



## Analyzing Waste Problems in Developing Countries: Lessons for Kathmandu, Nepal through Analysis of the Waste System in Tsukuba City, Japan

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### Authors' contributions

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

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### ABSTRACT

Implementing an effective solid waste management program has become a difficult challenge in many developing countries. In most cases, local authorities lack the capacity to collect all the waste generated, let alone facilitate appropriate disposal. Street littering, illegal dumping and associated health and amenity impacts exacerbate these problems. On the other hand, developed countries have already overcome waste management problems in their cities by the introduction and implementation of proper laws and regulations, encouraging people to segregate household waste for recovery of materials, with financial support from central governments, to name a few. Many

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studies suggest that it is necessary to change not only the waste management capacity by local authorities but also residents' perception regarding waste in developing countries. This article compares the waste system in Kathmandu, a typical city in a developing country, and Tsukuba city or Tsukuba Science City – as popularly known – in Ibaraki prefecture, Japan. The study argues that the segregation of waste at source and improvement of the waste collection system options for recovery of materials can not only help in managing waste problems but can also be a source of income if applied properly to Kathmandu city.

*Keywords: Developing countries; Kathmandu city; Tsukuba city; developed countries; waste management; recovery of materials.*

## 1. INTRODUCTION

The rapid urbanization combined with approximately a 30% - 50% population increase is an upcoming threat to waste management systems particularly in most developing countries in Asia [1]. Moreover, the booming economy and rise in living standards have caused a significant increase in solid waste generation rate in developing countries [2]. A World Bank report (2012) [3] addresses the alarming rise in the amount of waste generated and its associated costs. It is estimated that cities currently generate around 1.3 billion tons of waste per year, and with increasing urbanization, it is expected to reach 2.2 billion tons per year by 2025 – an increase of 70 percent [4].

Local governments, usually responsible for municipal solid waste management, lack not only the financial resources but also an effective management office [5]. Developing countries like Nepal could learn from the experience of developed countries such as Japan in achieving efficient waste management systems. The government of Japan, for instance, introduced waste classification for municipal and industrial waste for the first time in the 1970's and promoted the 3R (reduce, reuse and recycling) initiatives in the 1990's [6]. Specific recycling laws were also introduced to promote the recovery of valuable materials previously incinerated, such as the Containers and Packaging Law in 1995; the Home Appliance Recycling Laws in 1998; the Food Recycling Law in 2000 and the End-of-Life Vehicles Recycling Law in 2002 [7,8]. Waste management in Japan mostly involves recycling and thermal recovery of energy from the waste, composting and bio-gasification for organic waste materials limited to specific areas, highly advanced incineration facilities with final disposal sanitary landfill for residue that cannot go through further processing.

In the case of Nepal, Solid Waste Management Act of 2011 enacted by the government on 15

June 2011, has the objective of managing solid waste [9]. The act includes provisions regarding proper collection, minimization and disposal of waste including medical waste. It also mentions the participation of the private sector in waste management and the provision for waste management fees. It also addresses the provision for formation of a solid waste management council to determine policy regarding waste management and provision for formation of a solid waste management technical support center to provide technical support to local bodies for solid waste management and carry out research regarding waste management.

However, facilitating the proper implementation of the act for management of waste is a low priority as there is a higher demand for other public services in many municipalities in Nepal [9]. People are still unaware of the problems associated with solid waste management though people's perception about waste is very important [10]. The country lacks the infrastructure and human resources for proper management of the waste exemplified by the haphazard dumping of all the collected waste from Kathmandu city into the Sisdol landfill site, which pollutes the nearby environment. Waste from hospitals and clinics is often mixed with municipal solid waste [11]. Moreover, due to financial constraints, Nepal lacks proper infrastructure, experts and implementation of appropriate laws for efficient waste management. In addition, due to managerial inefficiencies, the available resources are often not utilized effectively. Therefore, waste management is one of the biggest challenges for not only the capital city Kathmandu, but for the whole nation, which requires urgent attention [11].

In this paper, we analyze what have been the major drivers that have contributed to the poor management system in urban areas in Nepal. The emphasis will be on the capital city Kathmandu. The paper also discusses some initiatives from local people through NGOs,

involvement of informal recyclers in waste collection, including how local government should engage these initiatives to manage waste in the city.

