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Characterization and Quantization of Solid Waste in Ganga Villages of Haridwar

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Abstract: One of the most emerging challenges of the modern world of rapid urbanization is management and disposal of solid waste. Solid waste is generated from each and every household of the society so it is one of the most important aspects to consider for the management and disposal factors of generated waste. About 47% of world's population (3.31 billion) and 68.84% (0.83308 billion) of India's population resides in rural areas. The results showed that average daily per capita of household waste and cattle waste generation is 0.18, 18 kg/cap-day respectively. The main portion of household solid waste is organic and bio-degradable which is around 75% and remaining fraction comprise of paper, polythene, plastics, textiles, rubber, glass, metal and inert are 6.62, 2.45, 0.89, 2.57, 0.32, 0.42, 0.41 and 5.26 in percentage respectively. The bulk density of household and cattle waste is 310.33 kg/m3, 805.076 kg/m3 respectively. The physical composition of household waste is moisture content, ash content, organic content is 83%, 31%, and 69% respectively and chemical characteristics (food and organic fraction) of the generated waste including the amount of carbon, nitrogen and phosphorus is 1.74, 0.34, and 0.7 % respectively. Heavy metals in the waste were found to be in a very trace amount, so no further treatment is required.

As the above results show that the bigger part of the solid waste generated in studied areas is organic and bio-degradable and most suitable techniques for this type of waste are composting and bio-methanation. For further treatment, this waste can be composted and used as fertilizer in agricultural fields and another way to deal with this waste is installation of bio-gas plant in which methane can be produced and the remaining slurry can be converted in to nutrient rich compost for agricultural purpose to minimize the chemical fertilizer application especially in the agricultural field nearby the river. Finally, 100% of the solid waste has been utilized and its useful by-products are bio-gas and fertilizer generation, creating a win-win situation.

Keywords: Rural Waste, Solid Waste, Planning, Designing, Implementation, Management Strategies.

I. INTRODUCTION

Solid waste management and disposal are the global challenges, especially in economically developing countries due to their growing populations, life style change, rising community living standards and increasing waste generation rates with the consequent increase in land requirements for waste disposing and dumping. Unsuitable collection and disposal of solid waste can result in problems that endanger human health (breeding of rats and flies that spreads pathogens, water pollution), affect economic, environmental (air and soil pollution), and living organisms, and consequently set back sustainable development.

In spite, of rapid worldwide urbanization in recent decades, according to a report of World Bank, about 47% (3.31 billion) of world's population and 68.84% (0.83308 billion) of India's population is still living in rural areas [1]. Management systems and characteristics of urban municipal solid waste have been reported by several researchers in different cities of developed and developing countries. Nevertheless, characterization, quantification, and management of household solid waste in rural communities have been less surveyed and reported in both developed and developing countries. Some limited studies have been conducted on rural household solid waste by Gonzalez et al. (2010) in northern Mexico, Dorenfeld et al. (2012) in rural Namibian communities, Shah et al. (2012) in villages near Tekanpur in India, El-Messery et al. (2009) in Egyptian rural areas, Mohammadi et al. (2012) in north of Iran, and De Medina-Salas (2013) in Cosautla ´n De Carvajal, Veracruz, Mexico [2-7].

Therefore, less volume of data is globally available about waste generation and composition in rural areas. Thus, without accurate detailed information, rural sanitation authorities would not be able to properly design and operate solid waste management systems in these communities. In addition, in most countries (especially economically developing countries), rural area's household, solid waste management has not received as much attention as urban communities. Therefore, planning waste management programs for rural areas is necessary to prevent the above-mentioned effects on humans and the environment and to reduce economic losses. On the other hand, for successful policy development and implementation of any waste management plan and infrastructure sizing decisions for various facets of an integrated solid waste management program, the availability of sufficient and reliable data on quantities and characteristics of the generated waste is one of the fundamental prerequisites [8, 9, and 10].

Hence, a survey was conducted to analyse the current management condition of solid waste and on the basis of data interpretation there is a need to propose an effective implementation plan for solid waste management system in the five villages nearby Ganga River in Haridwar city, is in the southwestern part of Uttarakhand state of India. Haridwar is situated at height of 314 meters from the sea level, between Shivalik Hills in the North and Northeast and the Ganges River in the south was the key objective of the present work.

