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Formulating waste management strategies based on waste management practices of households in Santiago de Cuba, Cuba

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Abstract

Rapid urbanisation, population growth and changes in lifestyles in low- and middle-income countries contribute to increasing the per capita domestic waste generation. This trend leads to deplorable environmental and public health conditions, especially in rapidly expanding cities of low- and middle-income countries lacking appropriate waste management systems, Santiago de Cuba is no exception. To improve solid waste management in the city of Santiago de Cuba, the generation of household waste was studied and individual waste treatment approaches were assessed. The principle of a household level analysis was adopted to enable the development of strategies based on the specific conditions of households, their awareness and needs.

In February 2004, a survey covering 1180 households was conducted on issues such as monthly consumed goods, waste generated and its treatment. The waste generated by the households was subsequently assessed by means of a measuring campaign. The measured volume not only comprised the collected waste fraction but also the waste materials treated on-site or recovered and recycled by all the different means available.

The paper contains the results of the composition and distribution of the waste generated by the households as a function of socio-demographic data. Furthermore, the paper describes the various household treatment strategies dependent on specific waste material types. Several types of household waste can be differentiated by statistical cluster analysis. These household types are characterised not only by the amount of waste generated but also by socio-economic status and waste treatment practices. The results obtained are used to develop a range of waste management strategies, each relating to a household type and characterised by its generated amount, waste material type and spatial urban distribution. Since the strategies are adapted to the requirements and needs of the households, they are more readily accepted by the population concerned. Such socially anchored strategies will contribute to improving the waste situation in the city of Santiago de Cuba and allow an optimised allocation of local resources.

Keywords: Household waste management; Recycling; Waste reduction; Recycling behaviour; Santiago de Cuba

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Introduction

Inappropriate waste handling, storage, collection and disposal practices pose environmental and public health risks. In densely populated urban centres for example, appropriate and safe solid waste management (SWM) is of utmost importance to create a healthy environment for the population. Although most governments have acknowledged this fact (Rabinovitch, 1997), numerous municipalities are hardly capable of providing even the most basic services. According to the World Resources Institute (1996) one to two thirds of the municipal solid waste generated in the developing world is dumped indiscriminately on streets or in drains, thus causing floods, insect and rodent breeding grounds and the spread of diseases (UNEP-IETC, HIID, 1996). The collected waste is generally dumped on land in a more or less uncontrolled manner. Such uncontrolled waste disposal not only creates serious environmental problems and affects human and animal health but also causes serious financial and socio-economic losses. Due to inadequate waste disposal, surface and groundwater are contaminated by leachate, the soil by direct waste contact or leachate, the air by burning of waste, the spread of diseases by different vectors such as birds, insects and rodents, or the uncontrolled release of methane from anaerobic waste decomposition (Schertenleib & Meyer, 1992).

The traditional approach applied to environmental problems has been one of "command and control" by the responsible authorities, which largely apply "end-of-pipe" solutions to existing problems. In the past, all waste management elements were often only evaluated from a purely engineering and technical viewpoint instead of being embedded in a local, institutional, socio-cultural and economic context, which is also influenced by national, political and regulatory aspects as well as national, global and economic factors.

In the last decade, focus has shifted towards finding approaches which could possibly avoid or tackle the problem as close to its source as possible. Central to this strategy is the need to minimise waste generation and enhance recycling. This is achieved by closer collaboration and exchange with the individual municipal residents. Household involvement is paramount to the success of recycling initiatives, where focus must be placed on the willingness of the individual to change its current behaviour and participate, provided he/she is informed and empowered to do so. Several studies report the successful change of household waste handling behaviour. Burn (1991) used block leaders increasing recycling behaviour. Wang and Katzev (1990) applied the approach of single and group commitment and Katzev and Mishima (1992) a posted feedback to increase recycling. In other studies the promoters successfully worked with the social context, where each behaviour is embedded (e.g. Derksen & Gartrell, 1993; Hopper & Nielsen, 1991).

This paper describes a study and survey conducted at household level in the city of Santiago de Cuba. It identifies specific household waste generation and management patterns, and develops appropriate strategies for the various household types to enhance and promote recycling activities.

The study area of Santiago de Cuba Province, the second most populated province of Cuba, is located in the south-eastern part of the island of Cuba. It has a population of approximately 1.2 million, with the largest city Santiago de Cuba (554,000 inhabitants) as its main administrative centre. The province is rich in natural resources such as iron and nickel. The economy, however, relies mostly on agriculture, with large banana, cacao and coffee plantations dotting the landscape. Industry and tourism are expanding in and around Santiago de Cuba. In Santiago de Cuba, waste disposal is seen as a major environmental issue. However, official information on waste management is scarce.

Since the 1959 revolution and the subsequent establishment of a one-party communist government, Cuba has created a social service system where the government is exclusively responsible for developing, implementing and financing all aspects of social service delivery (Erikson, Lord, & Wolf, 2002). Private service providers are non-existent, and apart from occasional minor exceptions, the system does not foresee fees for service provisions.

