Journal of Materials and Environmental Sciences
ISSN : 2028-2508
CODEN : JMESCN

J. Mater. Environ. Sci., 2019, Volume 10, Issue 10, Page 909-917

http://www.jmaterenvironsci.com

Scientific Management of Municipal Solid Waste in an Academic Campus – A Case Study of IIT(BHU)

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Received 12 June 2019,
Revised 22 Aug 2019,
Accepted 24 Aug 2019

Keywords
- ✓ *Solid Waste Management (SWM),*
- ✓ *Educational institution,*
- ✓ *biodegradable,*
- ✓ *Segregation,*
- ✓ *Non-biodegradable*
- ✓ *Temple Waste.*

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Abstract

An enormous amount of solid waste is generated daily in cities and towns of India. With increasing urban population, changing lifestyle and dietary habits, the quantum of waste has increased every year which has posed a challenge for authorities to manage it properly. This problem is one of the primary urban environmental issues. Studies have revealed that municipal authorities are only able to collect 40-70 percent of daily waste generated in cities and towns and the rest is left unattended. It causes environmental problems of varied dimensions and damage to human health. It has been observed that uncontrolled open dumping is still prevalent in most areas in general and educational institutions in particular. In the present study, an attempt has been made to analyze problems of waste disposal and its management in IIT (BHU) campus. There are various sources of solid waste such as hostels, mess, canteens, fruit shops, residential colonies and departments in the campus. On the basis of waste characteristics, an economically feasible solution is to find out for the scientific management of day to day collected waste. MSW Quantification & Characterization has been made to investigate types of treatment technology will be applicable in an institutional campus. Lastly, relevant suggestions and recommendations for improving the existing system, have been put forward.

1. Introduction

Waste management (solid and liquid), an important aspect of sanitation, includes handling, storing, collection, transportation, and disposal of waste. Improper and unscientific management of solid waste attracts rodents, flies, germs, etc. causing the spread of various vector-borne and infectious diseases.

Disposal of wastes is largely the domain of municipal authorities and public health engineers. Sanitary officers and health professionals need to have a basic knowledge of the ecology of the subject area since improper disposal of waste causes health hazard to mankind [1]. There are different types of solid wastes generated in cities and towns. It may be categorized on the basis of source of generation or nature i.e. household waste or residential waste, commercial waste, industrial waste, institutional waste, municipal waste, bio-medical waste, agricultural waste, construction-demolition waste and electronic waste (e-waste). The term "Solid Wastes" includes garbage (food wastes), rubbish (paper, plastics, wood, metal, throw-away containers, glass, etc.), construction -demolition waste (bricks, masonry, pipe, etc.), sewage sludge from cleaning and treatment, dead animals, manure and other discarded materials.

On account of the ever-increasing population and changing consumption pattern of commodities, there has been a substantial increase in the quantum of solid waste generated both in absolute and in terms of per capita generation. Like other cities in India, Varanasi is also facing similar problems caused by improper and unscientific disposal of solid waste owing to increasing population, change in dietary habits, the standard of living, and

consumptive uses of commodities and lack of awareness and people participation. The problem of collection, transportation, and disposal of solid waste has presently become a herculean task for the local authorities or the municipal corporation of the city[1].

1.1 Existing solid waste management scenario in Varanasi city

Presently solid waste management system in Varanasi is being managed by Varanasi Municipal Corporation (VMC). Previously, waste management was being managed by A 2 Z. The firm was assigned the task for door-to-door collection, transportation, treatment and disposal of solid waste from all the wards. This memorandum of understanding (MOU) was canceled due to the inefficient performance of A 2 Z Infrastructure Private Limited (2010-2012). Now the VMC along with Infrastructure Leasing and Financial Services Limited (IL and FS) is making use of its own resources to collect and transport the solid waste from every part of the city to the dumping site. In addition to street sweeping, the waste transported to the dumping sites is being treated at Karsanda and produce about 80 tons per week of compost (TOI, 2017)[1]

The waste generated from the city mostly comprises of biodegradable, compostable, and recyclable materials. This is perhaps due to the religious character of the city and the dietary habits of the large population. Besides a huge amount of plastic waste is also generated due to commercial activities in the city. (VMC, 2013). It is estimated that on an average of about 600 MT of waste is generated every day. VMC has employed 2,800 permanent and contractual workers for street sweeping and door-to-door collection of solid waste for all the wards. According to an estimate, solid waste generation will be 1206 MT per day in 2041 which is almost doubled the frequency quantity of solid waste generation. It is based on the projected population for 2014 and per capita generation of solid waste was 420 gm per day which was 400 gm in 2013 (VMC, 2013)[2].

