Household food waste disposal in South Africa: A case study of Johannesburg and Ekurhuleni

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Food waste is becoming an important issue in light of population growth and global food security concerns. However, data on food wastage are limited, especially for developing countries. Global estimates suggest that households in developed countries waste more food than those in developing countries, but these estimates are based on assumptions that have not been tested. We therefore set out to present primary data relating to household food waste disposal for South Africa within the sub-Saharan African context. As the Gauteng Province contributes about 45% of the total municipal waste generated in South Africa, the case study area covers two of the large urban metropolitan municipalities in Gauteng, namely Ekurhuleni and Johannesburg, with a combined population of 8.33 million, representing nearly 15% of the South African population. Municipal solid waste characterisation studies using bulk sampling with randomised grab sub-sampling were undertaken over a 6-week period during summer in 2014 (Johannesburg) and 2016 (Ekurhuleni), covering a representative sample of the municipal waste collection routes from households in each of the two surveyed municipalities. The food waste component of the household waste (excluding garden waste) was 3% in Ekurhuleni and 7% in Johannesburg. The results indicate that an average of 0.48 kg (Ekurhuleni) and 0.69 kg (Johannesburg) of food waste (including inedible parts) is disposed of into the municipal bin per household per week in the two municipalities, respectively. This translates into per capita food waste disposal of 8 kg and 12 kg per annum, respectively, in South Africa as compared to the estimated 6–11 kg per annum in sub-Saharan Africa and South and Southeast Asia.

Significance:

- Research on food waste in developing countries is limited.
- This study is the first of its kind undertaken in South Africa.
- Food waste research is important to address food security issues.
- This study provides evidence to support Sustainable Development Goal 12.3.

Introduction

Global estimates suggest that the world population will reach 9.6 billion by 2050.[1] At current lifestyle patterns, it is estimated that we will need the equivalent of nearly three planets to sustain the world population in 2050.[1] Increasing food production to ensure food security will put additional pressure on already constrained natural resources.[1] Yet, it is estimated that between a third and a half of all food produced globally never reaches the point of human consumption.[2] It is ethically unacceptable to waste food that could be used to feed people.[3] In South Africa, 12 million people (24.5% of the national population) go to bed hungry each day[4] and it is reported that South Africa has the largest proportion of food wastage in Africa[5]. Food waste can be seen as having a triple negative impact: (1) the waste of resources (including water and energy) used along the supply chain in the production, handling and distribution of food that is not consumed by humans; (2) the socio-economic impacts associated with food insecurity; and (3) environmental impacts associated with waste and emissions (including greenhouse gas emissions) generated during the production, harvesting, processing, distribution and disposal of food that is not consumed.[6]

All households, irrespective of income level, contribute to food waste.[7-9] Baker et al.[10] found a direct relationship between household food waste generation, household income and the number of people residing in a household. Food waste decreases when there are more occupants, yet increases with household income level.[10] As such, households in wealthier countries tend to generate more food waste than those in developing countries; while in all cases there are significant economic costs associated with food waste. The average annual cost of household food waste in South Africa is ZAR21.7 billion (EUR1.5 billion at an exchange rate of ZAR14.40/EUR1.00)[11]. Annual costs of food waste in Europe are reported as ZAR7 200 million (EUR500 million) in Finland[12], ZAR388.8 billion (EUR27 billion) in Norway[13], ZAR30.96 billion (EUR2.15 billion) in Denmark[14] and ZAR126.7 billion in the UK (GBP10.2 billion at an exchange rate of ZAR12.42/GBP1.00)[15]. Therefore, preventing food wastage will not only save money for households, but will have broader economic, social and environmental benefits.[16] Reducing food waste will address food and water security concerns[17] and contribute to the development of more sustainable food systems[18].

The choice of food waste disposal system by households can have environmental implications (e.g. composting is preferable to throwing food in the trash), but the largest environmental benefits will be derived from preventing food waste altogether.[19] Research found that 60% of the total household food waste in the UK is avoidable.[20] Initial findings of ongoing research in South Africa noted similarities in the food types being wasted as well as the reasons for wasting food between households in the City of Tshwane and the UK.[21] The main reasons why food is thrown away in the UK is because it either 'wasn't used in time', or too much was cooked, prepared or served.[20] Similar

reasons for food wastage are reported for households in South Africa.[9,21] The potential therefore exists that food waste at household level in South Africa can be reduced.

