues in PMC. The selected places for land field and dumping are becoming difficult to manage and operate on, additionally a nuisance to the locals of the area. Similarly, lack of knowledge and awareness about incineration has led to degrading air quality of the city. However, composting is proving to be the effective way to deal with household degradable wastes as the people are benefitted because of the manure after composting. Proper provisions regarding solid waste management is a must for the emerging city like PMC for effective and smooth development.

6. References

[1] World bank's "City-level Assessment and Draft Service Improvement Plan for Solid Waste Management for Pokhara Metropolitan City" (June 2020)

[2] Government of Nepal Central Bureau of Statistics, "Solid Waste Account for Urban Municipalities of Nepal 2022, System of Environmental Economic Accounting" (2022)

[3] Sarmila Bhattarai's "Solid Waste Generation and Management Practice in Pokhara" (23 November 2021)

[4] "Solid waste management practices and challenges in seven cities of nepal before and during lockdown against covid-19 pandemic" (2021)

[5] The World Bank's "WHAT A WASTE A Global Review of Solid Waste Management" , (March 2012) ,World Bank Document

[6] Asian Development Bank's "Solid Waste Management in Nepal Current Status and Policy Recommendations" , Solid Waste Management in Nepal: Current Status and Policy Recommendations (adb.org)

[7] Government of Nepal Central Bureau of Statistics, "WASTE MANAGEMENT BASELINE SURVEY OF NEPAL 2020" (February, 2021), Waste-Management-Baseline-Survey-of-Nepal-2020.pdf (un.org)

[8] | UNEP's "Beyond an age of waste Turning rubbish into a resource", Global Waste Management Outlook 2024 , global_waste_management_outlook_2024.pdf (unep.org)

[9] Kolekar, K., Hazra, T. and Chakrabarty, S' "A review on prediction of municipal solid waste generation models" (2016),A Review on Prediction of Municipal Solid Waste Generation Models - ScienceDirect

[10] Dunkel, J., Dominguez, D., Borzdynski, S. G. and Sánchez, N's "Solid waste analysis using open-access socioeconomic data" (2022)., Sustainability | Free Full-Text | Solid Waste Analysis Using Open-Access Socio-Economic Data (mdpi.com)

[11] Mr. Mohan Bhandari, Mr. Lal Mani Pokhrel, Mr. Manoranj Sharma, "Household solid waste generation and composition in Pokhara" Journal of Interdisciplinary Studies, (2019), GMMC-Journal-2019-Vol-8.pdf

7. Annexes

Photo 7: Waste management works in dumping site in Pokhara

Photo 8: Site visit to Lamaehaal dumping site in Pokhara