Due to its special geographic situation, the island of Cuba has limited space for landfill disposal, and ocean dumping is detrimental to tourism. Given its economic situation, recovery of secondary materials is of key importance in reducing resource dependency from other countries.

Special attention was paid to SWM after an outbreak of Dengue—a disease transmitted by the mosquito Aedes Aegypti (Schleenstein, 2002) and increased incidence of leptospirosis, a disease transmitted by rats (from 4.9 per 100,000 inhabitants in 1990 to 9.8 in 1997). A sectoral analysis conducted on SWM in Cuba in 1996, identified a total of 46 critical issues that were used as targets for the subsequent priority

setting (Delgado Reinoso, 2003). These key issues have been studied at institutional, legal, technical, financial, economic, environmental, health and socio-cultural level. The public cleansing services have since then been intensified, and the authorities have increased their focus on public involvement and participation (Schleenstein, 2002). The socio-cultural aspects pertaining to sector analysis revealed the following:

- Lack of strategy to educate and inform the community on attaining improved waste behavioural patterns.
- Poor systematic environmental education campaigns.
- Insufficient socio-cultural community involvement in the waste sector.
- Lack of material resources required to support environmental education.
- Lack of appropriate waste management awareness by the population, and poor level of knowledge on the relations between SWM and health.

Due to an increase in population and consumption, the city of Santiago de Cuba is confronted with a series of waste collection and disposal problems. On the one hand, since fuel shortages are common and all fuel oil has to be imported, waste collection is often irregular (Rivera, 2001). However, compared to other cities in the developing world (e.g. Halla & Majani, 1999), waste management is quite effective and allow further interventions. On the other hand, landfill space in the current landfill is limited and the setting up of new landfills outside the city poses additional problems due to increased transport distances requiring more fuel. The city is therefore looking for options to reduce the waste flow to the landfill and, if possible, to increase the use of secondary raw materials by its industries. This study is embedded in a collaboration project with the Universidad de Oriente (University of Santiago de Cuba), Materias Primas, Servicios Comunales and Centro de Investigaciones en Energía Solar. The project aims at assessing the feasibility of different technical waste treatment options (incineration, anaerobic digestion, etc.) to reduce the final waste disposal volume. The social component of the project aims at developing a social strategy to reduce waste at household level. To identify suitable measures, it was necessary to assess the individual solid waste generated by the households, and to analyse household awareness of waste management. Identification of key patterns helped to develop individual intervention measures to improve the SWM system. The following assumptions summarise the goal of the study:

- A household-centred analysis allows a clear identification of the waste generation and management patterns.
- Different types of households can be identified and described by their generated waste and further socio-demographic variables.
- Consequently, type-specific intervention strategies can be developed to reduce the waste at household level.
- The strategies developed at household level are more sophisticated and adapted to the actual waste management situation than strategies developed at district level.

Methodology

This paper discusses only part of a more comprehensive socio-technical study on waste handling practices in Santiago de Cuba, and describes the relevant methodologies used to develop waste generation and management strategies. It mainly analyses the current consumption and waste disposal patterns of households, and focuses on recyclable materials such as glass, aluminium, metal, organics and PET. The project team used a stepwise approach to assess the SWM situation in Santiago de Cuba.

Stakeholder analysis

A rough stakeholder analysis has identified key institutions and organisations involved in SWM. These were then contacted to obtain a better overview of the current situation.

Household survey

Based on the information obtained, a detailed questionnaire was developed for a household survey and survey plan (Cannell, Miller, & Oksenberg, 1981). The standardised questionnaire, comprising a comprehensive set of structured questions to assess quantitative and qualitative data with the SPSS software, is structured as follows:

(1) Spatial characterisation (areas and buildings) within the defined areas.
(2) Socio-demographic information (sex, age, household size, education, occupation and economic standing (e.g. animals or vehicles), etc.
(3) Waste generation and disposal practices at household level (e.g. separation, available storage space).
(4) Characterisation of waste types and their reuse.
(5) Awareness of existing waste management practices in Santiago de Cuba (e.g. cleanliness of area, satisfaction, need for improvement).
(6) Awareness of selected waste minimisation and treatment strategies at household level (own contribution to reuse, separation or recycling, perceived difficulties, etc.).
(7) Communication practices.

Households were chosen according to the "random route procedure" (Hoffmeyer-Zlotnik, 1997), as the interviewers were sent to randomly selected intersections through the city from where they started assessing households according to a fixed plan. The samples are therefore representative for the entire city. Analysis was based on the questionnaires completed by 1180 households.

Waste measuring campaign

The already interviewed households were subsequently asked to participate in a 1-week waste measuring campaign. The households were given seven plastic bags and instructed to separate their waste into seven fractions (organic waste, glass, plastic, paper and cardboard, aluminium, other metals and residues not covered by the aforementioned categories). Table 1 contains an overview of typical items found in Cuban household waste. At the end of the week, the bags were collected by students, weighed and the results incorporated into the existing database.

