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Solid waste management in Belbari Municipality, Morang, Province 1, Nepal

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Abstract

The study was done from January to June of 2018 in Belbari Municipality with the aim to estimate the total waste production, quantity of biodegradable and non-biodegradable, some parameters of solid waste and to detect the common methods adopted in waste management and the relation of economic level in waste production and relation of the education level of people and their ideas or degree of satisfaction for the existing management system. Direct fieldwork was done for the quantification and sorting of the wastes. pH was tested according to Pathak (2017). The temperature was measured according to Daniel (1987) and moisture content by the method of Trautmann (1996). The total waste from Belbari Municipality produced per day was 17.500 tons. The waste contained 62.83% biodegradable and 37.17% nonbiodegradable. The moisture content of dumped wastes was 66.64%, the temperature was 3.33°C, higher than the atmosphere. The average pH of all months was 5.05. On the basis of Chi-square test, there was no relation between the economic level and type of wastes (Biodegradable and non-biodegradable) ($p>0.05$). The most of the respondents (48.5%) revealed that they manage the waste by dumping with cattle dung. On the basis of the Chi-square test, there was no relation between education level and opinion on the demand for new waste management project ($p>0.05$).

Keywords: Biodegradable, composting, dumping, education, income

Introduction

Solid waste management is a global issue in terms of environmental contamination, social inclusion and economic sustainability (Gupta & Kumar, 2015). Solid waste refers to resources that are solid and that we do not use right now. Solid wastes, on the other hand, include any garbage or refuse, wastewater treatment plant sludge, homes, and other abandoned material resulting from industrial, commercial, mining, and agricultural operations, residential areas, and community activities. According to some experts, solid waste is not restricted to wastes that are physically in solid form but can be transformed into various forms and used for a variety of purposes. Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area (Sharma *et al.,* 2014).

Solid waste composition varies a lot from place to location and it also depends on the community, human evolution, and economic development and it changes a lot over time (Kumar *et al.,* 2016). At the beginning of the 20th century, domestic waste consisted the coal ash from open fires (Lewis, 2009).

Increased industrialization and rapid growth not only pose problems in terms of resource allocation and power but also pose serious threats to the natural environment. Solid waste management is described as the process of collecting, processing, and disposing of solid materials that have outlived their usefulness or served their purpose (Kumar *et al.*, 2016).

Solid waste should be managed properly. Poorly managed solid wastes can have a negative influence on human health, while on the other hand, landfilling technology is a poor sort of management strategy. As a result, the likely and relative effects of traditional and current landfill technologies on public health and environmental safety will be assessed in comparison to proposed alternative treatment technologies (Hamer, 2003). Solid waste has been increasing with rapid urbanization, improved living standards and changing consumption patterns (Rao, 1985).

Solid waste management includes the collecting, treating, and disposing of solid material that is discarded because it has already given the service and is now no longer useful in this form (Reddy, 2011). Waste management refers to the activities and actions required to manage waste from its inception to final disposal, which is organized around waste collection, transportation, treatment, and disposal, as well as waste management process monitoring and regulation, waste-related laws, technologies, and economic mechanisms (UNSTAT, 2018).

The study of municipal solid waste management in some cities of Nepal was done but not in Belbari yet. This work aims to find the amount, content, some parameters, existing management practices, local's perception of management projects, etc. The finding of the amount and content of waste supports the following suitable management method. The moisture content, temperature, pH, etc., show the decaying rate and what probability of energy generation. Hence the study was conducted.

Materials and Methods

Study area

Belbari Municipality is located in the Terai region of Nepal, covering an area of 132. Square Kilometers. Its elevation ranges between 112 and 166 meters above sea level. It locates at the coordinates of 26.67°N and 87.43°E. The majority of the town is situated on flat soil. The municipality is included in Province 1's Morang district. It was founded in the year 2015. Letang Municipality and Kanepokhari Rural Municipality border it on the east, Sundarharaicha Municipality and Gramthan Rural Municipality border it on the west, Letang Municipality and Kerabani Rural Municipality border it on the north, and Rangeli Municipality border it on the south. The total population is 65892 with sex ratio of 84.16. The total number of households is 15338 and average household size is 4.296 and the population density 496.21 (CBS, 2011). The municipality is divided into 11 wards. The major residential clusters are Belbari bazaar of Ward nos. 1 and 3, Lalbhitti of Ward no. 2, Tukre bazaar of 4, Kaseni of 5, ward office area of 6, Bahuni of 7, Balwui of 8, Dangihaat of 9, Bhaunne of 10 and Laxmimarga of 11.