At the southern end of the city, there is a huge campus of Banaras Hindu University inhabiting about 70,000 persons. This campus is much like a small town [2]. Educational institutions represent the main components of sustainability promotion in our society [3].Besides its own population, a large number of tourists visit BHU campus every day to see the campus, Bharat Kala Bhavan the university and Vishwanath temple. it also encompasses a huge area and other infrastructures causing a considerable increase in the quantity of waste every day. If it is not well managed and disposed off scientifically, it will pose risks to human health and other living organisms, environmental effects (CO_2 and CH_4 emissions) and higher running cost implications [4].

1.2 Condition of BHU campus, Varanasi

Banaras Hindu University is one of the largest residential international educational institutions in the country. It is like a small town with a resident population of around 70000 persons including students, teaching staff and non-teaching staff. There are various sources of solid waste generation viz. residential quarters, hostels, messes academic buildings as well as a few grocery shops and canteens. The campus generates around 3-5 tons of solid waste per day which varies from season to season. Besides, Vishwanath temple also generates a considerable amount of solid waste particularly flowers, etc. everyday. The waste quantity is reported high during spring season when trees in campus shed their leaves. The management of solid waste is the responsibility of the Sanitary Support Services (SSS) which has two trucks and a loader along with sanitary workers for collection and transportation of daily refuse. The department has two trucks and a loader for collection and transportation of daily refuse. The frequency of truck is 2-3 trips per day and takes around five days to collect all the waste from the campus. There is no facility of treatment and recycling process within the campus. Hence, all the waste collected is transported to the dumping ground. A good measure including scientific method of treatment like composting and biogas generation is needed to cope with the existing state of solid waste disposal in the campus and also to derive value out of it.

The Indian Institute of Technology (BHU), Varanasi is a public engineering institution located within the BHU campus, Varanasi (Fig.1). One of the oldest engineering college Banaras Engineering College (BENCO) established in 1919. Thereafter, two more colleges of engineering were created in BHU, namely College of Technology (TECHNO) and college of Mining and Metallurgy (MINMET). In 1968, all the three colleges namely BENCO, TECHNO, and MINMET were combined to become the Institute of Technology, Banaras Hindu University. It got the status of Indian Institute of Technology (BHU) on June 29, 2012. It has 14 engineering

[1] Times of India ,Varanasi Edition, (Feb 9, 2017,) https://timesofindia.indiatimes.com/city/varanasi/karsada-plant-starts-selling-compost-made-from-waste/articleshow/57047797.cms.

[2] City Development Plan for Varanasi, 2041, A report issued by MoUD in April 2013.

departments and three inter-disciplinary schools. The IIT (BHU) is spread over an area of about 400 ha within the BHU campus having an area nearly 1,300 acres (5.3 km^2) at the southern end of Varanasi. IIT (BHU) houses approximately 6000 persons. It has 17 hostels for students (12 for boys and 4 for girls) and one multi-flats for couples in addition to teaching and non-teaching quarters and apartments. In addition, it has a Guest House, cafeteria and a few tea stalls and fruit shops.

In the past, management of solid waste was done simply by transporting waste to distant places for open dumping and to allow nature to take care of it. However, the current scenario has changed due to increasing land value and inadequate space, characteristic of waste, limited capacity of nature to decompose unwanted and discarded materials and as a result, residues pose alarming threats to human health and welfare. It is becoming a herculean task for the municipal corporation of the city and Sanitary Support System (SSS) of BHU [1].Nowadays solid waste management (SWM) has become a matter of serious concern authorities and individuals. SWM has six basic components viz., generation, collection, storage, transportation, treatment, and disposal. The ultimate objective of SWM is to reduce the quantum of solid waste disposed of on land through the recovery of materials and energy from solid waste in a cost-effective and environment-friendly manner.

