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Analysis of Solid Waste in Hospitals of Lahan and Rajbiraj Municipalities, Madhesh Province, Nepal

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ABSTRACT

Hospital waste is a burning issue that severely impacts public health. This study in three big hospitals in Lahan and Rajbiraj, Nepal, for one year (2019 March-2020 February) aims to analyze some parameters that directly help waste management properly. Field study, questionnaire, and interview methods were followed. The average moisture content of wastes of all three hospitals was 55.79%. There was no variance in the three hospitals' moisture content values of wastes (F = 1.89 P-value = 0.165 F crit = 3.284917651). The average temperature of dumped waste was 23.23°C, and the temperature of all three hospitals was closely associated (F = 0.998, P-value 0.379, Fcrit = 3.28). The average pH value of wastes from the three hospitals was 4.44, and it from all three sites was strongly associated (F = 0.0668, P-value 0.935, Fcrit = 3.284). There was no relation between income and types of waste production (χ^2 = 0.8, df = 4, significance level = 0.05), but there was a high association between the level of income and amount of waste production. There was a high association between the nature of hospitals and types and the amount of waste (χ^2 = 77.09, df = 4, Significance level = 0.05). In Sagarmatha Choudhary eye hospital Lahan, there was no significant correlation between the number of patients and the amount of waste (Correlation = -0.187889 at 0.05% significance level). Unique Hospital Rajbiraj showed a correlation between the number of patients and the amount of waste (correlation = 0.1183 at 0.05% significance level). In Gajendra Narayan Singh Hospital, there was a correlation between the number of patients and the amount of waste (Correlation = 0.3453, at 0.05% significance level). There was no association between the qualification of respondents and their responsibilities regarding the services provided by hospitals (χ^2 = 1.43, df = 6, Significance level = 0.05). It is recommended for better management and installment of modern technologies for waste management.

INTRODUCTION

Solid waste is the undesired or pointless waste produced by a region's combined commercial, industrial, and residential activity (Sharma et al. 2014). The process of gathering, handling, and getting rid of solid waste abandoned because it has fulfilled its function or is no longer usable is known as solid waste management (Jerry 2020).

In many areas of Nepal, environmental deterioration, including contaminated water, declining groundwater levels, unhealthy soils, and dirty air, have been affected by waste materials. The resources required to lessen the negative effects of a damaged environmental situation are limited, but their destruction continues (Pathak 2016).

Different types of healthcare wastes, such as sharp, pathological, or other potentially infectious, pharmaceutical, biological, and hazardous wastes, need specific consideration and are typically referred to together as hazardous or special Health care waste (Johannessen et al. 2000). The Health Care Wastes (HCW) cover all wastes produced by medical institutions, research centers and labs (WHO 1999). According to (WHO 2004a), the waste from Health Care Facilities (HCF) falls into the following categories; non-risk and special care required wastes like infectious and high infectious waste and other hazardous and radioactive waste. Approximately 20% of HCF wastes are hazardous, and 80% are general. Managing healthcare waste (HCWM) was regarded as one of the key elements of effective infection prevention methods (WHO 1999).

According to one research, Nepal's healthcare waste equals 0.533 $kg.bed^{-1}.day^{-1}$. There was 0.256 $kg.bed^{-1}.day^{-1}$ of general, hazardous, and non-biodegradable waste, 0.147 $kg.bed^{-1}.day^{-1}$ of biodegradable waste, and 0.120 $kg.bed^{-1}.day^{-1}$ of infectious waste, including sharps, and 0.009

kg.bed^{-1}.day^{-1} of hazardous chemical and pharmaceutical waste (UNEP 2012).

Numerous institutions discard or dump rubbish near ponds, open fields, ditches, rivers, and in the backyards of hospitals and other buildings. Utilizing a container for municipal waste is the third possibility. In various sections of the nation, large hospitals use municipal waste in around 60% of cases (Bhatta 2013).

Nepal's government prioritizes offering all citizens high-quality healthcare services as per the concept 'Health for all' of the World Health Assembly. Government and non-government groups are using various initiatives to address the many diseases and problems the nation is now experiencing. So, the appropriate management of HCW is