II. SURVEYED AREAS

The study was carried out in five villages namely Shyampur, Kangri, Sajanpur, Bhogpur, and Dumanpuri of Haridwar district in Uttarakhand (India). Haridwar is the ancient city and municipality in the Haridwar district of Uttarakhand, India. Haridwar is regarded as one of the seven holiest places (SaptaPuri) to Hindus. Haridwar district has a population over 1,890,422 (2011), about 81% population of whom live in villages and very small in towns. The studied villages come under the peripheral distance 25 km from Haridwar district.

Surveyed areas i.e. five villages, situated at coasts of Ganga River in Haridwar district as shown below in Fig. 1 and their geographical locations/coordinates are mentioned in Table 1.

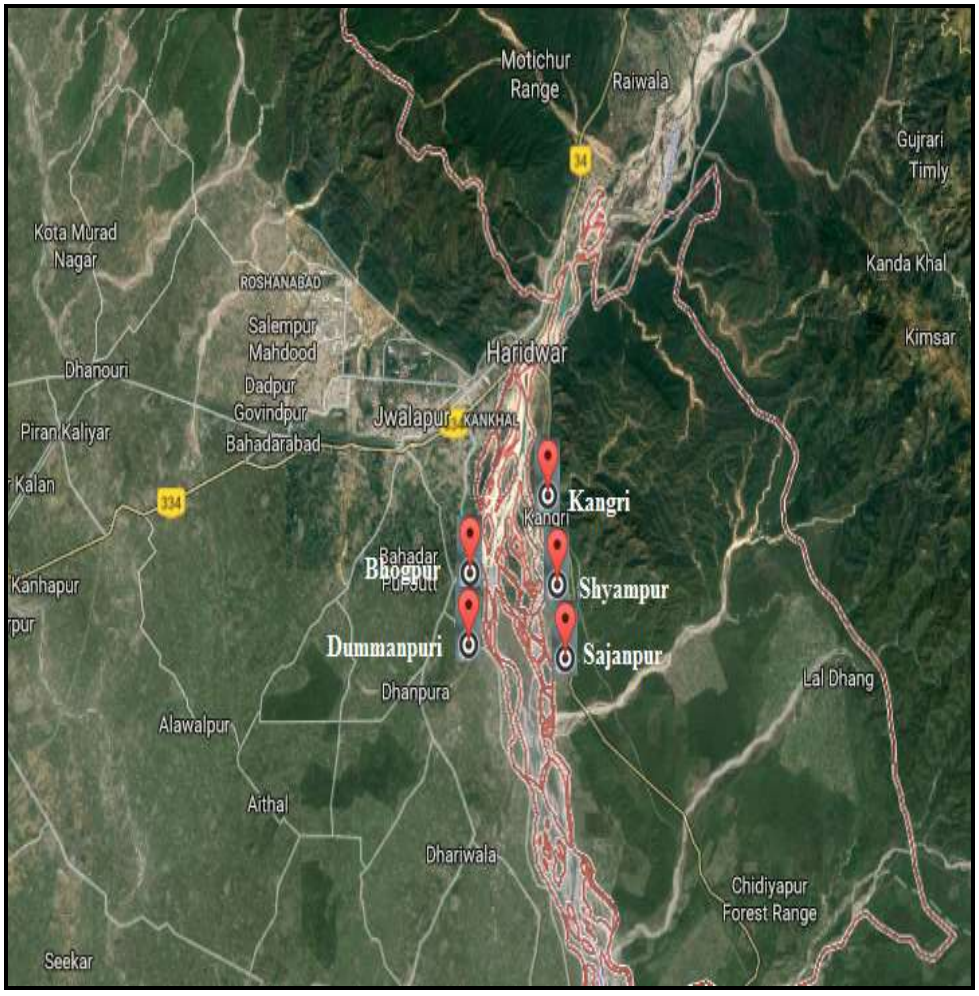

Fig. 1: Location of Surveyed Villages

All above surveyed villages are situated on the bank of river Ganga in which Sajanpur, Shyampur, and Kangri are on eastern side whereas Bhogpur and Dummanpuri are on the western side of the river.