2. Methodology

The solid waste from the different generation point from IIT (BHU) was collected, at the secondary collection point and mixed thoroughly to draw 1Kg sample by using the quartering method & Coning Method. The waste was then characterized and the percentage of each constituent was calculated. An intensive survey is carried out to identify point sources of Municipal Solid Waste (MSW) generation in the campus i.e.Vishwanath temple, fruit shops, hostels, messes, apartments, and residential colonies of teaching and non-teaching staff. An attempt is also made to visit sites of solid waste generation regularly to estimate the MSW spatiotemporal. Further, the waste is segregated to determine the physical characteristics of solid waste and the proportion of biodegradable component in it. The survey has been conducted at an interval of three months to find the out variation in waste generation.

2.1 Sampling and Analysis

Waste is collected from all possible generation points (Figure.1). It is thoroughly mixed and segregated/sorted manually as per MSW rule 2000 [5]. All the categories of material in the waste are separated and weighted to determine their compositions in the total mixture of MSW.

Sampling has also been done separately for all the targeted waste generation points as mentioned below:

- **Vishwanath temple (V.T.)**: A huge amount of biodegradable waste is generated every day from the Vishwanath temple area in the campus. Total waste is collected as sample and sorted out for studying its biodegradable and non-biodegradable components. Further, 10 percent of temple waste is segregated to estimate the content of flower and leaf compositions in biodegradable waste generated from Vishwanath Temple.
- **Fruit Shops**: - There are 3 fruit shops in the campus and their daily refuse is disposed off at roadside. It includes mostly organic or bio-degradable materials. It does not need segregation as it is comprised of only fruit peeling which may be directly used for cattle or biogas plant / composting.
- **Hostel Mess**: To assess the amount of solid waste generated from hostel mess estimates is made from bins put outside the mess premises. The three day average of waste generated depicts the amount to be 1061 kg/day (1 ton/day) with 0.21kg/capita/day but this has been utilized as cattle feed by local milkmen. Hence no food waste stocking is observed.
- **Hostels**: - To asses, the solid waste generation from hostels by weighing total MSW generated per day for two weeks has been undertaken. Randomly wastes from four hostels were selected to make a sample study for determining physical characteristics of waste by segregating garbage. It will help in drawing a conclusion with respect to waste management strategies to reduce, recycle and reuse of waste [4].
- **Residential Colonies:** There are 200 quarters for teaching staff and the same number of quarters for the non-teaching staff. For sampling 10 quarters each of teaching and non-teaching staffs was selected and solid waste generated for every day for a week collected and segregated to find out the content of different components of solid waste.
- **Canteen** – There are 14 canteens in the IIT (BHU). The sample of solid waste generated daily was collected from all the canteens and segregated to assess the quantity of different components. The percentage of compostable materials has been calculated from total waste generated from the canteen.

Figure.1: Location of Collection bins at IIT (BHU).

Table 1: Major point sources and types of MSW in the IIT (BHU) campus

S.no	Sources	A major type of components
1.	Hostels	Food, paper, plastic, thermacol, fruit peels, clothes, Metals, and dust
2.	Mess	Food waste and other waste
3.	Canteens	Plastics, eggs shells and vegetable peelings, food waste
4.	Fruit shops	Fruit peelings, plastic glasses, mug, etc.
5.	Vishwanath Temple	Flowers, leaves, plastic and earthen bowls
6.	Residential quarters	Food, paper, plastic, clothes, vegetables and fruit peels, clothes, metals, and dust

3. Results and Discussion

Effective management of solid wastes requires a complete understanding of the composition of wastes as well as activities involved in its generation [6]. Composition and properties of wastes are different depending on their source of generation, lifestyle, dietary habits Management programs of wastes are more successful if done on the basis of site characteristics [7] [8] [9]. The quantity and characteristics of solid waste vary from place to place in the study area. Vishwanath temple is a holy place in the BHU campus where people within the campus and from outside visit regularly for religious purposes. On a specific occasion like Shivratri and during Sawan month waste increases to an unmanageable amount. They usually offer flowers and other material to Lord Shiva. Consequently, the bulk of refuse of flower waste is generated. This waste is dumped outside the temple and left open to degrade which creates a nuisance and foul odor in the surrounding environment. The residual waste may be used as bio-fertilizers. [10].

Table2: Major Components of MSW at Vishwanath Temple per day.