Comparing per capita food waste at consumer level between different studies is problematic because of non-standard definitions and sampling methods when measuring food waste.[22] Attempts have therefore been made to standardise the definition of food waste. For example, a project commissioned by the European Union proposes the following definition:

> *Any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea).*[23]

The data reported in this paper include the edible and inedible parts of food that is disposed of by households into the municipal bin but exclude food waste being composted, fed to animals or disposed of in any manner other than in the municipal bin.

Current estimates of food wastage (edible portion only) throughout the value chain suggest that 'on a per capita basis, much more food is wasted in the industrialised world than in developing countries'[24]. The water and carbon footprint of the food wasted in the industrial world extends beyond the boundaries of the country in which the food is wasted, to the countries where the food is produced and processed.[17] The environmental impacts of wasted food are therefore a global issue in light of globalised food markets.

The per capita food wasted (edible portion) by consumers in Europe and North America is estimated to be 95 kg and 115 kg per annum, respectively; as compared to only 6 kg and 11 kg per annum in sub-Saharan Africa and South/Southeast Asia, respectively.[24] If we assume that food wastage patterns in South Africa are similar to those in the rest of sub-Saharan Africa, then South African households contribute about 4% of total food waste in South Africa.[6] The latest published estimates of the magnitude of food waste at consumer level in South Africa, using estimates from Gustavsson et al.[24] regarding the proportion of food wasted at each stage of the value chain (on average for sub-Saharan Africa), together with the Food and Agriculture Organization of the United Nations data on actual food production in South Africa, is 501 000 tonnes per annum[25]. This translates into 9.68 kg per capita per annum using 2011 population statistics for South Africa.[26]

In an earlier study, following a different methodology (i.e. using estimates from waste characterisation studies conducted in South Africa across various municipalities rather than Gustavsson et al.'s averages for sub-Saharan Africa), Nahman et al.[11] estimated household food wastage in South Africa at 1.4 million tonnes per annum, or 28 kg per capita per annum. This is nearly three times the 9.68 kg per capita per annum estimated by Nahman and De Lange[25]. However, Nahman et al.[11] caution that the 28 kg per capita per annum may be an overestimation, because of the difficulties of extrapolating food waste quantities from the reported organic waste quantities derived from waste composition analysis.

A study of households in the City of Tshwane, South Africa, found the average food waste generation to be 6 kg per household per week across income groups (with an average three people per household),[27] which is equivalent to about 98 kg per capita per annum. In this study, source separated food waste from 133 participating households was collected and weighed.[27] The study by Ramukhwatho[27] provides an accurate measure of the actual food waste generation across income groups prior to treatment or disposal, whereas the report by Nahman et al.[11] estimated the average food waste disposed of in the municipal bin.

The results from the studies by Nahman et al.[11] and Ramukhwatho[27] suggest that post-consumer food waste in South Africa is higher than in the rest of sub-Saharan Africa. South Africa is one of the high-income countries in the region, with a larger and more advanced economy in comparison with the rest of sub-Saharan Africa.[28] Higher household incomes are associated with a decline in consumption of starchy food staples and increased diversification of diets towards more fresh fruit and vegetables, dairy, meat and fish.[22] However, the study by Ramukhwatho[27] found that starchy foods (mealie pap, bread and rice) are still the most wasted food types across income groups with higher-income groups wasting more rice and vegetables as compared to middle- and low-income households. Wealthier people are reported to buy more food as a result of affordability[29] and are therefore likely to waste more. However, Koivupuro et al.[30] found no correlation between households' income levels and the amount of food wasted in Finland. Household food wastage in urban South Africa can be expected to be higher than in the rest of sub-Saharan Africa as a result of affordability, but this expectation still needs to be confirmed.

The small sample size (133 households) included in the study by Ramukhwatho[27], and the difficulties expressed in the paper by Nahman et al.[11], highlight the need for more accurate data on household food waste from a representative sample of households in South Africa. The data reported in this paper were collected as part of municipal solid waste characterisation studies in Johannesburg and Ekurhuleni – two of the larger urban metropolitan municipalities in the Gauteng Province of South Africa during the summers of 2014 and 2016. A limitation of reporting the results of two independent studies is that only directly comparable data can be used and, therefore, although both characterisation studies covered at least two seasons, only data collected during the summer seasons are reported here.

Contextualising the study area

Gauteng is the smallest of the nine provinces of South Africa, comprising only 1.5% of the land area, yet it is home to 25% of the national population[26] and contributes 34% of the country's gross domestic product (GDP)[31]. The Gauteng Province consists of three metropolitan municipalities – Ekurhuleni, Johannesburg and Tshwane – as well as two district municipalities – Sedibeng and West Rand – which are further subdivided into six local municipalities (Figure 1). Johannesburg is home to 36% of Gauteng's population, Ekurhuleni 26%, Tshwane 24% and the two district municipalities 7% each.[32] Being the most densely populated and urbanised province of South Africa (97% of the population in Gauteng is urbanised), it is estimated that Gauteng contributes about 45% of total municipal solid waste generated in South Africa.[33] Credible data on waste generation and composition in the rural areas of Gauteng are limited.