TABLE I
Surveyed Villages

S. No	Village	Area (km^2)	Co-ordinates	Population (2017)	Per capita Waste generation (kg)	Household Waste generated/day (kg)
1	Shyampur	3.58	29°52'00"N 78°10'57"E	2812	0.192	539
2	Sajanpur	3.40	29°51'27.4"N 78°12'7"E	2345	0.180	422
3	Kangri	4.91	29°53'48"N 78°10'25"E	2205	0.189	416
4	Bhogpur	33.62	29°46'56"N 78°10'0"E	9293	0.151	1403
5	Dummanpuri	8.25	29°39'40"N 78°5'17"E	3212	0.170	546

A. Condition of Solid Waste Management in Surveyed Villages

Waste segregation at the source, especially organic and recyclable portions have great environmental and economic advantages. Unfortunately, a systematic source separation program has not been applied to solid wastes (including food waste, plastics, paper and board, metal, and glass) at the studied villages. The residents sometimes separate valuable and profitable items such as metals. Generally, the people do not have enough awareness about undesirable environmental and health risks of solid waste disposal in the studied villages. In all the studied villages, no solid waste management authority was found and the generated waste is dumped openly which leads to various diseases and affects person's health. So, there is concern from environmental and public heath threatens in the villages. In addition to technical and environmental difficulties, the studied villages have serious problems for collection and transportation of generated waste to the disposal site. Of course, the provincial officials and government sometimes help the villages' council for waste management financially and technically, but they are not enough for integrated solid waste management.

III.MATERIALS AND METHODOLOGY

Five villages in the district of Haridwar were selected for the purpose of this study (Table 1). The population of all the studied villages was estimated about 17348 in 2011. Site visits were conducted in all the selected area to gather basic information, assess working conditions and evaluation current condition of waste management.

The survey was scheduled for all days of a week in the month of September and October in 2016. Total of generated waste in 5 studied villages has been gathered to a central disposal site. To determine the quantity and rate of waste generation, all the generated and collected waste was weighed on a daily basis for a total of villages during the investigation period (7–8 days). An access to the per capita rate of generated waste was made through dividing the total daily generated waste of 5 villages by the number of all of the rural population. Simultaneously to determine the physical composition of solid waste in the areas, the collected solid waste was thoroughly mixed and the samples were randomly selected. To determine the waste composition, it was manually sorted into organic and food waste, paper and cardboard, plastics, metals, rubber, textiles, glass, woods, and other wastes (including materials, the composition of which is impossible to be selected and determined, such as unselective organic waste, construction debris, dirt, ash, etc.). These categories were weighted separately and the results were recorded. As mentioned above at all the samples were taken during study for determining of the composition of waste. A special container with the volume of $0.028m^3$ was used to determine the waste volume, which allowed for calculating the onsite density of the waste that was reported in kg/m^3. The samples of solid waste were collected in polyethylene bags, brought to the laboratory, and analysed for moisture (according to wet weight) content immediately. After determining moisture content, the samples were grinded and sieving is done through 2 mm sieve and stored at ambient temperature before analysing for carbon, nitrogen, and phosphor and ash percentage by the standard methods [11].

IV. RESULTS AND DISCUSSION

A. Waste Generation Rates

Accurate measurement of waste generation rate is one of the fundamental prerequisites for planning and designing any waste management program and also that is vital to improve solid waste management practices [12]. Details of the amount of produced waste in the 5 studied villages are given in Table 2. As indicated, 5 villages (together) generated 2.916 ton of waste, while the individual village waste generation in Shyampur, Sajanpur, Kangri, Bhogpur, and Dummanpuri was 476.82, 360.61, 369.72, 1247.46 and 462.05 kg/day, respectively. The highest waste generation was in Bhogpur village due to its large population. These results indicated that average per capita of household waste generation rates in the 5 studied villages namely Shyampur, Sajanpur, Kangri, Bhogpur, Dummanpuri was about 0.192, 0.180, 0.189, 0.151, 0.170 kg/cap-day, respectively. According to Central Pollution Control Board (CPCB), the generation rate of household solid waste in cities of India is 0.5 kg/cap-day [13]. Considering the generation rate of Indian cities, it can be concluded that the waste generation rates of rural areas are less than that of urban areas. Because waste production and composition rates are related to many factors such as development stage, socio-economical, food habits, climate, geographical and cultural conditions.