S.no.	**Component**	**Average weight(kg)**	**Percentage** %
1	Flower	19.15	46.20
2	Leaf	11.3	27.26
3	Packing Leaves	3.6	8.69
4	Others	7.4	17.85
	Total	**41.45**	**100.00**

The solid waste collected from Vishwanath temple has been segregated to assess the availability of resource / reusable material (Fig 2; Table 2).

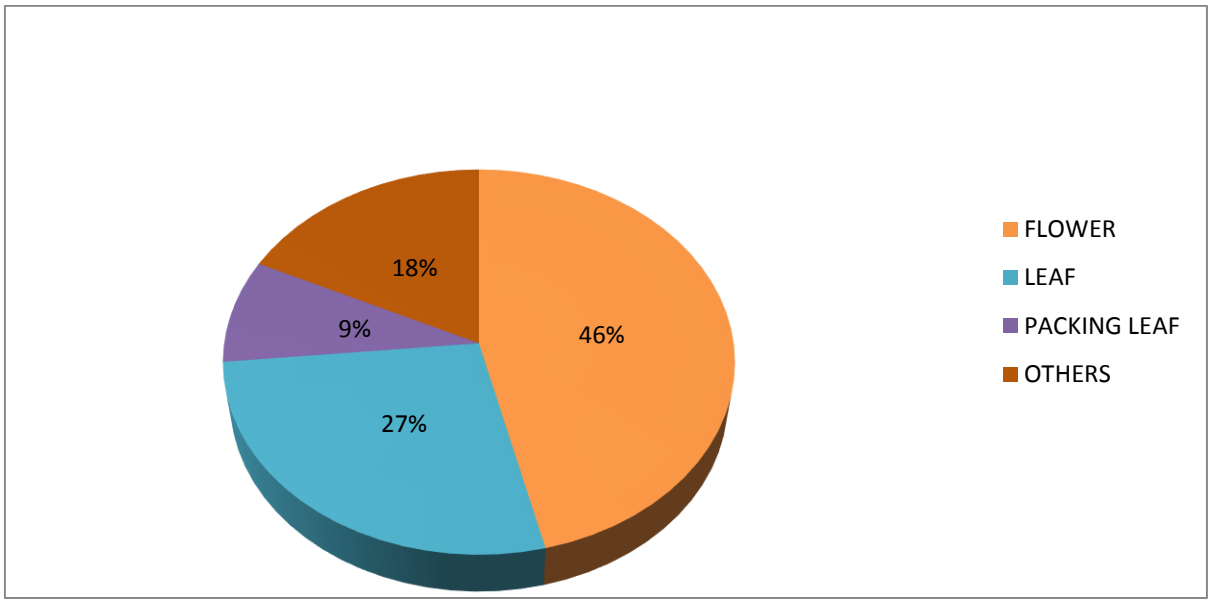

Figure 2: Share of various components in MSW at Vishwanath Temple

Approximately 70-75percent of total MSW generated from the area has a bio-degradable component in the form of flower and leaves, which may be a source feeder for bio-digester/composting [11].

All three fruits shops situated in the campus are also major sources of solid waste generation. On an average of 31 to 48 kg/day of fruit, peels are generated from fruit shops a week.

The waste is directly dumped into community bins in the campus while this waste is purely biodegradable consisting of only fruit peelings that can be utilized for resource recovery.

An attempt has also been made to assess the solid waste generation from the all the hostels situated in the IIT(BHU) campus. Table 3 presents two-week data of quantification of solid waste generated in different hostels under the category of sweeping waste. It is clear from Table 3 that only in Saluja hostel the total sweeping waste generation is less 100 kg in two weeks otherwise in other 15 hostels it ranges between 114 kg to 394 kg. The total waste generation from the entire hostel in the aforesaid period is 3825.42 kg.

