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Household solid waste generation and composition in different family size and socio-economic groups: A case study

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ABSTRACT

The household waste (HW) constitutes an important fraction in municipal solid waste (MSW). The composition of HW is an important factor in designing an effective solid waste management plan for a city. The aim of this study was to estimate the quantity and quality of HW in terms of socio-economic groups and family size in the Dehradun city, India. A total of 144 households were selected from 11 major blocks of the city and HW quantification and characterization were analysed for different blocks/colonies. The HW generation rates in the city ranged from 24.5 to 4147.1 g/day. The average HW quantity in households was estimated: 267.17 g/day (SD = 38.13, $n = 144$). The food/kitchen waste was the major constituent (≥80% of total weight) of HW in city the followed by polythene and plastic (≈7%), paper (≈6%), cardboard (≈2%), glass/ceramic scrap (≈1%) and other miscellaneous items (e.g. cloths, silt, dirt, rubber; all ≈4%). The HW quantity and composition varied significantly among different socio-economic groups in the city. The maximum HW generation rate was in higher- followed by middle- and lower-income group. The HW generation showed positive correlation with family size ($r_{xy} = 0.348$, $p < 0.01$). On the basis of obtained data sets, it is concluded that HW can be a potential resource for energy and manure production if proper waste management system is designed for the city.

1. Introduction

The household waste (HW) is an important part of the municipal solid waste (MSW) stream (Dangi, Urynowicz, Gerow, & Thapa, 2008; Dani, Pretz, Urynowicz, Gerow, & Reddy, 2011). The quantity of MSW has been increased several times in urban centres of developing countries during last few decades. The high population growth in urban areas due to rural migrants, changing life style of urban population, economical growth, social improvements in societal groups in urban areas, etc. are the important drivers of this enormous growth in MSW quantity in developing cities of Asia and Africa. The data of quantity as well as quality of HW clearly gives an idea about sustainability of the developing urban centres. HW waste also indicates the socio-economical conditions of the households and urban society. There is an interesting relationship between buying capacity of the urban population and amount of the domestic waste generated (Ojeda-Benitez, de vega, & Ramirez-Barreto, 2003). Few earlier studies have suggested a close interrelationship between waste quantity/quality and socio-economic status of households in developing countries (Qu et al., 2009; Sujauddin, Huda, Rafiqul, & Hoque, 2008; Thanh, Matsui, & Fujiwara, 2010). An increase in income can change the consumption patterns of households which results in changed composition and quantities of HW (Ogwueleka, 2013).

The quantification and characterization of HW should be done in order to design an effective waste collection and waste management plan for the residential block of the city. HW is a heterogeneous type of stuff which contains a variety of wastes of different chemical and biological nature (e.g., biodegradable, non-biodegradable, biologically contaminated, hazardous type, solid, semi-solid, inert, etc.). So such stuff needs close attentions while designing the major waste management processes (handling, segregation, transportation and treatment) to minimize the environmental and occupational health issues related to the whole waste management mechanism. For that a detailed characterization of HW is essentially needed in order to develop an effective waste management plan for the urban residential localities of the city. The solid waste management plan includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes. Unscientific disposal practices leave waste unattended at the disposal sites which attract birds, rodents, fleas, etc. to the waste and creates unhygienic conditions like, odour; release of air borne pathogens; greenhouse gases (GHGs) emissions; breeding

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of disease vectors (e.g., flies, mosquitoes, cockroaches, rats, and other pests), etc. in the surroundings. The uncollected waste piles left in the streets, blocking drainage channels, waste dumped in the watercourses, etc. are the major cause of public health risk. The uncontrolled waste disposal can threaten urban surface water resources and pose significant environmental health risks in residence those living nearby to it (Bhuiyan, 2010).

The composition of HW also reveals the trends of waste reuse/recycling habit which is in practice as informal act in many parts of the developing counties. In this practice, few wastes articles of economical/reusable/recyclable values (e.g., cardboard, plastic, empty liquor bottles, metal/tin containers, old newspaper scrap) are separated by the households (mainly middle-income and low-income groups of the society) for further sell to interim buyers (*Pheriwalas*), street hawkers or junk shops. In this way, such practice also affects the original composition of the HW to be received at community waste disposal and collections points. The composition of HW may also reflect the psychology of the local residents which are major actors of the MSW system of any city. In order to examine the role of households in MSW production and handling practices, a study on HW characterization may be topic of interest for city planners, policy makers and waste handling agencies in the city.