## 2. WASTE MANAGEMENT

### 2.1 Waste Issues in Nepal

Increasing population and urbanization in the 21<sup>st</sup> century has seen a dramatic increase in waste generation in Nepal. Although the increase in waste generation is expected, a lack of collection system throughout the city coupled with lack of support from residents has exacerbated the waste situation. The municipal wastes generated in and around the cities are not managed properly and cause not only severe health and environmental problems but also an image problem for the tourist destinations that Nepal is famous for (Figs. 1 & 2).

In addition, in many remote areas and slums located on the outskirts of metropolitan or urban areas, residents do not have the financial capacity to pay local government or private

organizations working for the collection and management of waste, which aggravates the situation. In general, open dumping is common practice and one can see waste scattered on roads, drains and open spaces, which is especially the case in poor urban settlements. Municipalities are wholly responsible for the collection, transportation, treatment and final disposal of solid waste. However, due to lack of finance, equipment and knowledge related to proper waste management municipalities are unable to manage waste properly which is often limited to street sweeping and dumping in the nearest river and on vacant land. Even if the government receives financial support for waste collection and disposal, it is difficult for cities to implement an effective management system due to lack of human resources with technical skills. In general, the concerned authorities in most cities do not have the data related to waste generation, which makes it even more difficult to manage the waste. However, as we describe below, some studies are available for the Kathmandu Metropolitan City (KMC) related to waste management.



Fig. 1. Current waste practices of local people in Kathmandu Metropolitan City (KMC)





**Fig. 2. A view of waste disposal in the Bagmati River, KMC**

## **2.2 Studies on Waste Management**

Previous studies have been conducted to collect Solid Waste Management (SWM) baseline information but most of them have been limited to the Kathmandu Valley's municipalities [11]. The Solid Waste Management & Resource Mobilization Center undertook a nationwide SWM baseline study in all 58 municipalities of Nepal (SWMRMC 2003, 2004) but these reports on waste quantities are incomplete due to lack of a scientific and systematic methodology. There was also a SWM survey of 58 municipalities of Nepal undertaken by ADB in 2013 in which lot of generalizations were made [9]. However, medical waste (most of the waste from industry goes to MSW stream with partial or no treatment), street sweeping, and parks were not included in the study [9]. There is a lack of waste management skills and resources for effective waste management. On average almost 13% of the total budget in 58 municipalities (now 130 municipalities) is spent on waste management however not in an efficient manner [12]. Small urban centers lack infrastructure, resources, finance and technical support to tackle the waste problem despite being considered municipalities. The number of municipalities has increased from 58 to 130 and we are yet to see waste

management in the new municipalities [9]. In some parts of Nepal, NGO's are involved in waste management at the community level, which is a positive development and good news for the community. In some regions, private organizations and local communities are working in collaboration with municipalities for waste management, i.e., Kathmandu Valley (Kathmandu district, Patan district and Bhaktpur district).

## **2.3 Waste Management in Kathmandu City**

Kathmandu city, the capital of Nepal, has an area 49.45 km<sup>2</sup> with a total population of 1,003,285. The population density is 20,289 people per km<sup>2</sup>. The total waste generated per day in the city is 466.14 tons. The main source of municipal solid waste is domestic waste followed by commercial and institutional. The generated waste from households is co-mingled without any segregation and is stored in household bins. Some waste is thrown in the community bins, on roadsides, abandoned spaces and on river banks [13]. The informal sector collects some wastes, such as paper, plastic, bottles and metals on a small scale for recycling. Kathmandu residences in many areas lack solid waste collection and

disposal services. Many NGOs, CBOs and private sectors are involved in the management of waste in Kathmandu city. A breakdown of general waste composed of household waste, commercial waste, and institutional waste is shown in Fig. 3. As is the case in many developing countries, most of the general waste is organic waste. Currently small scale composting is being carried out by the NGOs and the private sector.