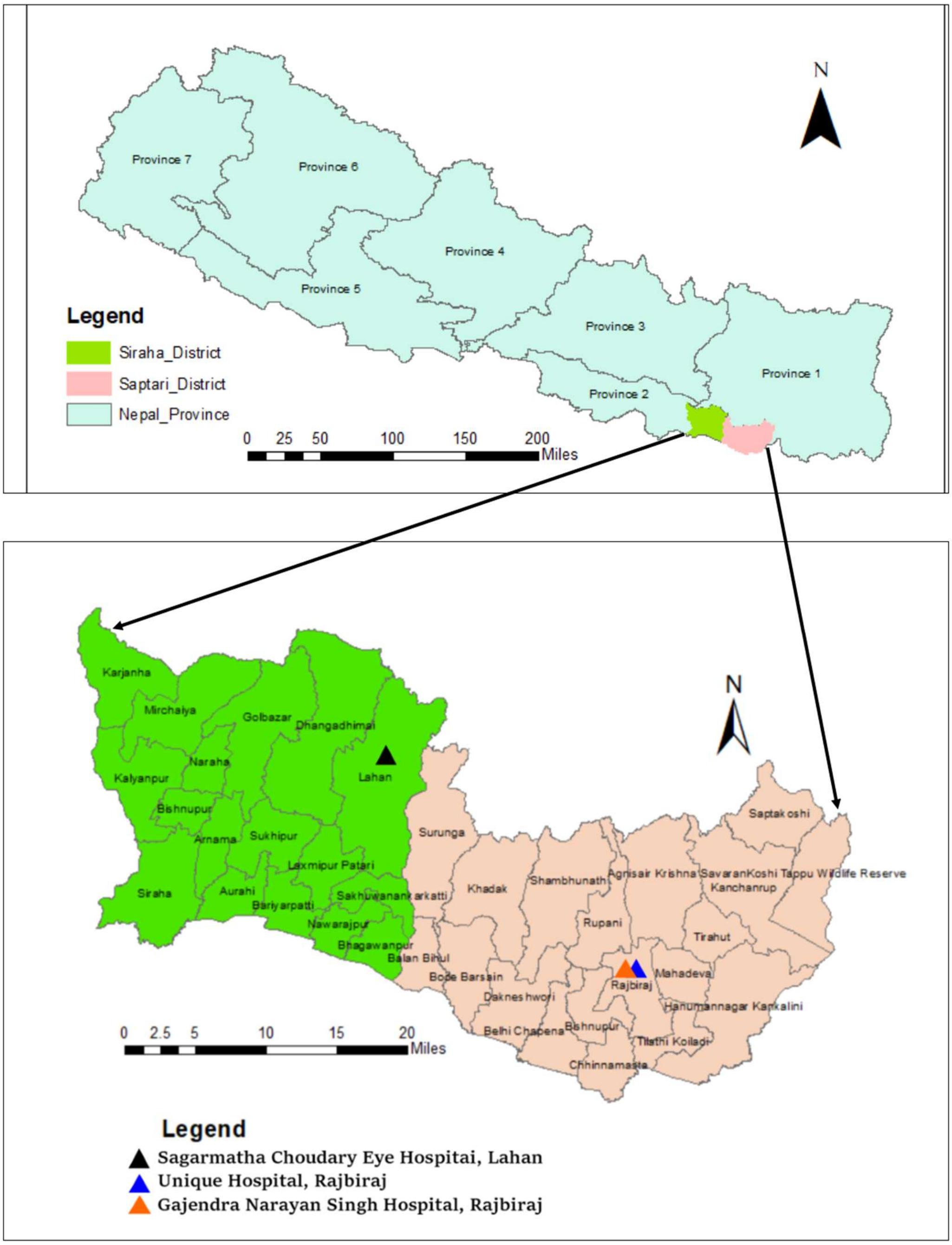

Fig. 1: Map of SCEH, Unique and GNS Hospital Rajbiraj.

one of the biggest issues the nation is now facing. The high risk of infection and the environmental population is caused by poor HCW management. Medical care waste affects the waste handlers, the general environment, and the waste creators. On the other hand, people have the right to survive in a neat and clean environment. Every person in Nepal has a right to a clean environment and basic medical treatment, according to the constitution of 2072.

Some surveys and works have been carried out in hospitals related to solid waste management in Nepal. But we did a different. We selected three big hospitals having over 100 beds in the Saptari and Sirha districts of Madhes province, Nepal. The complete work regarding sources, types, amounts, temperatures, pH, moisture content, and legal measures for healthcare waste has not been carried out in these hospitals. We aimed to analyze the types, parameters, and management practices of solid waste generated from Sagarmatha Choudhary Eye Hospital of Lahan, Unique Hospital, and Gajendra Narayan Singh Hospital of Rajbiraj municipality. We hope this study supports reducing hospital waste and properly managing it.

MATERIALS AND METHODS

Description of the Study Area

Sagarmatha Choudhary Eye Hospital Lahan: Sagarmatha Choudhary Eye Hospital (SCEH) Lahan is non- profitable eye hospital for residents of Eastern Nepal and neighboring districts of India. That was established in 1983 with more than 100 beds. The present services are general OPD, paying OPD, and fast-track OPD. The hospital can handle more than 250 patients in a day. The study area (Lahan) lies in 26.4230 °N, 86.2930°E (Fig. 1).