Statistical analysis

The next step consisted in a combined statistical analysis of the data obtained from the questionnaires and measuring campaign. Based on the results of the measuring campaign, the following two different analyses were conducted:

Spatial analysis
Is the conventional procedure for SWM analysis. The households are grouped into seven administrative urban districts and the average generation of all waste types is calculated. The important differences in waste generation and composition may be due to the economic and social standing of a district. However, such an analysis does not require a household survey but merely an assessment of the waste collection containers.

Household-focused analysis
The questionnaire and measuring campaign at household level allows a far more detailed analysis, since it places the household at the centre of the analysis. The objective is to classify homogenous clusters of households as a function of their waste generation and composition and other variables from the questionnaire. A cluster comprises households exhibiting similar types and amounts of generated waste but clearly differing from other groups. Bivariate correlation analysis was performed with the generated household waste and socio-demographic variables using Pearsons' "r" for the level of significance of $p<0.05$

Table 1
Definition of waste types

Type	Composition
Plastic	Containers for shampoo, oil, deodorants, medicine, lemonade, tubes
Metal	Containers for fruits and vegetables, components of vehicles and machines
Glass	Bottles of bier, rum, perfume, and medicine, glasses, window glass
Paper, cardboard	Newspapers, packaging
Organic waste	Inedible parts of vegetables, fruit peels, food leftovers
Aluminium	Cans of bier and soft-drinks, tubes of toothpaste, containers
Residues	Sweepings, sand, shoes, leaves, wood, clothes, building material

(Anderberg, 1973). In combination with socio-economic data, cluster analysis allowed to define different household waste management patterns and household awareness of waste management practices.

Focus group discussion

Finally, focus group discussions on waste management strategies were conducted with households, municipal waste managers and key persons of the city administration. Thereupon, a list was established of possible waste management strategies and interventions relevant to Cuba.

Results

The results are presented simultaneously with the described methodological steps.

SWM stakeholders

Several SWM stakeholders were identified in Santiago de Cuba. This paper only provides a summarised view, as the detailed results are discussed in Binder and Mosler (submitted for publication):

- Households play a key role in the context of this study. They generate the waste and already reveal different waste handling practices depending on the type of waste generated: (i) reuse of bottles, (ii) disposal of residues in household bins, (iii) storage and forwarding of recyclables to a collection service, (iv) offer recyclables as a gift to relatives or friends; (v) feed organic waste to pigs or chickens, (vi) sale of recyclables to recycling centres, the so-called "Casas de Compra". The recycling rate in Cuba is exceptionally high for a developing country and comparable to countries like Germany and Switzerland. (BUWAL, 2004; see Binder & Mosler, submitted for publication).
- In Santiago de Cuba, the "Casas de Compra" are the recycling centres (see Photo 1). Recyclables like PET, glass and metals are traded in for goods. For example, a household brings 20 empty PET bottles in exchange for a soft drink. "Casas de Compra" have a low reputation and many households prefer to give their recyclables to the "Comité de Defensa de la Revolución (CDR)", which provides a collection service.
- *CDR* is a political neighbourhood organisation which also fulfils a social control function. *CDR* motivates the household to separate recyclables, which are collected at irregular intervals. *CDR* is one of the main stakeholders in the SWM system, as households prefer to deliver their recyclables to this committee.
- Both "Casas de Compra" and *CDR* deliver the recyclables to so-called "Materias Primas", which are the central waste separation agencies in Santiago de Cuba. They sort and bundle the waste before transferring it as secondary raw material to the Cuban recycling industry.
- The "Servicios Comunales", the public waste collection agency in Santiago de Cuba, is responsible for frequent collection of the remaining residues. The household residues are disposed of in bags or bins. "Servicios Comunales" collect the waste every 2–3 days in open trucks and transport it to the official landfill.

Photo 1. Recyclables collected at a "Casas de Compra".

- The informal sector (e.g. waste-pickers) hardly plays a role in Cuban waste management. According to Binder and Mosler (submitted for publication), the inhabitants do not have to rely on waste picking as the social system maintains basic food at a very low price.

Characterisation of survey areas in Santiago de Cuba

According to "Servicios Comunales", the city is divided into seven areas with their settlement structures and living conditions. Although the income does not vary significantly, indicators allow to distinguish between low-, middle- and high-income neighbourhoods. This information is also provided by the questionnaires. Fig. 1 contains an overview of the city and its defined areas.

Area 1: Is situated in the south-western sparsely populated part of the city consisting mainly of one- or two-storey houses. There are few private gardens but numerous public green areas and undeveloped properties. The conditions of the houses indicate a rather middle-income neighbourhood.

Area 2: Is situated in the south-eastern densely populated part of the city consisting mainly of one- or two-storey houses. There are almost no private gardens, only few public green areas and few undeveloped properties. The conditions of the houses indicate a rather low-income neighbourhood.

Area 3: Is situated in the eastern sparsely populated part of the city consisting mainly of large one-storey villas with big gardens. There are many public green areas and no undeveloped properties. The conditions of the houses indicate an upper-income neighbourhood.

Area 4: Is situated in the north-eastern densely populated part of the city consisting mainly of one- to two-storey villas or houses. There are only few private gardens, few public green areas and few undeveloped properties. The conditions of the houses indicate a middle- to upper-income neighbourhood.