Most of the waste generated in Kathmandu goes directly to the only landfill called Sisdol landfill site, located in Sisdol, overseen by the Okharpauwa Village Development Committee (VDC), which is barely 28 km away from Kathmandu city [14]. The only landfill which was built with the help of JICA (Japan International Cooperation Agency) in 2005 with a projected life of 3 years but, as there is no alternative for the final disposal of waste, the waste from Kathmandu valley is still being dumped there

(Fig. 4). The government proposed a sanitary landfill site, which is yet to be commissioned (personal communication, RKS). There is a transfer station in Teku to unload the collected waste prior to the final destination at Sisdol landfill. Very few households segregate waste for compost or sell the recyclables to the informal recyclers.

The proposed landfill site named Bancharadada which is approximately 2 km from the Sisdol landfill site is under construction and is estimated to take around 3 years to complete [10]. Some uncollected waste including plastic bags, papers and pet bottles, etc. are present in drainage ditches, piled up in empty spaces, on the roadside or in and around the city's rivers. In 2011, the government passed the Solid Waste Management Act but enforcement of the rules and regulations is weak and detailed responsibilities are unknown [15].

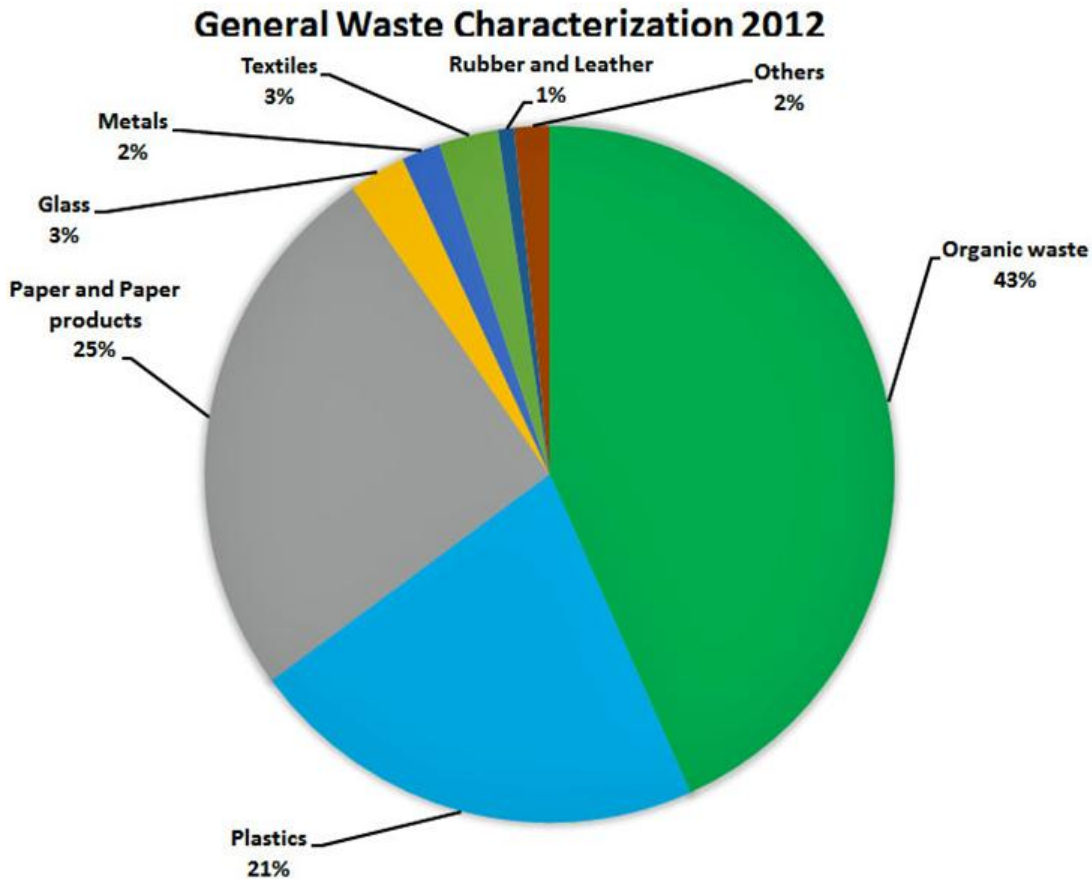


Fig. 3. Characteristics of the general waste generated in Kathmandu city. The pie chart represents data published by the ADB Report, 2013



**Fig. 4. Waste dumping in Sisdol landfill site. The photo also shows scavengers collecting the recyclables**

It should be noted that there is an official authority for waste management in Nepal. The waste management and resource mobilization center (SWMRMC) – the top body under the Ministry of Local Development (MoLD), Government of Nepal has the responsibility to make policies and provide technical support related with waste management to all the municipalities in Nepal including KMC, which is responsible for collection and disposal of waste in Kathmandu city.