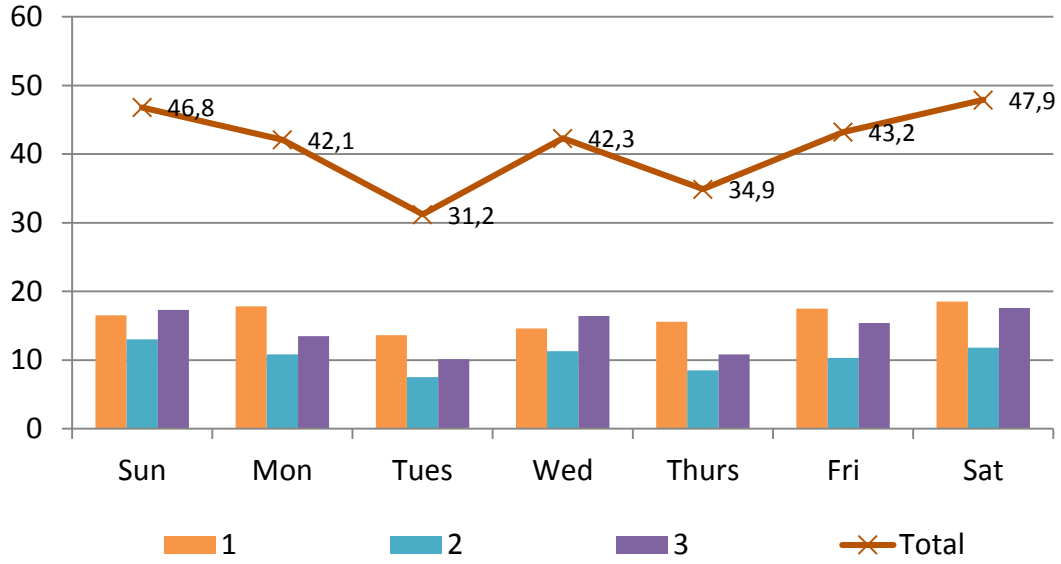

Figure 3: One-week data of solid waste of fruit shops in IIT (BHU).

Table 3: Two-week data of quantification of solid waste generated in different hostels. (Under the category of Hostel Sweeping Waste) in kg.

S.No.	Name of Hostel	in kg	S.No.	Name of Hostel	in kg
1	C. V. Raman	**254.5**	*9*	Vishwakarma	**253.4**
2	Morvi	**233.34**	*10*	Gandhi Smriti	**168.2**
3	Dhanrajgiri	**308.5**	*11*	New Girls GSMC Extn.	**169.1**
4	Rajputana	**393.88**	*12*	Saluja Hostel	**83.2**
5	Limbdi	**283.2**	*13*	G.R.T Apartments	**199.3**
6	S.C. De	**162.3**	*14*	S.N. Bose	**253.1**
7	Visvesvaraya	**330.1**	*15*	S. Ramanujan	**114**
8	Vivekanand	**269.6**	*16*	Aryabhatta	**349.7**
				Grand Total	**3825.42**