Unique Hospital: Unique Medical College and Teaching Hospital Pvt. Ltd is a private hospital that was established in January 2001. It is situated in Rajbiraj municipality, with its wing at Raipur. It has more than 100 beds and can handle more than 300 patients. The study area lies in 26.599195°N and 86.722810°E (Fig. 1).

Gajendra Narayan Singh Hospital Rajbiraj: The Gajendra Narayan Singh (GNS)/ Sagarmatha Zonal Hospital in the Saptari district of southern Nepal was established in 1996. It has more than 100 beds and can handle more than 500 patients. The study area Rajbiraj lies in 26.5420°N, 86.7567°E (Fig. 1).

METHODS

Site selection: Three hospitals were selected, one from Sirha and two from Saptari district. The selected hospitals of sites are given in Table 1.

Sample collection: Three color-coded buckets were managed in each hospital ward. The blue bucket was for general waste, the red color bucket was for hazardous waste, and the green color bucket was for sharp waste. The collected waste was bought on-site and transported from the point of generation to assembly storage by wheeled trolleys, containers, or carts with the bits of help of hospital waste management staff from each ward of the hospitals in the evening, daily. In the morning, such collected samples were poured into plastic bags to take their exact weight. It was accordingly (WHO 2004b).

Types of wastes: According to (WHO 1999), the waste from hospitals was divided into three types which were general, hazardous, and sharp. A brief description of them is described below.

- ***General waste:*** Those disposed of at landfill sites are called general waste. Examples are paper, plastic, polythene, metal, carton, food, vegetable waste, dust matter, glass, cardboard, and others.
- ***Hazardous wastes:*** Those wastes with the potential to cause hazards to the health and life of humans are hazardous wastes. Examples of hazardous wastes are cotton, gloves, pus, blood container, gauze-soiled bandage, the cotton used for dressing, blood bags, etc.
- ***Sharp wastes:*** Those wastes used to puncture or lacerate the skin are known as sharp waste. Sharp wastes are infected needles, syringes, scalpels, blades, glass, infusion sets, saws, knives, broken glass, etc.

Total production of wastes: To calculate the weight of general, hazardous, and sharp wastes, the weight from each ward was taken individually. These products (general, hazardous, and sharp) from each ward were summed to find the total weight of sharp, hazardous, and general wastes. The average total waste production per day and every ten days of each month were estimated. Then the average percentage

Table 1: Sampling sites in hospitals.

S.N	Hospitals	Site A	Site B	Site C	Site D	Site E
1.	SCEH Lahan	Refraction ward	Vision ward	Minor OT	Cornea and glaucoma	Retina ward
2.	Unique Hospital	Gynae ward	Pediatric ward	General ward	Emergency ward	Surgery ward
3.	Gajendra N.S Hospital	Gynae ward	Pediatric Ward	General ward	Emergency ward	Surgery ward

of sharp waste was calculated. Finally, the weight from each ward is summed to find out the total weight. This way, the total solid waste produced per day and month was calculated.

Measurement of moisture content: A sample of 100 g was taken in a Petridis. The Petridis was placed into a hot air oven for 48 h at 105°C in the Department of Zoology, Degree Campus Biratnagar laboratory. The calculation was done based on the formula given by (Nancy Trautmann 1996), which was calculated below.

Percentage of moisture content = $(X_1-X_2) \times 100/X_1$

Where X_1 = wt. of the wet sample

X_2 = wt. of dry sample

Measurement of temperature: To measure the temperature of the solid waste, (Daniel 1987) was followed. According to this, the temperature of the collected sample from the selected sites was measured by dipping a thermometer into the sample up to 10-15 cm depth. At the same time, its average was also calculated.

Measurement of pH: The pH was tested by using an electric pH meter. It was also checked with pH paper at the site. One gram sample was mixed into 20 mL of waste in the grinder of the mixture, and it was ground well. The pH meter was washed with distilled water, and the pH was adjusted to 7 by dipping into a buffer solution, and the pH meter was dipped into the sample solution hence giving the pH value of the sample. The above calculation was done based on the formula by Pathak (2016).

$$pH = -\log[H+]$$

Statistical analysis: From the software Microsoft (MS) Excel 2007, The Pearson correlation of the number of patients and the amount of waste in SCEH, Unique Hospital, and GNS Hospital was calculated by the formula

$$r = \frac{n\sum x_i y_i - \sum x_i \times \sum y_i}{\sqrt{n\sum x_i^2 - \left(\sum x_i\right)^2}\sqrt{n\sum y_i^2 - \left(\sum y_i\right)^2}} \quad \ldots(1)$$

Chi-Square was calculated. It was calculated for Economic value versus waste production. The chi-square of three hospitals with three different types of waste was calculated. Similarly, the Chi-square of the education level of respondents and their response to waste management was also calculated by formula.

$$\chi^2 = \Sigma(O - E)^2/E \quad \ldots(2)$$

Where, χ^2 = Chi square, O = Observed value, E = Expected value. Analysis of Variance (ANOVA) was also calculated using Statistical Package for Social Science (SPSS).