#### **2.4 Current Situation and Public Perception**

“Kathmandu’s garbage situation has reached a crisis stage and the citizens (authorities and residents) now urgently need to start planning for the long-term and involving the private sector might be a key to achieving that goal,” says Sumitra Amatya of the Ministry of Urban Development’s Solid Waste Management Technical Support Center [15]. Moreover, how to educate people will be another critical factor for this issue that hurts us all. According to the daily *Nagarik news* [16], the government will come up with a solution or solutions to the waste problem

in Kathmandu city within four months [16]. As per the report, currently, there is an on-going intensive study of the waste management of Kathmandu city by a consultancy from India and Finland. The experts will submit their results to the government within four months and the government will make further management plans for the proper management of the waste after analysis of the proposals. The recent SWM survey report by ADB, 2013 suggests that if a waste composting facility is built around Kathmandu city, the waste problem of Kathmandu city can be managed as more than 60% of waste in the city is organic waste. The survey also purposed the location of the composting facility in nearby Nuwakot district; moreover, it is estimated around 4 megawatts of electricity could be produced from the facility. However, it is not known whether the quality of waste in Kathmandu city is sufficient for compost production, and this can only understood after intensive research on the quality of waste (Mr. Ojha, of the *Nagarik news* (<http://nagariknews.com/society/nation/story/34800.html>)). Lack of public awareness is the main problem of SWM. In many cases not only residents but also municipal staff are unaware of



management of solid wastes even though they have waste management knowledge [9]. For example, in some cases, incineration of hospital waste does not occur and it is mixed with municipal solid waste, which goes to landfill site without any awareness of its health impact. The scavengers who collect the waste at the landfill site have no safety equipment and face huge health risks. Moreover, people living nearby the landfill are also at risk as they use the water from the river that flows besides the landfill for agriculture and drinking and the chances of the river pollution from the waste is very high. Nevertheless, some hospitals like the Bir hospital in Kathmandu manage all kinds of medical waste in proper and safe way.

### **3. WASTE TO WASTE MANAGEMENT IN DEVELOPED COUNTRIES**

#### **3.1 Waste Management in Japan**

In developed countries, the waste is managed from its collection until its final disposal. Most developed countries have strict laws regarding waste segregation, collection and recycling which helps them recover a lot from the waste and maintain a cleaner environment. Among the developed countries, Japan is a model for waste management due its integrated and effective approach. In Japan in the 1950s and 1960s, high economic growth and rapid urbanization led to an increase in waste volumes and worsening of the sanitation environment due to inappropriate management of waste. In response, the government revised and made various laws for the management and disposal of waste. Construction of disposal facilities and development of technologies were completed. Still there were difficulties in securing disposal facilities and handling disposal volumes. To improve the situation, recycling laws were created during the 1990s and implemented for promotion of recovery of valuable materials which had been incinerated previously i.e. Containers and Packaging Recycling Law, 1995; Home Appliance Recycling Law, 1998; Food Recycling Law, 2000 and End-of-Life Vehicles (ELV) recycling Law, 2002 [7,8].

Currently almost all cities in Japan have an efficient and integrated waste management system. The collection and transport system is very efficient as there are both door-to-door and bring collection schemes that cover combustible, recyclable, non-recyclable and hazardous wastes. The collection and transportation

account for a high percentage of total waste disposal operation costs. During collection of waste, compact garbage collection trucks (1 t to 2 t) are used for greater load capacity. Recently some local governments are using electric and hybrid trucks for the collection and transportation of waste. Japan uses advanced waste incineration facilities to treat part of the urban garbage. Most of the incinerators have energy recovery systems for heat and/or electricity and all of them have pollution control technologies.