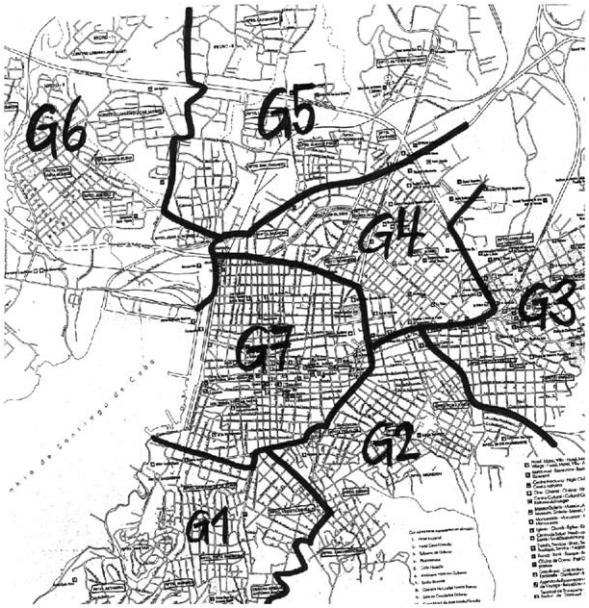

Fig. 1. Boundaries of defined survey areas in Santiago de Cuba.

Area 5: Is situated in the northern part of the city and consists mainly of one- to two-storey villas or houses with big gardens. There are only few public green areas and few undeveloped properties. The conditions of the houses indicate a middle- to upper-income neighbourhood; however, the entire area is very inhomogeneous.

Area 6: Is situated in the north-western part of the city and consists mainly of four- to six-storey blocks. The blocks are surrounded by public green areas and few undeveloped properties. The conditions of the houses indicate a middle-income neighbourhood.

Area 7: Is situated in the centre of the city and close to the harbour. It is very densely populated with no undeveloped sites. It consists mainly of colonial style one- to three-storey buildings; however, there are also a few 18-storey buildings. The conditions of the houses indicate an upper-income neighbourhood. There are only few public green areas in the centre.

Areal waste generation

The average amount of waste generated amounts to 86 g per capita and day. Compared to other countries in the region, these values are exceptionally low. The waste generation rate determined in the 1970s revealed that the waste produced in different communities varied between 150 g/capita/day (Santa Clara) and 600 g/capita/day (Guantánamo) (Schleenstein, 2002). Even in countries like Bolivia and Peru, the per capita waste generation rate ranges from 300 to 600 g/day. (Diaz, Savage, Eggerth, & Golueke, 1996). The household waste composition is given in Fig. 2. Glass (22%) and organic waste (34%) constitute the bulk of the household waste. The low fraction of residues (5%) proves that the separation instructions during the measuring campaign have been well understood by the responsible household persons. The relevant basic statistical mean values and socio-economic data are given in Table 2.

A comparison of the different areas surprisingly reveals only marginal differences in the per capita waste generation and composition as shown in Fig. 3. However, a statistical analysis reveals clear correlations and indications, which can be used to characterise these seven areas.

The correlation analysis also reveals that total waste per cap/day is negatively correlated to several socio-demographic factors, e.g. the per capita waste generation is decreasing with increasing household income (correlation factor $r = -0.36$, level of significance $p < 0.001$). Similar negative correlations are found for the standard of living ($r = -0.22$, $p < 0.001$), and persons per household ($r = -0.60$, $p < 0.001$). This correlation is

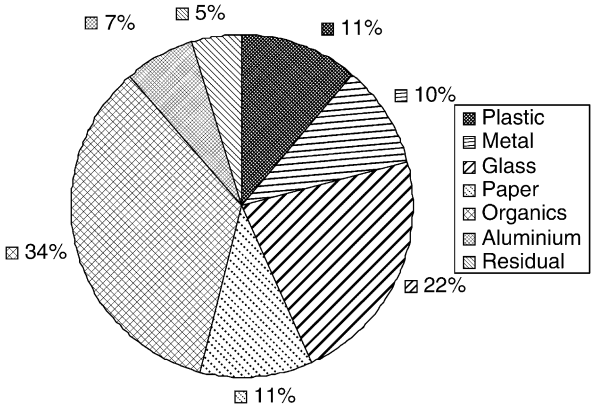

Fig. 2. Composition of household waste in Santiago de Cuba.

Table 2
Summary of interview results by area

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	City average
Number of households	196	171	122	164	161	161	111	1086[a]
Monthly household income (Pesos Cubanos)	383	363	507	383	333	375	389	389
Household size	2.3	2.8	3	2.5	2.3	2.6	2.3	2.5
Standard of living[b]	17.6	15.6	22.1	17.0	15.0	16.5	16.6	17.9
Per capita waste generation (g/day)	91	80	75	82	99	76	107	87
Waste storage time (days)	3.0	2.5	2.3	2.3	2.6	3.3	2.2	2.5

[a]Total of all areas. This number is lower than the total number of questionnaires received from the households, as some did not answer the relevant questions.