Management practices: To study the management practice by direct observation, a questionnaire, focal group discussion, and interview methods were used.

RESULTS

Moisture Content

The moisture content of solid waste of Sagarmatha Choudhary Eye Hospital Lahan varied from 50% to 65.5% from month to month. The moisture content was highest in November. The average moisture content of Sagarmatha Choudhary Eye Hospital Lahan collection was 55.65% (mean value 58.27, standard deviation 4.72, and standard error 1.36)

The moisture content of hospital solid waste of Unique Hospital varied from 52% to 65.5%. The average moisture content of the Unique Hospital was recorded at 50.98%. The moisture content was highest in January (mean value 59.58, standard deviation 5.28, and standard error 1.52).

The moisture content of hospital solid waste of Gajendra Narayan Hospital varied from 50% to 73%. The moisture content was highest in June, and the average was 60.74% (mean value 62.42, standard deviation 5.53, and standard error 1.71). There was a high association between the moisture content of solid wastes in three different hospitals. Hence null hypothesis was accepted, stating there was no difference in the variance of the moisture content value of the wastes of the three hospitals. (F = 1.898 P-value = 0.165 F crit = 3.284917651)

Temperature

In Sagarmatha Choudhary Eye Hospital, the temperature of the waste varied from a minimum of 9.5°C to a maximum of 37.5°C from February to July (The mean value was 55.59, with a standard deviation of 8.85 and a standard error of 2.55). In Unique Hospital, the temperature of the waste varied from a minimum of 9.5°C to a maximum of 36.5^{0}c from January to August (The mean value was 30.08, the standard deviation was 6.99, and the standard error 3.02). In Gajendra Narayan Hospital, the temperature of the waste varied from a minimum of 9.5°C to 37°C in January and September, respectively. The mean value was 29.27, the standard deviation was 8.87, and the standard error was 2.27. The temperature of dumped wastes in all three hospitals was closely associated. Hence null hypothesis was accepted, stating there was no difference in the variance of the temperature of wastes of the three hospitals. (F = 0.998, P-value 0.379, Fcrit = 3.28). The average temperature of the waste was recorded as 23.23°C.

pH

It was found that the wastes from the Sagarmatha Chaoudhary

Table 2: Economic level versus waste production (weight in kg).

Annual income (NRS)	General waste	Hazardous waste	Sharp waste	Total Waste Production in Hospital
0-5 lakhs	5	3.0	1.5	9.5
5-10 lakhs	10	3.5	2.0	15.5
10-above	15	4.0	2.5	21.5
Total	30	10.5	6	46.5

Eye Hospital Lahan had the highest pH value, which was 6.9 in July, and the lowest was 3.7 in April. The mean value was 4.96, the Standard deviation was 1.29, and the standard error was 0.37.

On the wastes of the unique hospital, the pH value was 6.7, which was highest in July, and the lowest pH value is 3.6 in March. The mean value was 4.98, the Standard deviation was 1.22, and the standard error was 0.35.

The pH value of Gajendra Narayan Hospital was highest (pH 7) in August, whereas the lowest pH value was 3.6 in March. The mean value was 4.82, the Standard deviation was 1.10, and the standard error was 0.32.

The pH value of all three sites was strongly associated (F= 0.0668, P-value 0.935, Fcrit = 3.284). Hence null hypothesis was accepted, stating there was no difference in the variance of pH value of wastes of the three hospitals.

The average pH value of the three hospitals' entire sampling site was 4.44.

Economic Level and Waste Production

From Table 2, as a whole, we can say that as the economic level increases, the production of waste increases and vice versa. Hence there was no relation between income and types of waste production ($\chi^2 = 0.8$, df = 4 at a significance level of 0.05). But from Table 2, it can be stated that there is a high association between the level of income and the amount of waste production.

Hospitals and Amount of Waste

Hence it showed high association production of the waste from different hospitals ($\chi^2 = 77.09$, df = 4, Significance level = 0.05) (Table 3).

Number of Patients and Amount of Waste Production

In Sagarmatha Choudhary eye hospital Lahan, there was no significantly correlated between the number of patients and the amount of waste. The calculated correlation (at 0.05% significance level) was 0.187889.

In Unique Hospital Rajbiraj, it showed a correlation between the number of patients and the amount of waste—the calculated correlation (at 0.05% significance level), i.e., 0.118375.

In Gajendra Narayan Singh Hospital, there was a correlation between no. of patients and the amount of waste. The correlation (at 0.05% significance level) was calculated, i.e., 0.3453.

Public Response in Solid Waste Management

The Chi-square value was 1.463, at 6 degrees of freedom, a 5% level of significance which was less than the tabulated value (12.592) (Table 4). It can be described that there was no association between the qualification of respondents and their responsibilities regarding the services from hospitals.