Household waste collection in the urban areas of Gauteng is typically done once a week in line with the National Domestic Waste Collection Standards.[34] Waste separation at source (S@S) is not yet common practice in South African households. Following the promulgation of the *National Environmental Management: Waste Act, 2008*[35] and approval of the National Waste Management Strategy, which sets targets for, among other things, initiating S@S programmes for households in all metropolitan municipalities, secondary cities and large towns[36] – a number of such initiatives have been launched in selected suburbs in the study area. S@S initiatives primarily target recyclables (i.e. paper, cardboard, plastics, glass and metals), and therefore food waste is still collected as part of the mixed household solid waste collection service provided by municipalities or their service providers, and disposed of at landfill.

Methodology

Sampling

Waste characterisation studies in Johannesburg and Ekurhuleni were undertaken using bulk sampling with randomised grab sub-sampling, as described by Jarrod Ball and Associates Consortium[37], covering a representative sample of the municipal waste collection routes from households in each of the two surveyed municipalities. This sampling methodology was used in order to collect data that are comparable to the 2001 characterisation results for Johannesburg as reported by Jarrod Ball and Associates Consortium[37]. The sampling areas were chosen purposefully to cover a range of socio-economic areas (high, middle and low income), but the routes within the selected areas were randomly chosen.

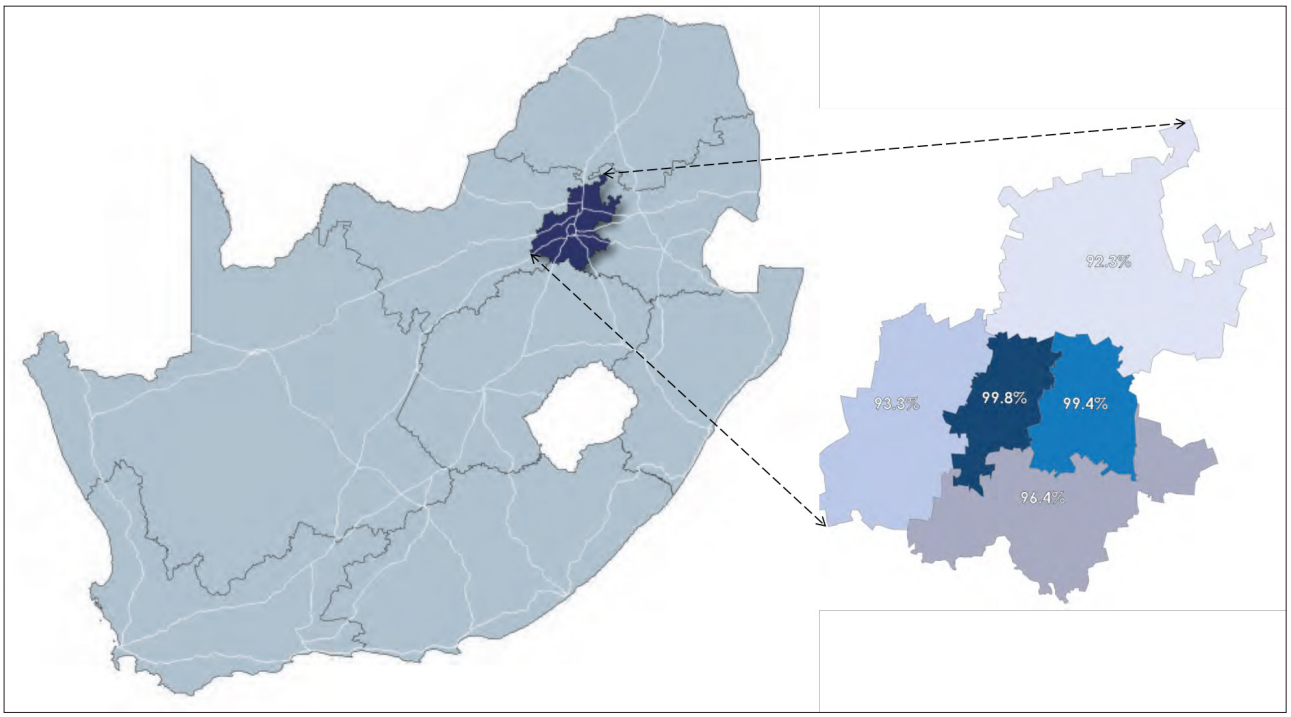

Figure 1: Geographical location of Gauteng Province, South Africa; and the percentage urbanised population per municipal area (adapted from Gauteng Provincial Government[31]).