[b]The standard of living is calculated on the basis of the housing condition, income and the availability of vehicles (weighed price calculation).

contrary to the generally accepted theory, since country comparisons show a positive correlation between economic standing and waste generation (Diaz et al., 1996). However, a survey by Bolaane and Ali (2004) also reveals a negative correlation between per capita waste generation and income when comparing the different household types within the city of Gaborone, Botswana. They attribute this fact to the different waste composition.

The recycling rates are rather high, as the households have established different disposal strategies as a function of the waste type. Forty per cent of the households feed organic waste to animals like pigs and chickens. Plastic, aluminium and glass are separated at household level and stored until CDR conducts one of its infrequent collection campaigns. Only about one-third of the interviewed households do not separate recyclables like glass and plastic. A relatively high fraction is reused, sold or transformed.

Waste generation and disposal by household type

In contrast to the area-based analysis, the household-focused analysis has identified different clusters allowing a characterisation of the household types as a function of the generated waste.

A cluster analysis was conducted to determine whether the different types of waste generating households could be identified. The household types can be identified if certain generated waste compositions predominate in different household groups. The analysis of a 0–10-cluster solution revealed that the eight-cluster result showed the best statistical values (see Fig. 4 and Table 3):

- *Type* 1 ($N = 58$): exhibits a high residual waste fraction (41%) and strong wish to improve the SWM system.

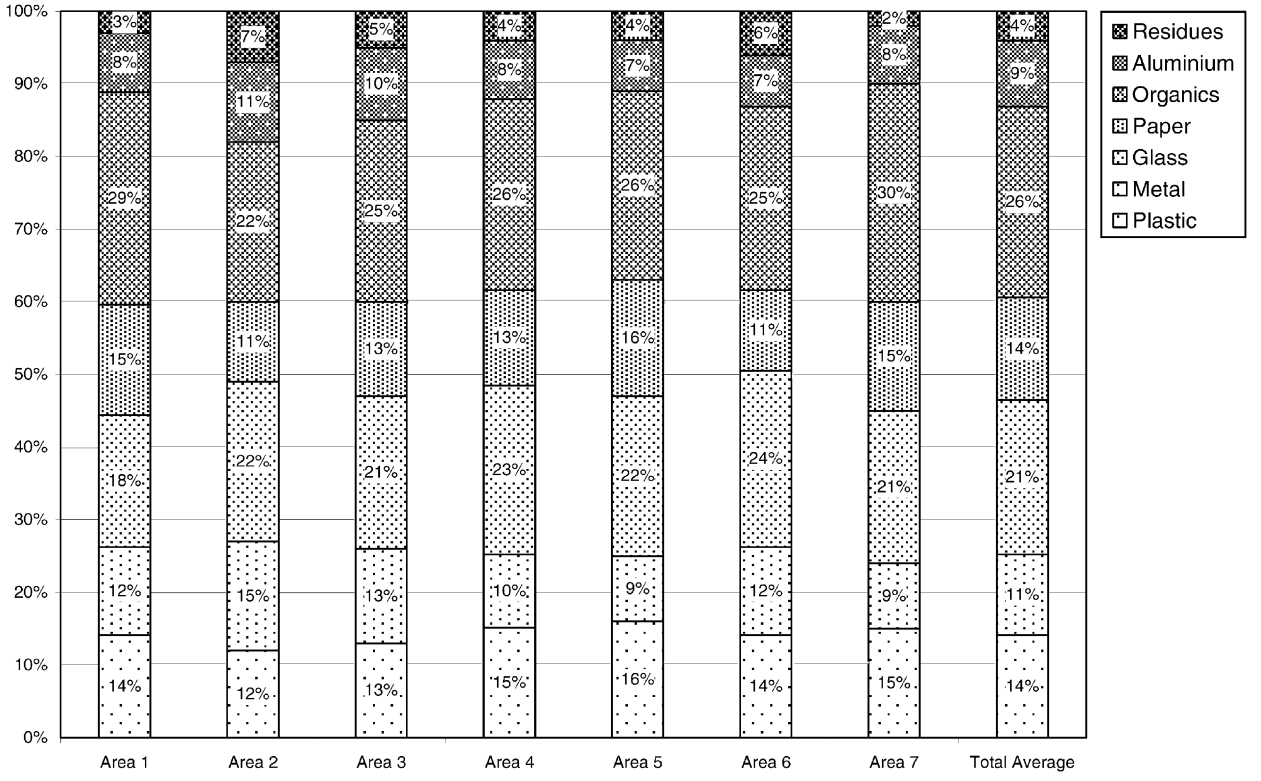

Fig. 3. Per capita waste generation and composition by area.