Existing Management Practices

a. Collection of wastes: Three color-coded buckets were managed for different types of wastes.

Table 3: Hospitals and type and amount of waste production.

S.N	Hospitals	General waste	Hazardous waste	Sharp waste	Total waste
1.	SCEH Lahan	12.05	5.39	4.71	22.15
2.	Unique Hospital	16.59	6.28	7.05	29.92
3.	G.N.Singh Hospital	18.6	8.41	9.82	36.83
	Total	47.24	20.08	21.58	88.9

Table 4: Public Response to existing solid waste management.

Education	Good	Worse	Bad	Total
Under SLC	**7**	4	5	16
+2 Level	8	6	4	18
Bachelor	6	5	7	18
Above	7	6	5	18
Total	28	21	21	70

b. Segregation of waste: Collection and segregation of wastes were done, but we found the mixing of all wastes in most cases.
c. Proper sharps management system: Sagarmatha Choudhary Eye Hospital Lahan uses puncture-resistant and sharp leakproof containers, whereas the other two hospitals usually use a needle destroyer to collect sharp waste.
d. Transportation: Different methods transported waste to dumping sites from all hospitals.
e. Safety measures: Only the use of masks, gloves, and shoes for the workers were managed, but no other modern and guaranteed safety measures were applied.
f. Treatment and Disposal: Treatment and disposal of the collected wastes were seen to be defective in these hospitals. They do not have any on-site treatment facilities. Sagarmatha Choudhary Hospital Lahan has an incinerator, but it remains unused.
g. Education training: All three hospitals had a monitoring and evaluation of the waste management works and a reviewing process for the regulation. Unique and Sagarmatha Chaoudhary Eye Hospital Lahan had a sufficient budget allocated for waste management, but Gajendra Narayan Singh Hospital often faces a scarcity of budget.
h. Policy and planning practices: They organized frequent refresher training programs, usually once a year.

DISCUSSION

The problem of healthcare waste (HCW) management problem was growing rapidly with increasing urbanization, modernization, a revolution in medical science, and hospitalization. The waste greatly affects the environment as well as human health.

The quantities and waste generation amount per day/ per week/per month vary widely. Health care wastes generated from different hospitals constitute a variety of wastes categorized mainly as general, hazardous, and sharp waste.

During the study period, the waste types were recorded as bottles, glass, metal, paper, plastic, carton, cotton gauze, gloves, bandages, broken glass needles, syringes, etc. They were produced from different sites such as the refraction ward, vision ward, minor OT, Retina ward, gynecology ward, pediatric ward, general ward, emergency ward, and surgery ward of hospitals.

UNCHS (1990) Studied wastes from hospitals and listed medical wastes, radioactive wastes, industries waste as hazardous wastes, organic wastes, and animal wastes as common sources of waste in the hospital.

The next study showed that medical centers and regional hospitals were major sources of healthcare waste. That study suggested that large hospitals were the major source of medical waste in Taiwan (Cheng et al. 2009).

Shrestha et al. (2014) studied wastes from the market and listed them as the major sources of solid waste production, with 66% of solid waste in Kathmandu. Starovoytova (2018) Studied wastes from industries, hospitals, institutes, municipalities, construction, residence, etc., and concluded that debris and agriculture were the main types of sources of waste.

Medical waste was a source of generation of hazardous biomedical waste. Medical centers, mainly hospitals, clinics, and diagnostic places, were the major places where large amounts of healthcare waste could be produced and might put people at risk of infectious diseases (Padmanabhan & Barik 2019).

This research collected data from different hospitals in Lahan and Rajbiraj over twelve months. The waste was categorized into general, sharp, and hazardous. It was found that out of the total waste generated, 52.21% of waste was general, 25.51% of waste was hazardous, and 22.27% of waste was sharp.

According to the Ministry of Health (MoH), 26% of the waste produced by HCF was hazardous, while 74% was general. According to (WHO 2004), of the entire quantity of HCW produced, 80% was general HCW, 15% was hazardous, 1% was chemical or pharmaceutical waste, and less than 1% was specific waste such as radioactive or cytotoxic waste.

The HCW_s produced at several hospitals in Pokhara city demonstrate that ed, 22% of the HCWs were hazard out of the total trash produced, and the remaining 78% of the garbage was an un-harmful general waste (Enayetullah et al. 2011).

According to CSH 2011, only 25% of the garbage produced by the Civil service hospital in Minbhaban, Kathmandu, was hazardous, with the remaining 75% being general waste.

The above bove scenario showed that the hazardous waste produced from the different hospitals of Lahan and Rajbiraj was improper and non-scientific management of HCWs in the HCFs due to a lack of effective training courses about hospital waste management and their associated hazards then.