In the case of pet-bottles, papers and cans, these are collected separately in different boxes under the 3R policy in accordance with the Act on the Promotion of Sorted Collection and Recycling Containers and Packaging. They are used as recyclable resources and a variety of new products are created. Home appliances are collected in accordance with Home Appliance Recycling Law, 2001 with the concept of Extended Producer Responsibility (EPR) whereby the producer is responsible for the recycling of the product at the end of its life. The recycling of products is more efficient through a high recycling rate using different technologies for more resource recovery that is ecologically safe. Home appliances can be a source of pollution if not managed properly, but can be useful resources if handled properly. Organic waste is also properly treated with byproducts like electricity and fuel. Food waste and sewage sludge is also treated and utilized for generating energy. Similarly, there are different final disposal landfills according to the category of waste. Harmful wastes from industries that contain heavy metals, which can cause severe environmental pollution, are disposed at isolated landfill sites. Non-harmful waste from industries, which can pollute ground water and public areas through odor and pests are disposed in controlled landfill sites. Inert material like plastic, rubber, metal, glass, bricks etc. are disposed in inert landfill sites.

In summary, Japan has established a "Sound Material-Cycle Society" which helps in the establishment of a sustainable society by reducing the environmental load and conserving the consumption of natural resources.

#### **3.2 Waste Management in Tsukuba City**

Tsukuba city is located in Ibaraki prefecture, Japan with area of 283.72 km<sup>2</sup> [17]. It has an estimated population of 219,402 as of 2013 [17]. The total waste generated in Tsukuba city was

79,091 tons per year in 2008 [18]. The waste is collected by the community and local government, which amounts to 1,682 t and 77,409 t, respectively [18]. Households are not responsible for the collection of waste. Industrial waste is mostly managed by the industries. General waste, which is composed of household waste and commercial waste, is managed by the

local government of Tsukuba [18]. Waste in Tsukuba is divided into burnable waste, non-burnable waste, recyclable waste, bulky waste and hazardous waste. The composition of burnable waste, non-burnable waste and recyclable waste is shown in Figs. 5,6 [19] & 7 [18].