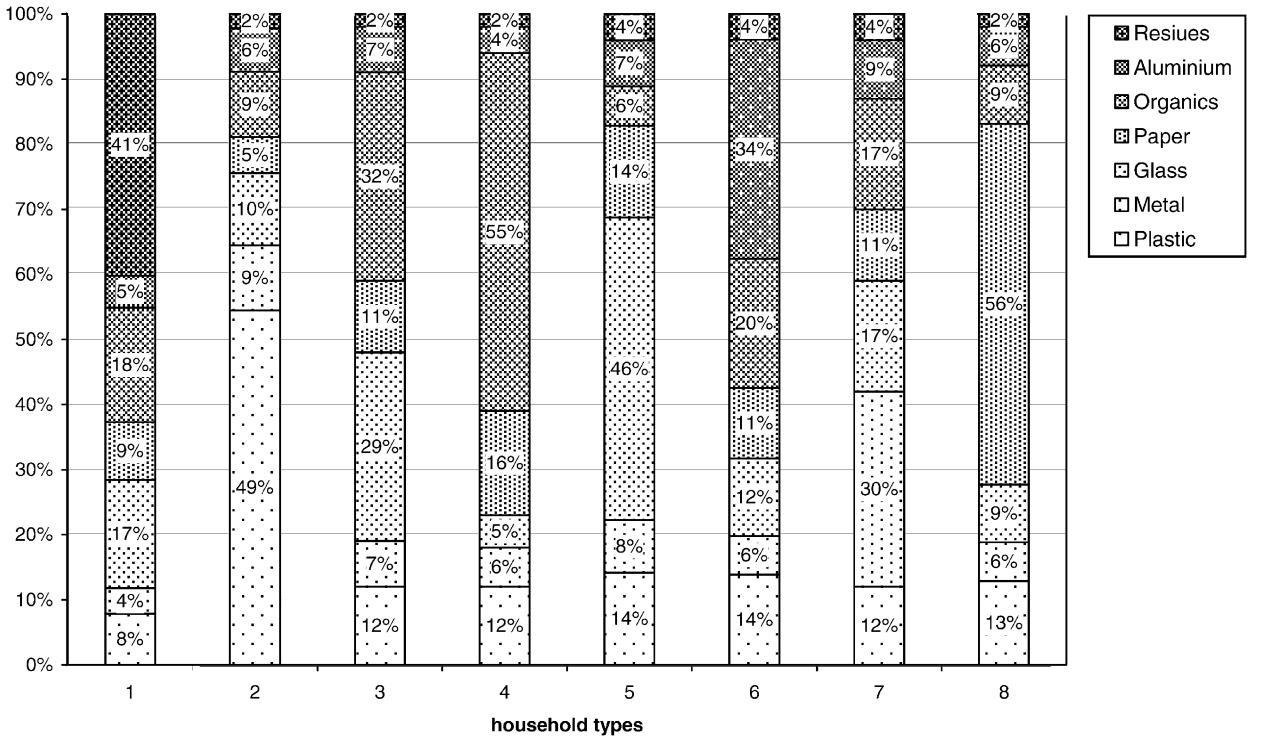

Fig. 4. Waste generation and composition by household types (cluster analysis).

Table 3
Additional characteristics of household types

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Average of all types
Number of households	58	59	248	186	161	79	163	58	1012[a]
Total household income (Pesos Cubanos)	375	326	408	395	403	403	398	399	389
Household size	2.6	2.1	2.7	2.8	2.4	2.4	2.6	2.4	2.5
Standard of living[b]	15.9	16.1	16.8	16.5	16.6	17.4	17.4	17.4	17.1
Per capita waste generation (g/day)	72	72	104	64	87	93	108	49	87
Waste storage time (days)	2.8	2.5	2.6	2.6	2.6	3.1	2.5	2.7	2.6
Wish for improvement[c]	2.8	2.4	2.3	2.5	2.7	2.8	2.6	2.7	2.5

[a]Total of all areas. This number is lower than the total number of questionnaires received from the households, as some did not answer the relevant questions.
[b]The standard of living is calculated on the basis of the housing condition, income and the availability of vehicles (weighed price calculation).
[c]The wish for improving the SWM services: 0 = no improvement necessary, 3 = strong wish for improvement.

- *Type* 2 ($N = 59$): exhibits a high plastic fraction (49%) and a relatively low income.
- *Type* 3 ($N = 248$): exhibits a relatively high organic (32%) and glass fraction (29%) and lowest wish to improve the SWM.
- *Type* 4 ($N = 186$): exhibits a very high organic waste fraction (55%).
- *Type* 5 ($N = 161$): exhibits a high glass fraction (46%) but very low amount of organic waste. There is a strong wish to improve the SWM system.
- *Type* 6 ($N = 79$): exhibits a high aluminium fraction (34%). There is a strong wish to improve the SWM system.
- *Type* 7 ($N = 163$): exhibits a relatively high metal fraction (30%) and highest total amount of per capita waste (due to the large metal fraction).
- *Type* 8 ($N = 58$): exhibits a very high paper fraction (56%) and the lowest per capita waste amount.

We can therefore conclude that different household groups can be identified depending on their waste composition fraction. These household types can be characterised by other parameters (see Table 3).