The Dehradun is one of the fastest growing urban centres in India. It is a one of the densely populated hill station in the country, located in foothills of Himalaya with enormous natural beauty and vegetations. As per last census report the total population of the Dehradun city is around 0.58 million (Census of India, 2011). During 1981–1991 the human population growth rate was the highest in India during a decade. This was due to massive migration of people from other areas after declaration of Dehradun as capital of newly carved state Uttarakhand in India. However, other than permanent residents city also has a large floating population of tourists, commuters and business travellers. Tourist arrivals in 2004 and 2005 were 1.25 and 1.26 million, respectively. The migration from remote areas in the city is creating unplanned urbanization and slum development, and these areas produce a lot of unmanageable quantities of solid wastes.

In order to design a decentralized waste handling and management system at community level in the city the characterization of HW need to be investigated for the local needs. The infrastructure availability, socio-economical status of households, social awareness level, environmental education and training, etc. are the important drivers for designing a decentralized HW management system in urban centres. Therefore, the aim of present study was to investigate on few issues: HW quantification and composition in the city, assessment of HW composition and generation rate in different socio-economic groups of the society in the city, and analysing the possibility of utilizing HW as valuable resource for energy and sustainable urban development plan. The information of city's HW characteristics can be further used for designing a community-based integrated solid waste management plan for a urban centre.

2. Materials and methods

2.1. Study site

Dehradun city is located in the foothills of Shivalik mountain ranges, Uttarakhand State, India. The city has an area of about 67 Sq. km. Dehradun is the administrative centre and the interim capital of the State Uttarakhand. The Himalayas borders the District Dehradun in north, the Shivalik forest range in south, the sacred river Ganga in east and the river Yamuna in west. The city Dehradun is surrounded by river Song on the east and river Tons in the west. The climate of this part is generally temperate and it varies greatly from tropical to severe cold depending upon the altitude of the area. The area receives an average annual rainfall of 2073.3 mm. Most of the annual rainfall in the district is received during the months from June to September, July and August being rainiest. The winter months are colder with the maximum and minimum temperatures touching 23.4 °C and 5.2 °C respectively.

2.2. Sampling methodology and data collections

The sampling procedure of HW was designed after in-house planning and workout on patterns of residential settlements in the city. To collect the information on HW quantity and quality, the survey on HW was conducted at mass level for about 3 months (March to May 2011) in the city. After analysing the city's settlement plan and demographical data the areas for survey and HW sample collection were identified in the city. A total of 11 different blocks/colonies in the city were selected and HW samples were collected from 144 houses from different blocks after taking prior consent from household to cooperate in the HW collection project. The sampling was designed by taking care of covering almost all localities of a colony/block for waste collection programme. A detailed questionnaire was prepared for collection of baseline data of sampling locations/points like number of residents per sampled household, total income of the household, HW management, segregation, recycling practices and disposal options. For assessment of socio-economic status of the household the information about annual income of the household, house/building structure, locality of colony, available facilities in house, type of vehicles in house, other luxury facilities in houses, etc. was also collected. On the basis of the collected datasets the participatory households in project were then classified into three sub-categories: low-income, middle-income and high-income group.

After initial workout, the HW sampling programme was started. The HW was collected from pre-fixed sampling points. For that a large sized polythene bag of 10 kg capacity was provided by the research team to households and instruction was given to store all kinds of waste generated from house during 24-h period. After the duration the garbage bags were collected from household and brought to the laboratory for further screening and analysis. In laboratory, garbage bags were emptied and weight of total garbage collected was measured dry weight-basis. After weighing, the garbage was hand sorted to separate the different fractions of the garbage and weighted further item wise. The results of different fractions of garbage were expressed in percent of the total HW.

The household garbage was divided into following main categories:

- Kitchen waste/food waste – peeling waste, discarded vegetables, food waste, discarded food, seeds, etc.
- Paper – paper scrapes, packing papers, discarded papers from students' bags, etc.
- Plastic and polythene bags – plastic articles, polythene and other items made of primarily plastic.
- Glass and ceramic scrap – scrape of glass, bottles, glass containers, broken kitchen articles made of glass and ceramics, etc.
- Cardboards – non-recyclable paper, cardboards, cartons, etc.
- Others – metallic items, can, rubber, textile, leather, jars of metal, soiled paper, wood, saw dust, leaf litter, garden pruning, dirt and other inert material.

After screening the garbage was then disposed safely to the waste collection facilities of the University campus for further disposing of the garbage.