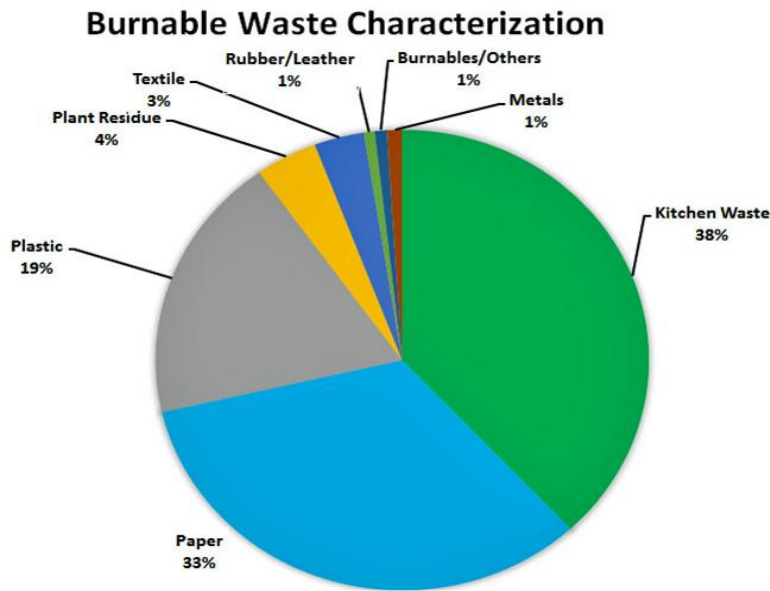


Fig. 5. Characterization of burnable waste in Tsukuba, Japan, 2008

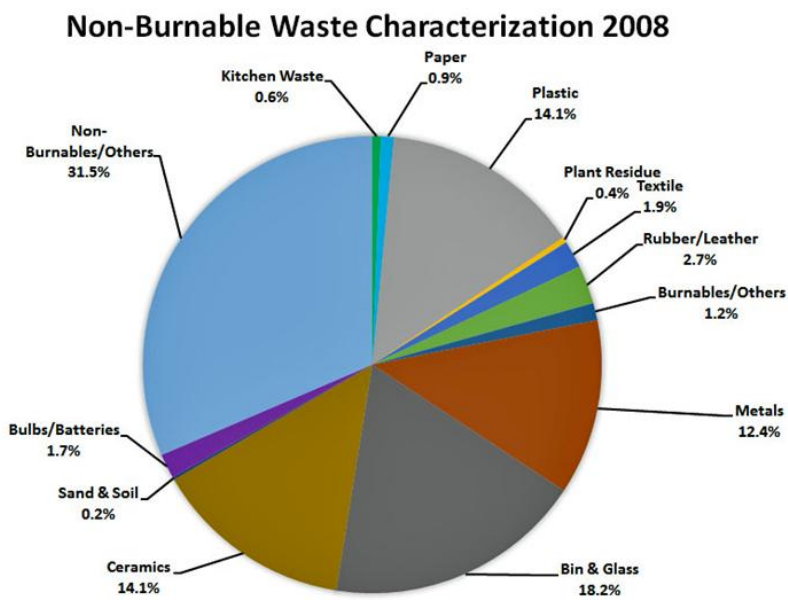
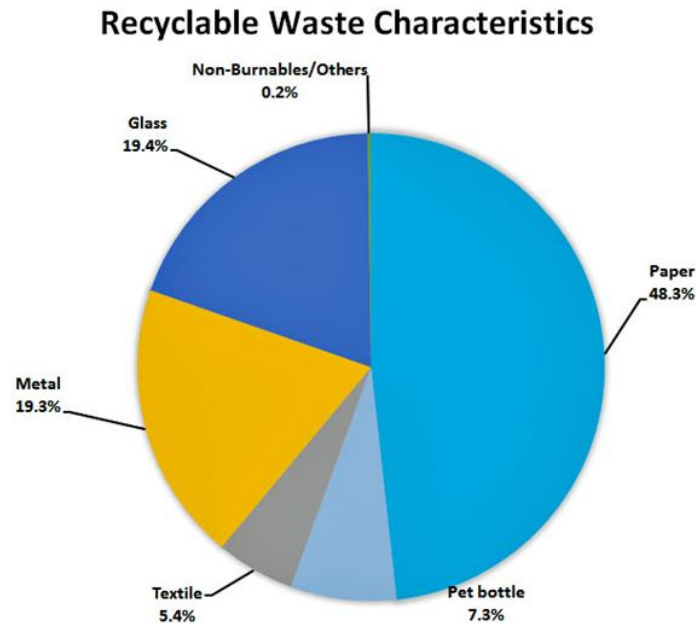


Fig. 6. Characterization of non-burnable waste in Tsukuba, Japan, 2008





**Fig. 7. Characterization of recyclable waste in Tsukuba, Japan, 2008**

Waste in Tsukuba is segregated into different categories such as burnable garbage, cans, glass bottles, spray cans, plastic bottles, non-burnable garbage, used paper & cloth and oversized garbage before disposal at source. All the waste except oversized waste is kept inside specific bags in a designated place on a designated date for the waste removal truck to take. For oversized garbage, a reservation with the Oversized Garbage Collection Center is necessary. Fluorescent tubes and Dry-cell batteries cannot be thrown out directly, and these materials should be taken to receptacles at the city hall or designated community centers [20].

#### **4. WASTE TO WEALTH AND HEALTH IN NEPAL**

##### **4.1 Toward Development of a Practical and Sustainable WADEPOL**

Integrated waste management with proper management of waste from collection, treatment and final disposal of waste to minimize environmental impacts while achieving economic optimization and social acceptance is the solution to our waste problem [6]. The first step in the process of waste management starts at collection. It is ideal to collect all the waste generated in the city through efficient collection points and find a way to take them out of the city. Proper collection points and collection facilities

covering the city are thus required. Later one needs to conduct scientific surveys to collect data on waste generation in order to make further policy and plan waste management accordingly. Residents should be aware of proper waste management and segregation methods so that segregated wastes are collected properly on the designated days. Children should be educated about proper management of waste and the importance of segregation at home as well as at school during childhood. The government should build trust in local people for proper collection of waste and its proper management through incentives to cooperate and help in the management process. In this way, recyclables can be separated from actual waste and can be used as a source of raw material for making compost or useful equipment. The final disposal site should be improved with facilities for sanitary landfill so that the surrounding environment is not polluted.

