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Recovery of consumer waste in India – A mass flow analysis for paper, plastic and glass and the contribution of households and the informal sector

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ABSTRACT

In most municipalities in India, the collection, transportation and disposal of municipal solid waste deviates from the mass flow envisaged by the municipal agencies and planning authorities. While multiple studies have focused on the environmental problems arising due to uncontrolled waste dumping and combustion, we present a qualitative study of the efforts towards resource conservation and recycling by various actors involved, and a quantitative estimate of the amount of material recovered at various stages.

Both the informal sectors (garbage collectors, waste pickers, waste dealers, small stores and itinerant merchants) and the households in India, play a vital role in recovering consumer waste. In order to have an in-depth understanding, a case study has been performed to better understand the contribution of households, garbage collectors and itinerant waste merchants towards recovering consumer waste. Our study shows that consumer waste is far more efficiently recovered in India than what has been reported in literature until now. The waste recovery takes place in multiple-stages and the final waste that reaches the municipal corporation mostly comprises of biodegradable waste, inerts and highly non-recyclable waste.

Households, itinerant waste merchants and garbage collectors in India jointly recover 1.2–2.4 million tonnes of newspapers, 2.4–4.3 million tonnes of cardboard and mixed paper, 6.5–8.5 million tonnes of plastic, more than1.3 million tonnes of glass, more than 2.6 million tonnes of metal waste and 4–6.2 million tonnes of other recyclable material per year. Overall, 30–60% of all paper and cardboard, 50–80% of all plastic and close to 100% of all glass bottles produced in India are recycled.

1. Introduction

1.1. Recovery of consumer waste in India

In India, rapid industrialization, a growing middle class with surplus disposable income and population growth have led to an increase in demands of consumer products and also an increase in generation of consumer waste.

The current study focuses on the aspect of resource recovery and recycling of consumer waste in particular by the informal sector and households using mass flow analysis as a tool.

Using a combination of new data, industry data and a comprehensive literature review, we provide top-down and bottom-up estimates of the amount of paper, plastic and glass recycled by household and by the informal sector in India. In particular our study quantifies the recovery rate of newspaper, provides first estimates of the amount of mixed paper and cardboard, plastic, metal and glass recovered by, garbage collectors and itinerant waste merchants in India. We make recommendations to improving the

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resource recovery from waste categories currently not treated in a satisfactory manner.

1.2. Waste generation in Indian cities

Numerous studies have investigated the municipal waste generation in India (Chattopadhyay et al., 2009; Gupta et al., 1998; Hazra and Goel, 2009; Kumar and Goel, 2009; Kumar et al., 2009; Pattnaik and Reddy, 2010; Sharholy et al., 2007, 2008; Talyan et al., 2008; Yedla and Kansal, 2003; Zia and Devadas, 2007; Zurbrügg, 2002) and the per capita waste generation in different cities (Agarwal et al., 2005; Gupta et al., 1998; Hazra and Goel, 2009; Sharholy et al., 2007, 2008) and found that per capita waste generation increases much slower than the exponential increase in the Indian GDP since 1991 would suggest. van Beukering et al. (1999) at a time when the informal sector recycling sector in India was still in its nascent stage, suggested that in India, the waste generation increased by ~0.033 kg/capita day for every 1000 INR increase in the monthly per capita income. We summarized the information on waste generation, per capita waste generation and waste composition of major Indian cities for the time period 1999–2013 in Table 1. The monthly per capita income in New Delhi in the fiscal year 1999–2000 amounted to approximately INR 3000. It increased to ~18000 INR in the fiscal year 2013–2014. This should have resulted in an increase of 0.5 kg/capita/day in terms of municipal waste generation, i.e., a per capita waste generation of approximately 0.8 kg/capita/day a value very close to the average per capita waste generation in lower middle income countries 0.79 kg/capita/day (Hoornweg and Bhada-Tata, 2012). Wilson et al. (2012) suggested a logarithmic relationship of per capita income and waste generation and their model fits the increase in waste generation from 1999–2000 to 2004–2005 in most cities ($R^2 = 0.1$) and the data from Pune, the only city with a continuously increasing per capita waste generation, better ($R^2 = 0.8$). However, most cities show no clear increase in per capita waste generation (Table 1), and some show a decline from 2004–2005 to 2010–2011 despite the fact that per capita income doubled in this time period. For Pune the slope of the relationship between the logarithm of the per capita income and the increase in waste generation is a factor 2.9 steeper than the slope reported in Wilson et al. (2012). These numbers demonstrate that the complex reality in India is not easily captured by any model. Often the apparent per capita waste generation seems to reflect variations in the fraction of waste recovered by the municipal cooperation crews rather than the real trend in per capita waste generation. This can be illustrated using the example of Chandigarh and New Delhi. Both have similar per capita income yet the per capita waste generation is different.