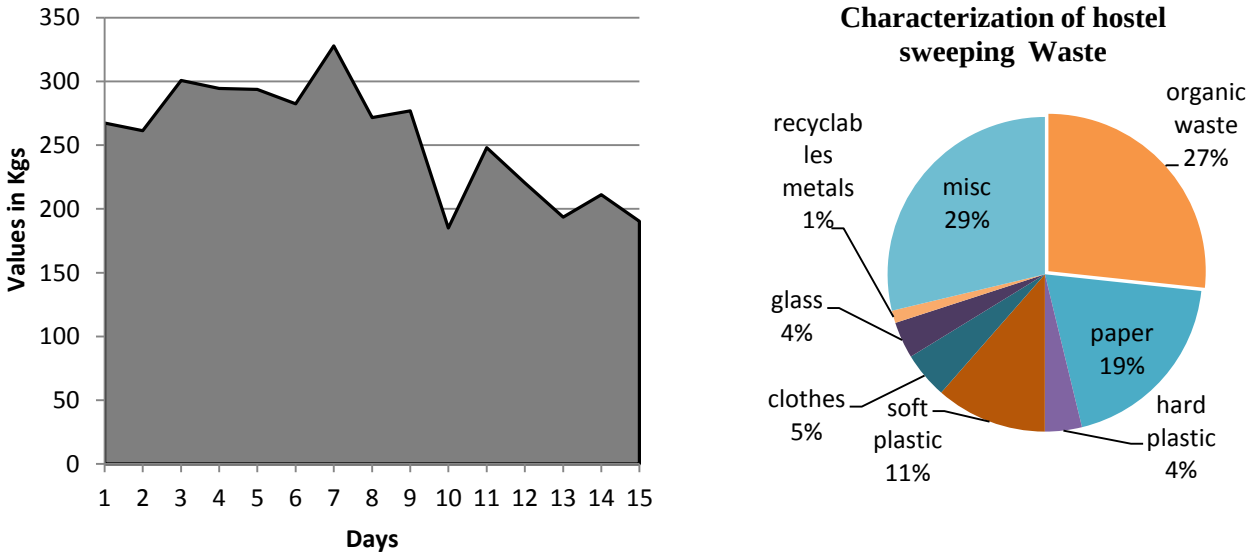

Figure 4: Representing Quantification & Characterization of Municipal Solid Waste from IIT (BHU) hostels.

It is evident from Fig. 4 that everyday approx. 200 kg of sweeping waste is generated from hostels and occasionally it is more than 300kgs. The major portion of organic waste in sweeping consists of leftover food, packaging materials by students. In order to acquire the data regarding solid waste generation from residential areas, ten quarters were selected from both the teaching and non-teaching staffs residential Quarters. It is observed that organic fraction in MSW is very high in non-teaching staff as compared to teaching staff. The reason behind this is the bigger household size including more children in the families [12]. Organic waste and other bio-degradable components constitute a major portion of the total waste generation from both the residential areas in a week. After obtaining all the results from different sources data has been tabulated (Table 4, 5 and 6) Fig. 5 shows a solid waste generation from the IIT (BHU) campus.

Table 4: Quantification of total biodegradable generated in the campus

Bio-degradable (kg).				
Source	**No .of Units**	**Min**	**Max**	**Avg.**
Teaching Staff quarters	200	104	182	150
Non-Teaching Staff quarters	200	146	208	150
Hostels	16	70	87	68.27
Fruit shops	3	31	48	41
Total		**351**	**525**	**409**

***Source:** *Based on field survey*

Table 5: Quantification of total biodegradable generated in the campus.

Non-Biodegradable (kg).				
Source	**No .of Units**	**Min**	**Max**	**Avg.**
Teaching Staff quarters	200	45	118	108
Non- Teaching Staff quarters	200	42	117	70
Hostels	16	200	260	200
Canteens	15	25	52	33
Total		**312**	**548**	**411**

***Source:** *Based on field survey*

Waste generation rates work out to be approximately 409 kg/day biodegradable and 411 kg/day of non-biodegradable materials i.e., 820 kg /day MSW is generated from the IIT (BHU) campus in a day. Hostel mess activities generate about 1060 kg/day that do not enter the collection system of MSW in the campus. This is because most of the food waste generated by the hostel mess is used as cattle feed.

Table 6: Quantification of total MSW generated in the campus.

Components	**Min(kg)**	**Max(kg)**	**Avg.(kg)**
Biodegradable	351	525	409
Non-Biodegradable	312	548	411
Total	**663**	**1073**	**820**

4. Sustainable Solid Waste Management Plan

Solid waste management is an integral part of urban and environmental management. Like many other infrastructural services, it has become great stress and a matter of concern low priority for the public and authorities. It was never taken up seriously either by the public or by the concerned authorities and now a huge amount of waste is piled along the roads and street corners threatening our health, environment, and well-being [13] [14]. Waste minimization is a methodology used to achieve waste reduction, primarily through reduction at

source, but also including recycling and reuse of materials [4].The benefits of waste minimization are both environmental and financial and wide in their coverage [15]. To achieve maximum reduction and recycling rate, this study further focused on designing a management plan based on findings from characteristics of solid waste. The plan has been developed in accordance with the Indian Solid Waste Management Handling Rules, (2000) [5].