Many times, low waste value is associated with its mixed and unknown composition. Therefore, the key to waste management is sorting the waste at home/source for sustainable waste management strategies. Plastic, paper, glass and organics, which compose a high proportion of the waste stream in Nepal, can be recycled through use of different technologies like Refuse Derived Fuel (RDF), Material Recovery Facilities (MRF), green-composting and bio-gasification.

Hospitals and industries should take care of medical waste and industrial waste respectively. Care is necessary so that these wastes are not mixed with general waste. The government should formalize the informal sector that works in a hazardous environment by collecting waste from the community bins and final disposal site without any safety measures. Workers in this sector should be provided with safety equipment and health insurance. The high organic waste proportion mixed with all different kinds of waste, sometimes even medical waste, is the feature of waste in Kathmandu city unlike waste in Tsukuba city. Open dumping and littering are very common practice in Nepal. Moreover, there is only one landfill in the city.

In the past, similar problems were also observed in Japan. From 1950 to 1970, rapid urbanization and industrialization created a huge amount of waste in the domestic and industrial sectors. The ensuing pollution resulted in the outbreak of several different diseases such as Minamata disease (caused by accumulation of methylmercury) in Kumamoto Prefecture in 1956 and Yokkaichi Asthma Disease (caused by sulfur dioxide) in Mie Prefecture in 1961. Limited landfill space resulted in a waste management problem at this time.

The Public Cleansing Law, introduced in 1954 had the aim to improve public health by sanitary disposal of waste and cleaning the environment. Further, the government introduced "The Japanese waste management and public cleansing law" of 1970 aimed at health protection using waste treatment technologies with high capacities such as incineration. The law aims on waste classification, business responsibilities and standard for disposal.

In 1980s, the lifestyle of Japanese people changed due to higher income driving the increase and change in the nature of wastes. The products with small volume and great variety were common which led to increased use of plastic products and more plastic waste generation [6]. The government introduced the constructive policies of the 1980s through the mid-1990s based on the 3R principle with the aim to promote recycling (EOL products) and enforcement of actions to protect health. From the mid-1990s, to overcome the challenge of security and resilience, quality of life, global issues and transboundary movements, the fundamental law for establishing a sound material-cycle society was introduced in 2000

with the aim to promote sustainable lifestyle, improve quality of life, and efforts to prevent climate change through low carbon measures. This reflects the step-by-step evolution in Japanese waste management policy and technologies to establish integrated waste management system.

In Tsukuba, the challenge is that almost all organic waste is being incinerated. In Japan, the local governments try to reduce environmental pollution and consider residents' safety the top priority. Thus, the local government in Tsukuba has a very good waste collection system to collect all the waste from city. Local government manages the waste. They collect burnable garbage twice a week and other garbage once in two weeks on respective days. All Tsukuba residents are provided with a calendar including information related to waste, its collection days along with instructions related to designated bags for the designated waste. An example of calendar for north district of Tsukuba for the month of April, May, June and July is shown in Fig. 8. Although it is in the Japanese language, international residents can identify the designated dates for different waste according to the colors and category written at the lower part of the calendar.

Moreover, for the separation of waste, one can find different category of waste bins around the city as shown in Fig. 9. After collection of different wastes separately, the recyclable materials are used for a different purpose or product. The recycled pet bottles are used to make textiles, sheets, egg racks or stationary. Clear glass is used to make clear glass. Brown glass is used to make glass and other glass is used to make asphalt, which is used in concrete for road construction. Aluminum cans are used to make car parts. Steel cans are used to make steel products. Newspapers are used to make newspaper or low-quality paper. Magazines are used to make quality paper and cardboard to make cardboard or an export product. Textiles are exported or reused in factories for different purposes. Moreover, in Japan, they collect municipal tax from residents out of which they allocate a large percentage for management of the city waste. The government of Tsukuba collects 72,732,314,737 yen (602,188,796.94 US \$) [21] in revenue, which includes the 39,702,064,682 yen (328,714,116.32 US \$) [22] tax from the residents for maintenance and smooth running of the city. It includes expenditure 1,980,434,980 yen (16,397,054.90

US \$) [22] on waste management, which is 2.7% of total revenue collected by Tsukuba city. For this reason, it is our recommendation that the government in Nepal should come up with ways

to collect tax for waste management in the city. One suggestion is adding the tax for the management of waste to the electricity bill.