WHO (1999) reported that unsafe injection practices (reusing syringes and needles without sterilization) and HCW transmission result in about 20 million cases of hepatitis B, C, and HIV yearly. These viruses are typically spread by wounds caused by syringes, needles, or other objects contaminated with human blood.

The moisture content was higher in November at 65.5%, whereas the lowest was in April in the Sagarmatha Choudhary Eye Hospital Lahan. Among the sampling, Unique Hospital showed that the highest moisture content was 66.6% in January, and the lowest was 52% in September. The moisture content of Gajendra Narayan Hospital Rajbiraj was higher by 73% in June, and the lower moisture content was 50% in September. The average moisture content was 55.65% in Sagarmatha Choudhary Eye Hospital Lahan, 50.98 in the Unique Hospital collection, and 60.74 in Gajendra Narayan Singh Hospital Rajbiraj.

The type and nature of waste determine the amount of moisture content Garbage comprising of meat, fruits, vegetable, etc., have a moisture content of about 70%. In contrast, the moisture content of rubbish (paper, wood, leather, metals, glass) is about 25% (Rajbhandari 1997). The higher the moisture, the greater the chances of microorganisms' growth. The average moisture content of the wastes of Biratnagar was found to be 64.47%.

Some researchers reported that the higher moisture content results in stronger leachate production. This would help particularly at the onset of the biodegradation process. Hence they boldly described the effects of moisture contents on the leachate treatment facilities (El-Fadel et al. 2002). Gawande et al. (2003) found that present moisture content measurement techniques suffer several drawbacks in Orlando. A moisture sensor recorded 72% of garbage materials. Adhikari (2005) suggested any waste containing greater than 80% moisture content will create problems unless the addition of a suitable absorbent takes special care. Nyoung & Vrisheid (2008) reviewed landfill solid waste's physiochemical and biological characteristics. He also described the moisture content of wastes in Japan and suggested higher moisture content higher will be the rate of decomposition. Some authors in Pakistan launched the next work relating to the moisture content with a special research design, and they found the moisture percentage decreased from 50% with the increase in an interval of time. Their results highlighted that the compost was mature in a good way to be used as organic manure or biofertilizer (Ameen et al. 2016).

Sagarmatha Choudhary Eye Hospital, the temperature of the waste varied from a minimum of 9.5°C to a maximum of 37.5°C from February to July. In Unique Hospital, the temperature of the waste varied from a minimum of 9.5°C to a maximum36.5°C from January to August. In Gajendra Narayan Hospital, the temperature of the waste increased from a minimum of 9.5°C to 37°C in January and September. During January and February, the temperature of the solid waste was recorded as the minimum due to the low production, whose land coverage area at the landfill site was less, due to which the recorded temperature was less compared to July when the production of the waste was higher than the average resulting in the accumulation of the waste in the landfill site as bulky so temperature noted down was maximum.

The average denoted soil temperature of the waste was recorded as 23.23°C. Gawande et al. (2003) recorded the maximum average temperature of 28°C and the minimum average temperature of 10.5°C in Orlando. The temperature of waste varied from a minimum of 10.5°C to a maximum of 37°C. The average denoted temperature of the waste was recorded at 23.5°C. Yesiller & Hanson (2003) found the annual average high temperature was 15.1°C, and the annual average low temperature was 5.5°C in the USA. Since the beginning of the study, the warmest month on record, July, was 23.5°C. The coldest month on record was December or January, and the temperature was 3.3°C. Liu et al. (2016) found that the temperature of solid waste in China ranged from 22°C to 45°C. During the study, three kinds of controlled temperatures were performed: the variation of weight, leachate, and biogas production.

It was found that the wastes from Sagarmatha Choudhary Eye hospitals have the highest pH value, 7, and the lowest, 3.7, in August and April, respectively. Among the sampling sites, Unique hospitals showed the highest pH value of 6.9 in the month of 3.6 and the lowest value of August in March. The pH value of the wastes from Gajendra Narayan Hospital showed the highest pH value on July 7, whereas the lowest value was 3.6 in December. The average pH value of all of the sampling sites of the hospitals was recorded as 4.66.

Ying et al. (2002) found the pH from the trace metals and 4-8 from heavy metals in China. Some researchers reported that the pH affects the decaying rate of solid wastes. Acidity or alkalinity changes the basic environment of solid wastes accelerating and retarding microbial activity (El-Fadel et al. 2002). Ahmad & Hazi (2016) found alkaline nature (pH 7 -8) of municipal waste in Lahore, Pakistan. The alkalinity was due to the few short-chain organic acids, mainly lactic and acetic acids.

The output of Hospitals and the amount of waste (between the nature of the hospital and the types and amount of waste) were high association between hospitals and types and amount of waste because the calculated value was higher than the tabulated value. Hence it shows that there was high association production of the waste from different hospitals ($\chi^2 = 77.09$, df = 4 and significant level = 0.05).