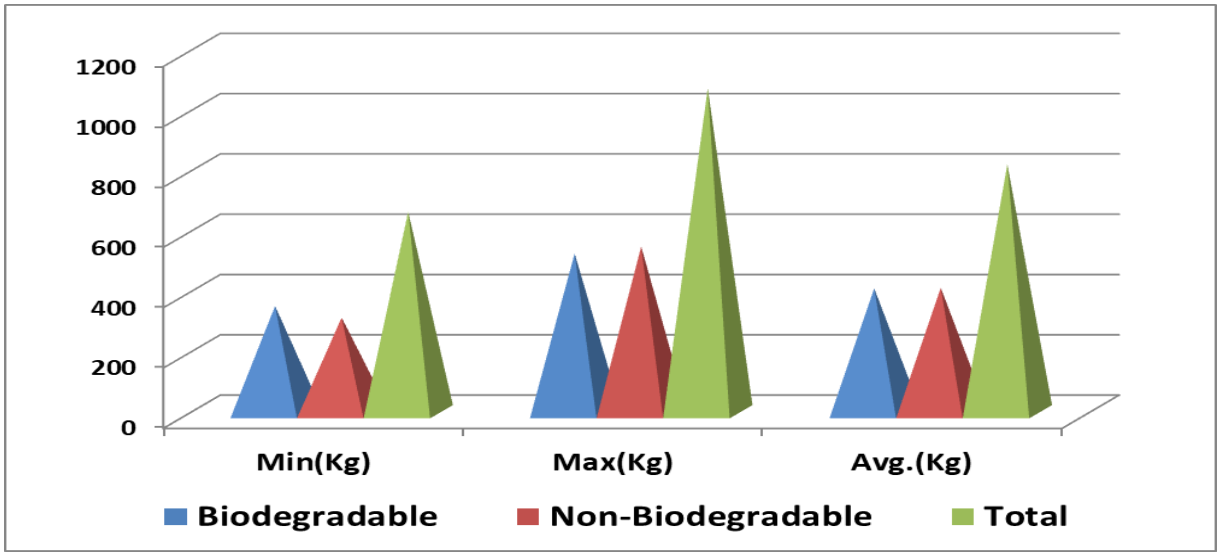

Figure 5: Quantification of total MSW generated in the campus.

The most preferred element in the integrated solid waste management system is reducing waste generation; This can be achieved only through changing the consumptive pattern of materials and source reduction. It is the most effective way to reduce the waste quantity, waste handling cost, and environmental impacts. The waste reduction may be practiced through design, manufacture, and packaging of products with minimum use of material, and longer useful life. The waste reduction may be exercised both at the household and commercial level through selective buying patterns and the reuse of products and materials. This may also be done through 3 R i.e. reuse, recover, and recycling of waste. It will significantly minimize the environmental impacts associated with raw materials extraction, materials manufacturing, and transportation. Recycling involves separation and collection of waste materials for reuse, reprocessing, and remanufacture. Reducing the overall generation of solid waste is not just saving valuable land for landfilling but also curb methane generation that benefits our environment [16].

All the MSW should be segregated at source to be utilized at maximum potential. Biodegradable waste having high organic content may be used for running a Biogas plant handling 400 kg/ day rather than proposed one-ton Bio-boxX in IIT (BHU) campus because the quantity of one-ton waste generated from the messes is completely utilized rather than dumped into bins. So only available bio-degradable waste can be used for either windrow composting or vermicomposting as per area feasibility. The biodegradables can be transported to Bhagwanpur STP located near BHU to utilize in its bio-digestor process. Manual sorting of MSW has a huge proportion of recyclables like paper and plastics which can be sent to recycling units and helpful in creating financial credits. A huge amount of generated recyclable can become a source of livelihood to sanitary workers (sweepers).

Conclusion

Proper solid waste management is an important aspect to minimize environmental deterioration. Awareness of the problems and impacts associated with solid waste generation, collection and transport, and disposal must be promoted through campaign and education. The concerned authority should take an initiative to improve or modify the solid waste management system and create a periodical monitoring system. Also, public and private participation can play an important role in the success of a solid waste management program. A community based integrated solid waste management system could deliver a positive impact on proper waste collection and management in the campus. Waste minimization through proper waste segregation of recyclable

materials will not only help in reducing waste the amount of generation but also in generating additional income to scavengers. Direct disposal of solid waste into open dumps or landfills should be discouraged. Processing of organic fraction of waste (kitchen waste and yard waste) by composting or anaerobic digestion is sustainable options that produce reusable material such as compost or biogas. Inert fractions of waste may be managed by practicing sanitary landfill. Plastic and other combustible fraction in the waste can be processed for Refuse Derived Fuel (RDF) production which promotes "waste to energy" option. Waste should not be treated as a throwaway material only, it is able to sustain part of living needs. Also, it should be managed scientifically in order to preserve the environment and resources for the coming generation.

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