The meteorological records are average annual rainfall of 1312 mm, average annual minimum and maximum temperatures of 14.2°C and 30.6°C, respectively (Adhikari & Thapa, 2017).

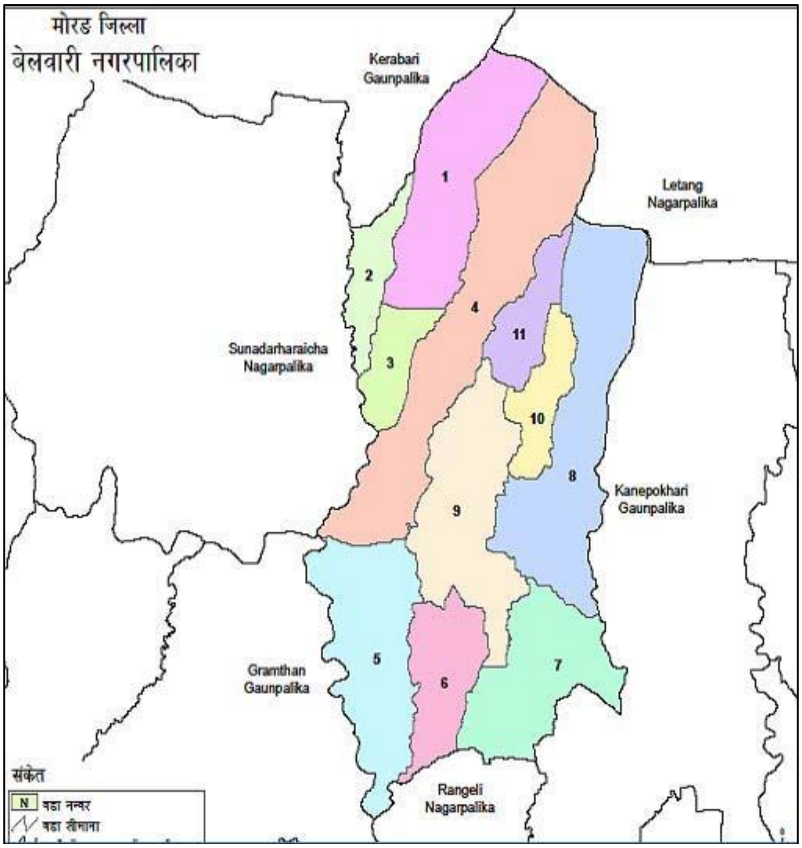

Figure 1. Map of study area.

Materials

For the detail analysis of waste drums, shovel, gloves, forceps, masks, etc. were used. Soil thermometer (Model RT 0124 with cone size of 150 mm fitted with yellow back mercury), pH Meter (SPH 510 pH meter), Camera (Canon 90 D Auto SLR), Electronic balance (NKS Series), and Spring balance (Luggage Scale Digital Electronic Weighing Machine, Upto 15Kg) were used.

Site Selection

The waste was collected from all the wards of Belbari Municipality. The sampled sites were major markets and head quarter of each ward. They were Belbari bazaar of Ward nos. 1 and 3, Lalbhitti of Ward no.2, Tukre bazaar of 4, Kaseni of 5, ward office area of 6, Bahuni of 7, Balwui of 8, Dangihaat of 9, Bhaunne of 10 and Laxmimarga of 11. They were selected depending on purposive sampling technique.

Sample Collection

Tractors collected the wastes from above mentioned sites and carried to dumping site, on the bank of Lohandra river about one Kilometer south of East west highway. Five kg of samples were collected in plastic bags randomly in about one foot depth at about 10 A.M. from dumping site. The collected samples were then taken to a separate place for detail analysis. The analysis was performed within one hour of collection to minimize error from moisture loss and to get accurate results.

Five households were sampled randomly in above mentioned major residential clusters and waste was collected in drum from each household once a week at 10 A.M. with help of trained manpower.

Classification of waste

The wastes from belbari were divided into two categories which are biodegradable and non biodegradable wastes, according to Pathak (2017). Biodegradable wastes: kitchen waste, garden waste, textile, paper, wooden piece, bone & leather. Non biodegradable wastes: plastics, metals and aluminium cans, foam, glass, rubber, construction waste, ceramics, coal and ash, soil, sand etc. By sorting them the calculation of percentage of biodegradable and non degradable was done.

Total production of waste

In order to find out the total quality of waste production, a container of waste was weighed. Similarly, the volume of waste carried by the tractor was also calculated. Now, the volume of carriage was divided by the volume of the container, this gives the total number of containers in a carriage. Total number of containers was multiplied by the weight of the waste in a container. This gives the total weight of waste in a carriage. Finally, daily production of waste from three sites could be estimated by multiplying weight of waste in a tractor's carriage by total number of tractors.