B. Waste Composition

The composition of generated solid waste is a significant subject in waste management planning in each society, since only based on waste composition, the best methodology for reduction, recycling, processing, and final disposal of waste can be selected and applied [14, 15]. Results of determining the composition and density of the generated solid waste 5 studied villages are presented in Table 4. As revealed in this table, there was no significant difference in the waste composition of the studied villages. However, maximum density was obtained in Shyampur village (334.14 kg/m^3). According to Table 3, about 65 to 80 % of total generated waste in the studied villages was organic and food waste, while paper and cardboard, plastics, metals, rubber, textiles, glass, woods, and other waste constituted 35 to 20% of the total generated waste. Results showed that that about 10 % of the generated waste was directly recyclable waste (including paper and cardboard, plastics, metals, and glasses). So, considering separation and recycling programs at the source can be very useful for reducing waste generation. Due to high percentages of food and organic contents in the studied villages, use of household composting or vermicomposting (as an organic fertilizer, natural and healthy alternative for chemical fertilizers) can be recommended to reduce the generation rate of rural communities' solid waste. Nevertheless, there were highly noticeable differences between the results of this study with those of other rural and urban areas. For instance, as indicated in Table 3, organic and food waste in the current study was 65-80 %. According to the results and survey of the related literature, it could be concluded that the composition and density of the generated wastes vary not only between rural and urban areas, but also between different rural communities, which can be due to variation in geographical, economic, cultural, and social conditions.

TABLE III
Average Waste Composition (%) in Five Studied Villages

Component	Shyampur	Sajanpur	Kangri	Bhogpur	Dummanpuri
Organic & Food Waste	78.46	80.16	65.61	76.52	71.88
Polythene	3.23	2.18	5.54	0.59	0.73
Textiles	1.38	1.09	8.65	1.10	0.66
Rubber	0.35	0.30	0.37	0.22	0.37
Plastic	1.21	1.21	0.74	0.59	0.73
Metals	0.52	0.18	1.21	0.00	0.15
Paper	3.57	2.73	14.14	1.54	11.16
Glass	0.92	0.73	0.47	0.00	0.00
Twigs/Leaves	4.72	4.13	1.32	13.39	8.96
Inert	5.65	7.28	1.95	6.07	5.36
Total	**100**	**100**	**100**	**100**	**100**
Density(kg/m^3)	334.14	324.98	262.71	298.42	227.00

V. MOISTURE AND CHEMICAL CHARACTERISTICS OF ORGANIC AND FOOD WASTE

Moisture content and chemical characteristics of waste including carbon, nitrogen (C/N ratio), potassium and phosphorus are important for assessing the composting potential of waste. The result of analyses of these constitutes the basis on dry weight (since the samples involved measuring moisture content) in the studied villages presented in Table 4. It was not possible to compare the moisture content and chemical characteristics of the waste with those of other rural areas due to lack of access to their data. The amount of moisture content, carbon, nitrogen, phosphorus, potassium, and ash of studied villages are shown in Table 4. The amount of moisture in organic and food waste was reported as about 79–87 % in the studied rural areas.

TABLE IV
Moisture Content and Chemical Characteristics of Organic and Food Water at Studied Villages (%)

Component	Shyampur	Sajanpur	Kangri	Bhogpur	Dummanpuri
Moisture	86	82	79	87	80
Carbon	39.09	39.56	41.45	38.84	41.02
Nitrogen	1.74	2.00	1.13	1.68	1.88
Phosphorus	0.96	1.08	0.94	0.78	0.82
Potassium	0.40	0.46	0.48	0.59	0.53
Ash	33	32	29	30	32

VI. CONCLUSIONS

According to the results and survey of the related literature, it could be concluded that the amount of solid waste production per capita varies in different rural communities, even within a country. Also, generation rates of rural communities are less than those of urban areas. The generation rate of in the 5 studied villages namely Shyampur, Sajanpur, Kangri, Bhogpur, Dummanpuri was about 0.192, 0.180, 0.189, 0.151, 0.170 kg/cap-day, respectively. In addition, it was concluded that the composition and density of the generated waste vary not only between rural and urban areas but also between different rural communities with various geographical, economic, cultural, social, etc., conditions. Less volume of data is available about waste generation and composition in rural areas, and also the household solid waste management of rural areas has not received sufficient attention in comparison with urban communities in most countries. Therefore, more studies are recommended on quantity and quality (composition) determination of waste in the rural communities, also their waste management and disposal systems.

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