The output of solid trash and people's income levels are closely related. According to the study, the amount of garbage produced by households was positively correlated with household size, monthly household income, and other factors. Alternatively, there is a negative link between home trash production and the household head's education level. Poor economic conditions may cause developing nations to create less solid trash, yet poorly managed garbage has been causing several environmental and health issues. Due to urbanization, economic activity, and quality of life, around 145 emerging nations experience comparable issues with solid waste. Issues have worsened as garbage production and population increase have increased (Kumar et al. 2019).

In the next regard, the author reviewed the literature and found that waste production varies according to income level. It was recorded from 0.25 kg to 1.38 kg per capita per day in developing countries. In South South America, it was reported that 1.07 kg per capita per day, and in Asian countries, 0.4 to 1.62 kg per capita per day. And in the African region, it was estimated as 0.49 kg per capita per day of waste production. It was concluded the amount of waste production is directly proportional to the amount of income (Adhikari 2022).

The correlation between the number of patients and the amount of waste produced in Sagarmatha Choudhary Eye Hospital Lahan is no connection between income and the many forms of waste output. (χ^2 = -0.8, df = 4, 0.05 level of significance). In particular hospitals, it was discovered that families with higher income levels produced significantly more solid waste than those with lower income levels. Unique Hospital Rajbiraj demonstrates a strong correlation between waste generation from various situations (df = 4, significance level = 0.05, χ^2 = 179.98. However, there was a link between the quantity of trash produced and the number of patients at Unique Hospital (correlation = - 0.118375). Similarly, from the Gajendra Narayan Singh Hospital (correlation = 0.34). It could be described that there was no association between the qualification of respondents and their responsibilities regarding the services from hospitals (χ^2 = 1.463, df = 6, at significant level = 00.05).

A non-significant negative association was found between polyethylene waste and total monthly income (r = -0.064, p> 0.05). It implies that the production of polyethylene trash declines as household wealth rises (Duminda & Prasansa 2005). The recycling of polyethylene waste was the major cause of the negative connection. In the research region, about 40% of residents recycle polyethylene waste. By doing this, they produce less polyethylene waste at home. The creation of metal was shown to have a significant positive connection (r = 0.308, p 0.05), increased wealth results in more consumption of commodities, which may have contributed to an increase in the production of metal waste.

Present research work clearly showed that in the hospitals of Lahan and Rajbiraj, there were no waste minimization policies to reduce the waste. Only some materials, including glass, plastic, aluminum cans, paper, cardboard, and iron, are recycled without sterilization. But plastic, syringe, and waste are contaminated with radioactive substances and not recycled or reused.

The HCW_s are segregated at the site of generation into color-coded containers, but information for proper handling is not displayed properly. The wastes are collected by trolley and wheel card to store at the storage area before being transported to the off-site treatment facility. The collected wastes are stored for 24 hours. This area is not marked with warning signs but is located away from patient rooms, laboratories hospital functions. The municipal vehicles collected HCW and disposed at the landfill site without pre-treatment.

All individuals who create, collect, receive, store, transport, treat, dispose of, or otherwise handle bio-medical waste in any way should be subjected to the bio-medical waste (management and handling) laws of 1998. Additionally, it provides rules for different bio-medical waste types, color-coding of containers, transportation, and processing using autoclaves, microwaves, and incinerators.

Segregation, mutilation, disinfection, storage, transportation, and final disposal are essential to safely and effectively manage bio-medical waste at any facility (Acharya & Singh 2000).

According to research (CEPHED 2012), just 6.45% of hospitals have any source separation procedures, and 90.32% do not use any environmentally sound waste treatment system. The criteria for establishing the supplied facts are not entirely clear. Still, among them, 67.42% of hospitals have extremely inadequate transportation, and 80.65% do not implement suitable and separate garbage collection.

According to the MoHP research (MoHP 2012), supported by WHO and done at hospitals throughout Nepal, the waste management system was subpar, and only 38.7% of institutions have implemented proper HCW segregation. The rubbish, including medical waste, was by municipal vehicles in Kathmandu and dumped in the Okharpauwa dumping site without pre-treatment. In and near hospitals and disposal sites, most rag pickers may frequently be observed gathering plastic bags, plastic bottles, syringes, needles, and iron materials. These widespread practices increase the danger of illness and harm to rag pickers and the local people.

Research done in western Nepal (DoHS 2013) found that 63% of non-clinical employees and 70% of clinical staff reported a needle stick injury (NSI) or other sharp injuries at some time.