Five households were sampled randomly in above mentioned major residential clusters and waste was collected in drum from each household once a week at 10 A.M. with help of trained manpower. Weight of waste was taken by using balance. It was converted to daily production.

Measurement of moisture content

A sample of 100 gram was taken in a Petridish. The Petridish was placed into hot air oven for 48 hours at 105°C. The calculation was done on the basis of formula given by Nancy Trautmann (1996) as below.

Percentage of moisture content = (X1-X2) x 100/X1

Where, X1 = wt of wet sample

X2 = wt of dry sample

Measurement of temperature

In order to measure the temperature of the solid wastes, Daniel method (1987) was followed the below mentioned way in which the temperature of the collected samples in dumping site was measured by dipping thermometer into the sample up to 10-15 cm depth. At the same time, the atmospheric temperature was also noted.

Measurement of pH

The pH was tested by using electric pH meter. It was also checked by pH paper at the site. One gram sample was mixed into 20 ml of wastes and was shaken well. The pH meter was washed with distilled water and pH was adjusted to 7 by dipping into buffer solution and pH meter was dipped into the sample solution hence giving the pH value of the sample. The above calculation was done on the basis of formula given by Pathak (2017).

Economic level of households, education level of respondents and opinion of local people for the waste management were made cleared by direct interview and questionnaire methods. Chi-square test was done for these findings as following.

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Results and Discussion

Total waste production

Wet waste

Weight of the full drum of waste = 16.50 kg
Weight of drum = 1.50 Kg
Actual weight of waste = 16.50-1.50 = 15 Kg
Number of drums in a tractor = 170
Total number of tractor used = 3
Wet waste production = 510 x 15
= 7650Kg
= 7.650 tons

Dry waste

Weight of the full drum of waste = 8.50 kg
Weight of drum = 1.50 Kg
Actual weight of waste = 8.50-1.50 = 7 Kg
Number of drums in a tractor = 150
Total number of tractor used = 2
Dry waste production = 300 x 7
= 2100 Kg
= 2.100 tons

Wet waste means wastes from market area and household wastes with moisture and dry waste means wastes from the roadside and institutes.

Total wastes collected for dumping in Belbari per day = 7.650+2.100= 9.750 tons
The waste production from households which was not collected officially = 7.750 tons
Total wastes from Belbari Municipality per day = 9.750+7.750 = 17.500 tons

According to one research, the per capita production of solid waste generation in New Delhi (India) was found to be of 0.5 kg waste per person per day (Pienvichtir, 1990). The per capita production of solid waste generation in Bangladesh, Indonesia, Myanmar, and Sri Lanka was found to be of 0.2 kg/c/d, to 3.3 kg/c/d, 0.6 kg/c/d and 0.8 to 0.9 kg/c/d respectively. The United States produced 6,414 pound of waste per individual per day. It produced 160 million tons of garbage's per year with an expected increase of 20% by the year 2000 AD. The range of solid waste weight generated per person per day was between 250 and 1000 gm. depending on the level of industrialization and other factors.

Relying to the outcome of that research it would be about 160.5 million tons per year by 2041 (Annepu, 2012).Tanmoy Karak and other two researchers overviewed the waste production globally. They after reviewing the literature found that in the average the developed countries generate 521.95–759.2 kg/person/year solid waste. The developing countries have the data of 109.5–525.6 Kg/person/year (Karak, 2012).

According to that the Asian developing countries are mentioned here with their waste production rate. Bangladesh produces 0.25 kg/day/capita. Bhutan 0.54, China 0.80, India 0.28, Indonesia 0.90, Nepal 0.35, Pakistan 0.84, Philippines 0.67, Sri Lanka 0.83, Thailand 1.10, and Turkey produces 0.60 Kg/day/capita wastes (Gurrero *et al.*, 2013).

Type of wastes

The study showed that the percentage of biodegradable wastes was maximum in May and minimum in March. In totality of all six months the biodegradable wastes was recorded as 62.83% in average and non biodegradable was 37.17%. Regarding with the composition of wastes in Biratnagar sub metropolice about 72% of waste was biodegradable and rest was non biodegradable (Adhikari, 2005). The next finding wasThe waste if analyzed in landfill site about 40 to 70% organic content might be recorded. Hence it is the method of choice in developing nations because it is the lowest cost disposal option. Not only in developing countries but mostly developed and industrial nation also still using this method of waste management (Agamuthu, 2013). In Kathmandu Valley, Key household waste constituents included 71% organic wastes, 12% plastics, 7.5% paper and paper products, 5% dirt and construction debris and 1% hazardous wastes (Dangi *et al.* 2011). The next study in Kathmandu valley showed that the major waste constituent was the organic with 67.77% of the total waste volume and 32.23% non biodegradable (Sodari & Nakarmi, 2018).