Focus group discussion

On the basis of discussions with focus groups from the population, responsible waste managers and several city administrators, the following most appropriate waste reduction and treatment strategies for households in Santiago de Cuba have been identified:

- *Promote reuse*: Reuse of mainly glass and aluminium could be enhanced, and the reuse of other residual waste, such as clothes for example, could be promoted.
- *More frequent collection*: Introduction of a more frequent collection service could motivate households to separate and store special waste like metals and aluminium.
- *Promote the "bring system"*: The existing recycling sites in the districts could be improved by increasing the available space and improving their reputation. The population could be requested to bring more recyclables such as paper, aluminium, and plastic.
- *Promote the keeping of domestic animals*: The available practice of animal feeding (pigs and chickens) could be promoted to reduce the organic fraction of the waste to be transported to the landfill site.
- *Introduce composting*: Although composting is not practised in Cuba, it could be a potential treatment option to reduce the waste to be transported to the landfill in areas with sufficient space. Consequently, this strategy requires a greater change in habits from the inhabitants of Santiago de Cuba.

These different strategies will be discussed in the following section in the light of the results of the survey and measuring campaign.

Formulating waste management strategies

The spatial and cluster analyses are two different approaches leading to different conclusions and intervention measures. It is worth comparing the results of these two approaches and discuss a possible combination of the two.

Spatial analysis versus household-focused analysis

As spatial analysis reveals a rather similar waste composition in all areas, focus could be placed on just one intervention, i.e. on the main waste fraction or on the most valuable waste component. This intervention would be applied throughout the city, irrespective of households with different waste fractions or individual waste management strategies. As shown in the previous section, the household survey and cluster analysis allow a much more detailed characterisation of the households and their waste generation:

According to Table 3: Type 3 (organic waste) and Type 4 (organic waste and glass) are the main household types with $N = 248$ and 186, respectively. The household size is the largest among these types. The presence of children is assumed to lead to a different consumption behaviour resulting in a higher content of organic waste. Types 5 (glass) and 7 (metal) also mainly predominate in number compared to the others with $N = 161$ and 163, respectively. Only households with a relatively high income generate a high amount of glass waste (Types 3 and 5). The high plastic fraction generated by Type 2 household could not be explained by a higher income.

Types 3–5 households can be easily grouped as they all mainly produce organic waste and glass. They account for 59% of the total households surveyed. Hence, it is worth considering interventions especially adapted to these groups, such as the separation and reuse of glass or the separation and treatment of organic waste.

Since Type 7 is also a major group, it should also receive special attention. The questionnaires reveal that the high metal fraction can be attributed to the presence of cars in these households. This group has one of the highest standards of living. The poor economic conditions of the inhabitants of Santiago de Cuba force them to repair their cars in their backyard with partly self-constructed spare parts. The scrap metal is collected by the public waste collection service, thereby increasing the metal fraction as well as the total per capita waste fraction.

Combining spatial information and household survey

The analysis reveals eight household types allocated to the defined areas in Santiago de Cuba. The results provide additional suggestions regarding the development and focus of intervention strategies. As illustrated in Fig. 5, some household types are concentrated in certain areas. Type 7 for example with a high metal fraction is relatively widespread in the areas 2, 3 and 6. According to the areal description in section ''Area waste generation'', two out of these three areas are high-income areas, which also correlate with the standard of living indicators. These comparisons can be conducted for all types and areas to obtain additional indications for suitable interventions strategies. The aforementioned interventions to attain changes of the waste management strategies do not only depend on household perceptions but also on the surrounding housing conditions. Interventions like raising animals or composting require sufficient space like a garden or backyard. Hence, not all the strategies can be applied in all the areas. Income or standard of living is another factor determining household acceptance of new waste management strategies. Poor households will be more likely to accept strategies which improve their economic situation (e.g. reuse or sale of recyclables), while relatively rich households will tend to accept other strategies, such as carrying the waste to a collection centre if this activity is socially recognised. The questionnaires contain more information on these aspects; however a further discussion would go beyond the scope of this article.

Comparison of interventions

Table 4 summarises the aforementioned and compares the different intervention strategies developed from the two approaches. The intervention based on the spatial analysis does not allow focused interventions. Since