Sampling teams consisted of one person accompanying the waste collection vehicle during normal waste collection from households to record data on the route and the number of households serviced, and another four people to collect and sort the waste samples at the landfill.

Bulk samples were collected using municipal waste collection vehicles following the normal collection schedules (weekly collection). At the end of the collection routes, the mass of the waste load collected was determined using the weighbridge at the landfill. A random grab sample of 100–200 kg was then taken from each load and manually sorted into pre-determined waste categories, including food waste, by trained waste sorters. Sorting was done at dedicated sorting areas on the landfill sites, away from the active workface (the landfill operational area). Any food and inedible parts of food (including drinks and cooking oil) that were present in the waste sample were sorted into the food waste category (if it was still in packaging material, the packaging was removed). Each sorted waste fraction was weighed using a calibrated scale and accurately recorded. At the end of each day, the sorted waste was returned to the workface for proper disposal.

Calculations

Waste disposal per household (kilograms/household/week) was calculated by dividing the mass of each bulk sample by the number of households serviced by the specific vehicle. Then, the mass of food waste per household for each sample was calculated by multiplying the percentage food waste determined from each sub-sample with the total calculated household waste for the bulk sample from which the sub-sample was taken.

Limitations

It was not in all instances possible to clearly determine the number of households from which waste was collected in the case of townhouse complexes, apartment buildings and communal collection points. Therefore, the results reported here only include data collected from routes for which the number of households serviced could clearly be determined; data from townhouse complexes, gated communities and apartment buildings are not included in the results presented here.

Using bulk sampling of waste collected by the municipal waste collection service, limits the results to the food waste disposed into the municipal bin. Food and drink waste fed to pets, disposed of into the sink and treated through home composting is not included in the scope of this study.

Results and discussion

The data reported were collected from 74 waste collection routes covering 44 927 households in the Johannesburg metropolitan municipality and 41 routes covering 20 439 households in the Ekurhuleni metropolitan municipality (Table 1). Data in both municipalities were collected in summer, which is the rainy season in Gauteng Province.

Table 1: Samples obtained and analysed

Samples	Johannesburg	Ekurhuleni
Total number of collection routes sampled	74	41
Total number of households included in the samples	44 927	20 439
Combined weight of bulk samples collected (kg)	938 220	80 380
Combined weight of sub-samples analysed (kg)	10 761	13 829
Average weight of sub-samples (kg)	145.42	246.72
Percentage of bulk sample analysed	1.15%	17.2%

The average food waste disposed per household in Johannesburg (0.69 kg/week) is higher than that in Ekurhuleni (0.48 kg/week) across all income categories (Table 2).

The differences in weekly food waste disposal (kg/hh) between income groups and municipalities appear to be small and therefore a statistical analysis was done to determine the significance of the differences between high, middle and low income as well as between high and low income. The Mann–Whitney test was done because of the skewness of the data. The results indicate that there are no statistically significant differences in the food waste generation (kg/hh), i.e. there is a consistent pattern of differences between municipalities and income levels (Table 3).

Table 2: Food waste disposed of by high-, middle- and low-income households into the municipal bin (kilograms/household/week) in two metropolitan cities in Gauteng

Income category	Average (kg/hh)	Median (kg/hh)	Minimum (kg/hh)	Maximum (kg/hh)	Number of bulk samples	Number of households sampled
Johannesburg metropolitan municipality						
High	0.72	0.56	0.00	3.00	29	15 719
Middle	0.56	0.01	0.00	2.92	12	5967
Low	0.73	0.34	0.00	4.66	33	23 241
All	0.69	0.32	0.00	4.66	**74**	**44 927**
Ekurhuleni metropolitan municipality						
High	0.53	0.19	0.00	1.67	19	8599
Middle	0.45	0.20	0.00	1.76	18	9357
Low	0.38	0.26	0.05	0.96	4	2483
All	0.48	0.19	0.00	1.76	**41**	**20 439**

Table 3: Mann–Whitney test results of comparison of food waste between income groups and the two municipalities ($p > 0.05$ implies no statistically significant difference)