Table 1. Types of wastes in Belbari Municipality

Year	Month	Types of wastes with quantity in Percentage	
		Biodegradable	**Non Biodegradable**
2018	January	63	37
2018	February	59	41
2018	March	55	45
2018	April	57	43
2018	May	73	27
2018	June	70	30
	Average	62.83	37.17

Moisture content

The moisture content of dumped wastes varied from 61.3% to 75.5% from month to month. The moisture content was highest in June. Average moisture content was 66.64%.

One study found that present moisture content measurement techniques suffer from several drawbacks in Orlando. A moisture sensor recorded 72% on garbage materials. Moisture content is a crucial parameters for degradation of solid waste in landfills (Gawande, 2003). The average moisture content of the wastes of Biratnagar was found 64.4, 7% (Adhikari, 2005). The next researcher found that with an energy conversion efficiency of 68.5%, under such a circumstance, the further increase of the MSW moisture content is effective for stimulating hydrogen production (Dong, 2016). The appropriate MSW moisture content is found to be lower than 20-25% in China. In Kathmandu valley in average, the total moisture content in the wastes was 49.93% (Sodari & Nakarmi, 2018).

Table 2. Moisture content of solid waste in Belbari

Year	Month	Moisture content (%)
2018	January	66
2018	February	68
2018	March	61.3
2018	April	62
2018	May	65.8
2018	June	75.3
	Average	66.64

Temperature

During the study period, the minimum atmospheric temperature was recorded 21°C in January and February and maximum in June. The average temperature was 26°C. Similarly the temperature of waste recorded in dumping site minimum 23°C in January and maximum 36°C in June. The average temperature of wastes was 29.33°C. The difference in temperature between atmosphere and solid wastes was about 3.33°C. One study found that annual normal average high temperature was 15.1°C and annual normal average low temperature 5.5°C in USA. The warmest month on record since the beginning of the study has been July or August was 23.5°C. The coldest month on record was December or January and the temperature was -3.3°C (Yesiller, 2003).

The next study found that the temperature of solid waste in China ranged from 22°C to 45°C. During the study, three kinds of controlled temperature were performed which were the variation of weight, leachate and biogas production (Liu, 2016)**.**

Table 3. Temperature of solid waste of Belbari with atmospheric temperature (Dumping site)

Year	Month	Atmospheric temperature (^{0}C)	Temperature of waste in dumping site (^{0}C)	Difference (^{0}C)
2018	January	21	23	2
2018	February	21	24	3
2018	March	26	29	3
2018	April	27	32	5
2018	May	29	32	3
2018	June	32	36	4
	Average	26	29.33	3.33

pH

The observed pH values of the solid waste in different months were tabulated below. The pH value of wastes varied from 4 to 6. The lowest pH was found in January (4) and maximum in May and June (6). The average of all months was 5.05. Some other found alkaline nature (7-8) of municipal waste in Lahore Pakistan. The alkalinity was because of the very less amount of short-chain organic acid mainly lactic acid and acetic acid (Ahmad *et al*., 2016). Next finding regarding with pH was that the pH was 2-4 from the trace metals and 4-8 from heavy metals in China (Ying *et al.*, 2002).

Table 4. pH of solid waste of Belbari

Year	Months	pH of wastes in Dumping site
2018	January	4
2018	February	4.5
2018	March	4.8
2018	April	5
2018	May	6
2018	June	6
	Average	5.05

Economic level and waste production

This study found that the people having economic income below two lakhs produced the waste of 2 Kg/family/day. The family having annual income between two to four lakhs produced waste of 4 Kg/day and family having income above 4 lakhs annually generated wastes about 5 Kg/day. Chi-square was done in significance level 0.05. Chi-square tabulated was 9.49 and calculated was 0.089. Hence, tabulated value was greater than the calculated value. Null hypothesis accepted means no relation between the economic level and type of wastes (Biodegradable and non biodegradable)

In the study of Dharan it was observed that comparatively the production of waste was higher in the middle and lower class family of ward no. 16 whereas it was higher in the upper class family of ward no. 10 (Thapa, 2005). The solid waste has been increasing with rapid urbanization, improved living standards and changing consumption patterns (Rao, 1985). It was estimated that 1.2 billion tons of municipal solid waste was generated in 2016 and due to economic improvement of people and all nations, by 2030 this figure is predicted to increase to 1.5 billion tons and it would be continued and reached to 1.9 billion tons by 2050 (World Bank, 2018). The average municipal solid waste generation rate was 523.8 metric tons/day or 0.66 kg/day as compared to the 320 metric tons/ day reported by the city (Dangi *et al.,* 2011).