Chandigarh is a planned city, which is subdivided into rectangular sectors of 0.8 × 1.4 km each. It is a designated model city with a public private partnership, wherein residents of a sector jointly pay informal sector workers to bring the garbage to the municipal collection points and the municipal corporation transports the waste in closed trucks to a modern waste processing plant (Jaypee's Municipal Solid Waste Processing Plant), a RDF plant (Rani et al., 2012). Only the waste that cannot be treated by the RDF plant is landfilled. The informal sector garbage collectors are allowed to operate using tricycle carts. They sort the waste, deliver only the waste fraction that is of no economic interest to the collection points, and sell the fractions of economic value to informal sector waste merchants. Moreover, those working in the sectors close to the border of the Union territory and in industrial areas frequently bring the waste to a secluded spot, where they recover the waste fraction with is of economic value and dump and or burn the remaining waste. The waste fraction that finally reaches the RDF plant consists of 95% sand, organic matter and inert materials and contains only less than 5% recyclable material, mostly broken glass (Sharma and Arora, 2012). The waste received by the plant is poorly suited for waste to energy conversion via direct combustion and often needs to be land filled. Currently, attempts to retrofit the plant with a MSW drying system to reduce the moisture of the final RDF are under way (Kalyani and Panday, 2014), although biochemical conversion to methane may be a better option for the waste-to-energy conversion of waste with such a high organic matter fraction. The data from Chandigarh aptly demonstrates how efficiently the current system recovers all items of economic value from the waste stream and also results in a very low apparent per capita waste generation (Table 1). Based on our estimates of the amount of materials garbage collectors in a typical middle class neighbourhood recover (Section 3.3), the real per capita waste generation is likely to be ~0.45 kg/capita/day assuming that all garbage collectors offload the waste fraction with no economic value at the municipal collection points and twice the amount if half (i.e., garbage collectors from the two outermost sectors on three sides of the city) sort at other sites in the hinterland and dispose of the fraction that is of no economic interest through dumping and burning.

In New Delhi on the other hand, tricycle carts have been banned in part of the City and there is constant pressure to push the dirty informal recycling sector towards the fringes of the City (Gill, 2009). Distances are large and undeveloped spaces scarce. This hampers the efficiency of the informal sectors waste workers, at least in some of the more affluent neighbourhoods and results in a substantially higher apparent per capita waste generation.

Studies investigating the fractions of recyclable and compostable materials in the municipal waste reaching the final disposal site found that in 1999–2000 an unusually large fraction of the municipal waste consisted of inerts such as soil and ash (40.3%) and the rest comprised of compostable matter (41.8 %), paper (5.7%) and textiles (3.5%) which once soiled are difficult to recover (Narayanan, 2009; Sharholy et al., 2008; Tanaji et al., 2011). The fractions of recyclable materials that can be cleaned after recovery such as plastic (3.9%), glass (2.1%) and metal (1.9%) were surprisingly low (Sharholy et al., 2008). Rajamanikam et al. (2014) reported 31% recyclables for waste segregated at source in Pondicherry, a city that unlike most of the cities in Table 1 does not feature among Indias top 10 cities in terms of per capita income. A more recent study by CPCB & NEERI (2004–2005) found a decrease in the inert fraction, probably caused by the more widespread use of compressed natural gas (CNG) cylinders, and a decrease in the number of households using wood fired stoves, which produce a lot of ash. The same study also found a higher fraction of compostable matter in most cities. A slight increase in the fraction of recyclables was observed in some cities (Delhi, Mumbai, Chennai, Ahmedabad and Kanpur) but a decrease of similar magnitude in others (Chandigarh, Kolkata and Pune).

A high fraction of organic matter is characteristic for municipal solid waste left behind by informal sector recyclers in most developing countries (Wilson et al., 2009; Wilson et al., 2012). Dry waste with economic value is recovered successfully in most developing countries including China (Li, 2002; Mo et al., 2009; Chen et al., 2010), African Countries (Agunwamba, 2003; Fahmi and Sutton, 2006; Masocha, 2006; Nzeadibe and Iwuoha, 2008), Latin America (Medina, 2000, 2005; Dias, 2011); and other Asian countries (Beall, 1997; Zurbrügg et al., 2012), while, successful models for the recovery of organic waste are more limited (Binns and Fereday, 1996; Cofie et al., 2005; Nunan, 2000; Zurbrügg et al., 2004, 2012).

A limited number of studies in India have investigated the role of the informal sectors, in particular the role of waste pickers and scrap dealers in recovering various materials such as paper, plastic, glass and metal (Agarwal et al., 2005; Kashyap et al., 2010; Talyan et al., 2008; van Beukering, 1994; Zia and Devadas 2008)