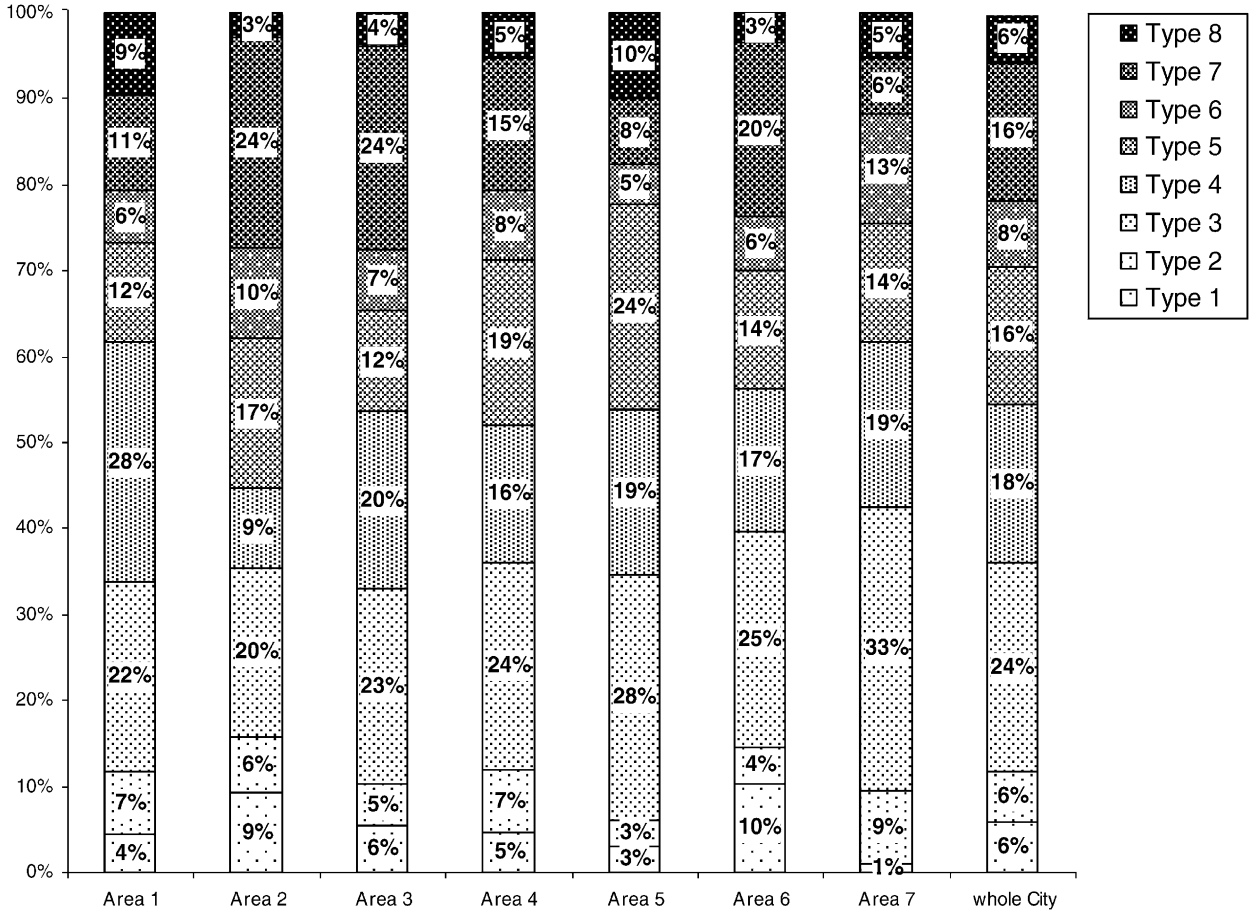

Fig. 5. Areal distribution of household types.

Table 4
Comparison of strategies based on spatial analysis and household waste types

Area	Intervention strategies based on household waste types and spatial information	Intervention strategies based on the spatial analysis	
1	Promote the keeping of domestic animals/composting and glass separation	City-wide intervention for organic waste: Promote the keeping of domestic animals and probably composting	City-wide intervention for glass: Enhance reuse/separation and collection of glass
2	Promote metal collection		
3	Promote metal and glass collection, keeping of domestic animals/composting		
4	Promote glass separation and collection		
5	Promote the keeping of domestic animals/composting and glass collection		
6	Promote metal collection		
7	Promote organic waste separation and collection for composting outside the area		

only glass and organic waste have been identified as main waste fractions, possible interventions could promote the keeping of domestic animals (pigs and chickens), composting of the organic waste fraction and promoting of glass recycling. These interventions could be applied citywide, as spatial analysis does not reveal any differences between the surveyed areas.

It is possible to develop a more focused intervention strategy as the household survey classifies the household types, main waste generated and local conditions in these areas. If waste separation is promoted throughout the city, increased metal separation and collection should be promoted in areas 2, 3 and 6. Composting and the keeping of domestic animals may be applied in areas 1, 3 and 5. Area 7 (city centre) requires further considerations, as the dense housing structure is unsuitable for composting or keeping of pigs, although the waste reveals a very high organic fraction. In this case, a more suitable strategy would consist in promoting waste separation and introducing a collection and treatment service outside the city centre. Such a differentiated strategy allows a more efficient allocation of the limited local waste management resources (e.g. trucks, public workers, equipment, etc.).

Conclusions

Waste composition surveys on household level provide more detailed and valuable information on the actual waste generation patterns of a city. In combination with spatial information, it is possible to identify household types and adapt possible interventions to the available waste management strategies and prevailing housing conditions. The analysis allows a selective intervention for different household groups (e.g. information campaign or adjustment of collection schedules) or the saving of valuable resources in specific areas of the mostly ill-equipped SWM departments. Additionally, such household level interventions will finally reduce the waste to be transported and disposed of in landfills, prolong the lifespan of these sites and reduce their environmental impact.

It is interesting to note that the findings of this study concur with the ones of Bolaane and Ali (2004), which conclude that waste generation does not necessarily increase with higher income within one survey area. However, this is likely to be true at national level.

The project team will continue research on a mostly psychological level and further elaborate and apply the intervention strategies to certain household types in the relevant areas (e.g. separation of metals and introduction of composting). Perception and acceptance of these new interventions by the households will be studied further to learn more about the effect and scope of user-targeted interventions on SWM.

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