Table 5. Economic level versus waste production (weight in kg/family/day)

Annual income	Waste production (kg/family/day)	Degradable waste	Nondegradable waste
Upto 2 lakhs	2.0	1	1
2-4 lakhs	4.0	2.5	1.5
4 lakhs above	5.0	3.0	2.0

Management practice of solid wastes

During the study period and according to the survey done in the various specified areas of Belbari Municipality approximately 200 houses were surveyed and was found that various processes of solid waste management were adopted for treating which were listed below in table. Among them, the mostly adopted method was mixing with cattle dung. Most of the respondents (97) revealed so. Only few (15) give the wastes to collection system of municipality.

In this world in the year of 2015, more than two billion people were without access to such services (UNEP & ISWA, 2015). Among the collected waste only 9% was treated through composting and rest was disposed in uncontrolled open landfills (Talyan *et al.*, 2007). Joshi and Ahmad listed out the practices which were open dumping, landfilling, landfilling to energy generating, thermal treatment, biological treatment like aerobic and anaerobic composting, vermicomposting, etc. (Joshi & Ahmad, 2016). Some people make compost, either at the household level or through the private sector or municipality (Gurreo *et al*., 2013). Composting even in individual (private) level was the best possible option of waste management and it will reduce even small amount of waste to be managed (Lohani, 2017).

Table 6. Practices of waste management in Belbari

S.N.	Practices	Number	Percentage
1	Open dumping	27	13.5%
2	Mixing with cattle dung	97	48.5%
3	Incineration (burning)	32	16%
4	Burying	29	14.5%
5	Giving to collection system	15	7.5%
	Total	200	100%

Peoples' opinion for the new system of waste management

Through the questionnaire survey and interviews with sampled 300 local people it was found that 150 or 50% of respondents expressed their idea for the demanding of new waste management project in municipality.

Chi square test was done at significance level 0.05. The Chi square tabulated value was 5.99 and calculated value was 3.12. The tabulated value was greater than calculated value. Hence null hypothesis was accepted. So there was not relation between education level of respondent and their opinion for the demanding the new project of waste management.

Table 7. People opinion for the new system of waste management

Education level of respondents	New project necessary	New project not necessary	Total
Below SLC	52	48	100
+2 level	55	45	100
Bachelor and above	43	57	100
Total	150	150	300

One research regarding with public perception for the waste management was done in India. It found that, because they are aware of reduce, recycle, and reuse, the majority of households, about 71%, are willing to utilize recyclable materials to transport vegetables, grains, and other items from entire shops/markets (R3). A higher level of community participation in trash reduction at the source through scientific campaigns was required (Kumar & Nandini, 2013). Another study in Malasiya checked the education level and peoples perception. It showed that reuse and recycling behaviors were strongly connected with age and education. Overall, for Malaysia to establish an efficient waste management system, it was critical to provide a comprehensive waste management education (Choon *et al.,* 2017).

Conclusion

The study was done from January to June of 2018 in Belbari Municipality. It aimed to estimate the total waste production, quantity of biodegradable and non biodegradable, moisture content, temperature, pH of dumped waste on dumping site. It also aimed to detect the common methods adopted in waste management and relation of economic level in waste production and relation of education level of people and their ideas or degree of satisfaction for the existing management system. Direct field work was done for the quantification and sorting or classification of the wastes and pH were tested according to Pathak (2017). Temperature was measured according to Daniel (1987) and moisture content by method followed Nancy Trautmann (1996). Chi square test was done for showing the relation between income and waste production and education level and opinion for waste management.

Total wastes collected for dumping in Belbari per day was 9.750 tons. The waste production from households which was not collected officially was 7.750 tons. So, total wastes from Belbari Municipality per day was 17.500 tons. In totality of all six study months the biodegradable wastes was recorded as 62.83% in average and non biodegradable was 37.17%. The moisture content of dumped wastes was 66.64%. The average temperature of dumped waste was 29.33°C which was 3.33°C higher than atmospheric temperature. The average pH of all months was 5.05. On the basis of Chi square test there was no relation between the economic level and type of wastes (Biodegradable and non biodegradable) ($p>0.05$). Most of the respondents (48.5%) revealed that they manage the wastes by dumping with cattle dung. Only few (7.5%) was found giving the wastes to collection system of municipality. On the basis of Chi square test, there was no relation between education level and opinion for the demand of new waste management project ($p>0.05$).

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