Comparison	*p*-value	Interpretation
Comparing municipalities		
Ekurhuleni to Johannesburg	0.604	Not significant
Comparing Ekurhuleni to Johannesburg within income categories		
High	0.5839	Not significant
Middle	0.2009	Not significant
Low	0.7149	Not significant
Comparing income categories		
High-middle-low	0.2131	Not significant
High-low	0.8730	Not significant
Middle-low	0.1173	Not significant
High-middle	0.1240	Not significant
Comparing income categories within municipalities		
High-middle-low in Johannesburg	0.2294	Not significant
High-middle-low in Ekurhuleni	0.9371	Not significant
High-low in Johannesburg	0.6817	Not significant
High-low in Ekurhuleni	1.0000	Not significant
Middle-low in Johannesburg	0.0958	Not significant
Middle-low in Ekurhuleni	0.9664	Not significant
High-middle in Johannesburg	0.1604	Not significant
High-middle in Ekurhuleni	0.7035	Not significant

It is interesting to note that 27% of all samples collected in Johannesburg and 14% collected in Ekurhuleni did not contain any food waste. This is very odd as all households are assumed to generate at least some unavoidable food waste in the form of egg shells, bones etc. However, this may be as a result of the random grab sampling method used for sub-sampling or it may be an indication that some households use alternative food waste management strategies which may include feeding of food waste to pets and/or home composting.

Global estimates of food waste assume similar food wastage in South Africa compared with the rest of sub-Saharan Africa.[24] For comparative purposes, the data collected in this study from metropolitan households in South Africa were converted into food waste per capita per annum. This results in estimates of approximately 8 kg and 12 kg per capita per annum in Ekurhuleni and Johannesburg, respectively (Table 4); which is higher than the average of 6 kg per capita per annum for sub-Saharan Africa, but lower than the 95 kg in Europe.[24] Furthermore, the estimates for sub-Saharan Africa and Europe include all food that was meant for human consumption and that reached the consumer, but was never consumed[24]; whereas our results include only the waste disposed of into the municipal bin.

Table 4: Calculated per capita food waste disposed of per annum using 2011 census data from StatsSA[26]

Variable	Johannesburg	Ekurhuleni
Population	4 439 991	3 178 470
Number of households	1 437 168	1 015 645
Per cent urbanisation	99.80	99.40
Number of urban households	1 434 294	1 009 551
People per household	3	3
Food waste (average kilograms/household/week)	0.69	0.48
Food waste (kilograms/capita/week)	0.22	0.15
Food waste (kilograms/capita/annum)	11.61	7.98
Food waste disposed of by urban households (tonnes/week)	989.66	484.58
Food waste disposed of by urban households (tonnes/annum)	51 462.46	25 198.40

The study by Ramukhwato[27] was conducted in urban households in Gauteng which kept food diaries; 86% of respondents mostly wasted starchy staples (i.e. mealie pap, rice and bread), and 17% managed their food waste either by feeding it to pets (14%) or by home composting (3%). The results reported here are therefore likely to be a conservative estimate of household food waste generation in Gauteng.

Based on the 2011 urban population of each municipality, the amount of food waste disposed to landfill by urban households in Ekurhuleni and Johannesburg can be calculated at between 25 198 tonnes and 51 462 tonnes per annum.

Conclusions and recommendations

An average of 0.48 kg and 0.69 kg of food waste (including inedible parts) is disposed of into the municipal bin per household per week in the municipalities of Ekurhuleni and Johannesburg, respectively. These figures translate into per capita food waste disposal of about 8 kg and 12 kg per annum, respectively, and between 25 198 tonnes and 51 462 tonnes from households per annum.

Because the results reflect only the waste disposed of into the municipal bin, and it is reported that other food waste management strategies are also employed by households in Gauteng[27], this should be seen as a conservative estimate for urban households. It is important to note that rural households were not included in the survey, and therefore extrapolation beyond urban households in Gauteng using these data is not possible.

It is evident from this study that initiatives focusing on urban households' food waste reduction and diversion from landfill have the potential to divert significant amounts of food waste from landfill. The results from this study will specifically be useful to the two surveyed municipalities, as they provide accurate data against which the success of food waste reduction strategies can be measured.

It is recommended that future research should consider different sampling methods in addition to bulk sampling, including random sampling of individual household bins or bags across a city or by asking participants to keep food diaries and record the reasons for the food wastage at household level. All future research should aim to collect complementary evidence for the development of food waste reduction strategies for South Africa including data across the different types of municipalities in South Africa (A, B1, B2, B3 and B4) to obtain representative data across metros, large cities and more rural towns.

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Authors' contributions

S.O. conceptualised the article, identified relevant data sets, extracted relevant data, interpreted the data and drafted the bulk of the article. A.M. was involved in the data collection, contributed to the methodology section and assisted with the interpretation of the data and conclusions. F.R. assisted with the literature review and drafting of the introduction.

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