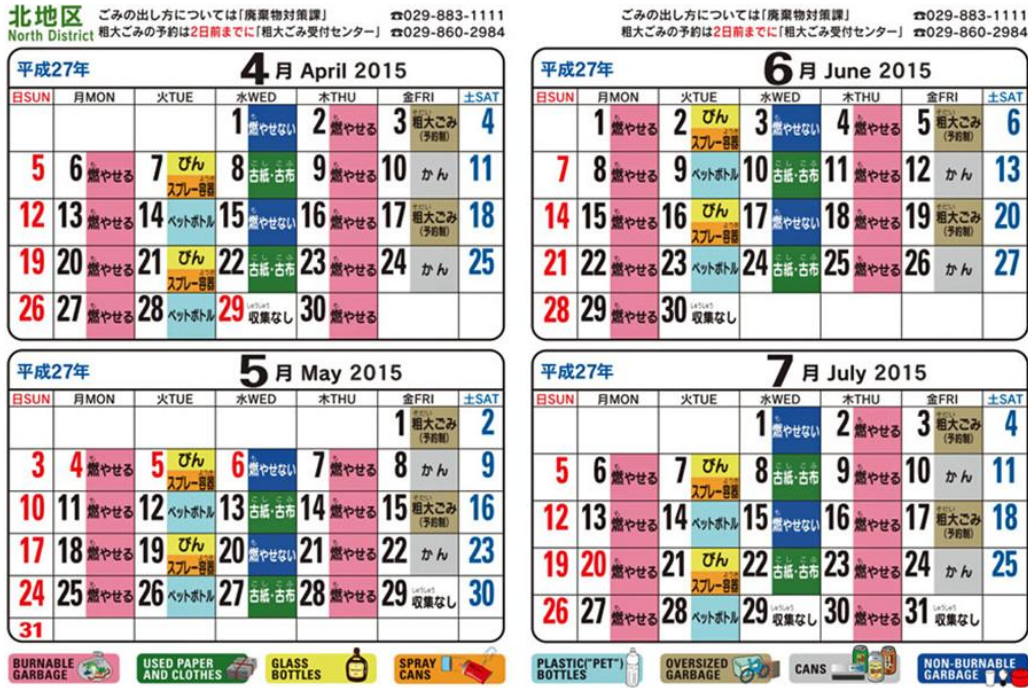


Fig. 8. An example of the north-district waste calendar including information related to waste and its disposal days in Tsukuba, Japan



Fig. 9. An example of different waste classification/collection boxes in Tsukuba, Japan

In summary, learning from the above, firstly, KMC should focus on the total collection of waste from the city and move it away from the city to the final disposal site (Sisdol landfill site) or another location to make the environment and people in the city safe. Secondly, the central and local governments should create strict laws to treat medical waste at source before mixing it with general waste. In addition, incorporation of the informal recyclers into the government waste collection system and provision of safety equipment and measures for them is a necessity. Thirdly, the establishment of proper sanitary landfill is necessary for disposal of the total waste. Only after this, the city should focus on waste classification, waste separation and recycling of waste for resources recovery and sustainability. Furthermore, education of the public in Kathmandu city should reinforce the fact that joint responsibility for managing waste belongs to the government and residents. They should identify with the city, possess a sense of ownership and believe that the city is common property, which must be taken care of by everyone, similar to the Japanese people. Japanese people always follow laws and work on an individual level to make their surroundings or city clean.

Kathmandu city should consider the above treatment system and try to adopt or adapt the system for waste management used by Japan locally according to the available resources. Moreover, research on other developed and even developing countries is necessary to gain further experience on setting up a sound waste management system. The implementation of a nationwide response to the waste management problem must integrate local people, industry, government and academia to develop appropriate policy and strategic planning for Kathmandu city for integrated waste management.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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