A study by (Bhatt 2013) revealed that almost all of the studies that covered HCF_s focused only on solid waste management, mostly by incineration. 70% of the incinerators were not working as planned due to the lack of skilled manpower, spare parts, high fuel consumption, cultural and public objection, and lack of management commitment. Many institutions dumped or throw waste in the back yard, ditches, rivers, open fields, corners of the hospital building, nearby ponds, or anywhere around the premises. About 60% of the big hospitals in different parts of the country followed municipal waste disposal systems for the final disposal of the HCW.

A cross-sectional study conducted at the Gandaki Medical College Teaching Hospital revealed that 70.79% of healthcare professionals had experienced Needle Stick Injuries (NSI); of these, 52.5% had occurred while using unused needles, and 47.5% had used needles. Of those who had experienced NSI from used needles, 68.42%had reported the incident (Gurung et al. 2010).

In the context of Nepal, it can be actively encouraged for the commercial sector, $CBO_{s,}$ and NGO_s to get involved in collection and transport. Many hospitals in Nepal were found to be in accordance with the Local Self Governance Act -1999. Lahan and Rajbiraj Municipality were deemed to be adhering to the Solid Waste Management Acts to handle solid waste- 2011. Nepal government has formulated dozens of acts, rules, and regulations for the protection of the environment and biodiversity, including waste management acts (Adhikari 2020, 2022).

One research showed that the hospital in Nepal had no healthcare waste management committee. They did not formulate a policy or standard operating procedure for the waste. Especially in the medical waste management system, there was no color coding system for waste segregation and collection of wastes. That investigation also did not find an implementation of particular acts and rules for transportation and storage. No specific well-trained waste handlers were working in the field (Sapkota et al. 2014).

CONCLUSION

This study analyzed the waste physically and categorized wastes into general waste, Hazardous waste, and sharp waste. The research showed that the general waste was higher than the sharp and hazardous waste. Maximum general waste occupied 52.21%, minimum sharp waste occupied 22.7%, whereas the hazardous waste was occupied between the two, i.e., 25.5%.

The moisture content of the solid waste of Gajendra Narayan ranged from 50.08% to 73.0% from month to month. The moisture content was highest in June. Unique Hospital's solid waste's moisture content ranges from 50.98% to 70.0%. Similarly, the Gajendra Narayan Hospital's moisture content of Solid waste ranged from 50.65% to 65.5%. The average moisture of the collection was 50.98% and 55.65%, and the average moisture content was 60.74%. It could be concluded that since the waste had higher moisture content, it could be easily disposable. There was a high association between the moisture content of solid wastes in three different hospitals; hence null hypothesis was accepted, stating there was no difference in the variance of moisture content value of wastes of the three hospitals.

The temperature of the waste varied from a minimum of 10.5°C to a maximum of 37°C. During January, the temperature of solid waste was recorded as minimum due to low production of solid waste whose land coverage area at the landfill site was less due to which the recorded temperature was less as compared to June when the production of the waste was higher than the average resulting in the accumulation of the waste in landfill site as bulky. Hence, the temperature noted down was maximum. The temperature record showed the decaying rate might be slow. The temperature of dumped wastes in all three hospitals was closely associated. Hence null hypothesis was accepted, stating there was no difference in the variance of the temperature of wastes of the three hospitals.

It was found that the wastes from the eye hospital of Lahan had the highest pH value of 7 and the lowest of 3.7 in August and April, respectively. Among the sampling sites considered, the unique hospital showed the highest pH value of 6.6% in August and the lowest value of 3.6 in March. The pH value of the wastes from Gajendra Narayan Hospital was 7 highest pH value in July, whereas the lowest value of 3.6 in March. It could be concluded that the waste was more acidic and harmful to the environment. The pH value of all three sites was strongly associated; hence null hypothesis was accepted, stating there was no difference in the variance of pH value of wastes of the three hospitals.

There was no relation between income and types of waste production. ($\chi 2 = 0.8$, df = 4 at the significance level of 0.05). It was found that families with higher economic levels comparatively produced higher amounts of solid waste in unique hospitals than that in lower ones. Hence it shows that there is high association production of the waste from different hospitals $\chi 2 = 179.98$. df = 4, Significance level= 0.05). The finding showed no positive relationship between the number of patients and the amount of waste production (correlation = - 0.1878) in SCEH. But there was a positive relation (correlation = 0.118375) between the number of patients and the amount of waste produced in Unique Hospital; the same finding was in Gajendra Narayan Hospital (correlation = 0.34). It could be described that there was no association between the qualification of respondents and their responses regarding the services from hospitals ($\chi 2$ = 1.463, df = 6 at significance level= 0.05).

Partly the legal measure was implemented, but it could strongly recommend formulating and implementing more legal provisions. Since wastes contain a high quantity of hazardous (infectious) waste, it is recommended that at hospitals of Lahan and Rajbiraj, judicious reduction, segregation, storage, processing, and disposal of HCWs is essential to reduce the risk to public health. And it is also recommended to install advanced technology for hospital waste management.

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