



Sustainable waste management: the example of the informal settlement “Las Fincas” on Cozumel Island, Mexico

T. L. Steenbeck¹, O. Frausto Martinez², M. Schirmer¹, C. Koch¹
& S. Giese³

¹*University of Applied Sciences Jena, Germany*

²*University of Quintana Roo, Mexico*

³*Thuringian State Institute for Environment and Geology, Germany*

Abstract

The study is part of the long-term research project called “Indicadores de productos de Interés Sustentabilidad aplicados a regional – México-Argentina” in collaboration with the University of Quintana Roo and the University Litoral of Argentina.

The project deals with the question: “How can you create sustainable waste management for an informal settlement to improve the social and environmental problems?” The knowledge gained from the last survey in 2014/2015 indicates that there is no systematic waste management within the settlement where 1015 people currently live. An unknown part of the waste is collected and disposed of in a disposal site by the waste management company PASA (Promotora Ambiental, S.A.B. de C.V.). The other part is burnt either on private property or improperly disposed illegally outside the land by residents. This leads to social tension between residents and to environmental pollution, such as, soil and groundwater pollution.

So far there are no data of waste and recycling management of the informal settlement Las Fincas. The study attempts to investigate the situation, to find out how the waste on the island is treated and how the municipal waste of Las Fincas is composed. The total amount of waste and its composition is analyzed by means of a waste analysis. Later a disposal plan for the settlement will be developed.

The basis for the analysis of waste are the corresponding sorting work guidelines and the household waste analysis data sheets of the Thuringian State Institute for Environment and Geology. The amount of waste of selected families



is collected and analyzed in two consecutive samples. The average amount of waste per inhabitant per year is determined by the earnings projection. The results obtained are used on the one hand for the development of a sustainable waste management concept and on the other, for the economic analysis in the case of recyclable materials. In addition, the aspects of waste prevention and recycling, the use of bio-waste were considered as well.

Keyword: waste analysis, sustainable waste management, informal settlement, waste concept, environmentally influencing, bio-waste composting.

1 Introduction

The island of Cozumel is located on the eastern coast of Mexico's Yucatán Peninsula in the state of Quintana Roo (see Fig. 1). It has a maximum north-south length of 45 kilometers and a maximum east-west distance of 15 kilometers and covers an area of approximately 684.48 square kilometers. It is the third largest island of Mexico [1]. About 95,000 inhabitants currently live on the island [2]. The island's capital is San Miguel de Cozumel, where almost the entire population lives.

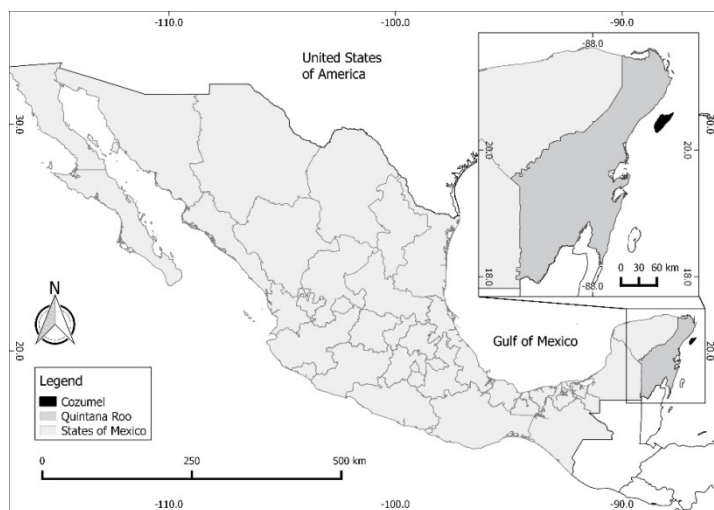


Figure 1: Geographical location of the island of Cozumel.

The Yucatán Peninsula is mainly composed of limestone. Cozumel Island is part of the Yucatec carbonate platform. Dissolution processes in the limestone lead to karstification; groundwater preferentially flows into karstic cavities and underground, the groundwater moves through karst cavities [3]. Because of the location of the island the groundwater is in contact with seawater.

The present study deals with a study area in the northwest of the island of Cozumel. This is the informal settlement Las Fincas, which is located outside the town of San Miguel de Cozumel. Due to the informal urbanization of

the settlement there is no public water or power supply nor a sewerage or waste disposal system. The construction of buildings and the inhabitation of parceled land takes place in an uncontrolled manner. Streets and roads are unpaved. The aquifer has a high sensitivity to anthropogenic influences. The fact that no public supply exists, constitutes a danger to the ground water, which can easily be contaminated by waste and sewerage.

In this study a waste analysis was implemented in Las Fincas. The sorting technology has been applied according to the specifications of the waste sorting guidelines respectively household waste analysis data sheets of the Thuringian State Institute for Environment and Geology. As a result, a recommendation for action on sustainable waste disposal and waste recycling was elaborated.

2 Waste management in Cozumel and Las Fincas

The Secretary of the Environment (SEMARNAT) and the Federal Environmental Agency (PROFPEPA) of Mexico are responsible for environmental policy. The Waste Management Act of 2003 (*Ley general para la prevención y gestión integral de los residuos*) forms the basis and legal forms for Mexican waste and recycling management. However, the individual states have their own environmental legislation. The definition and implementation of the legal forms are regulated by the state government – except in the case of special waste (here the Federal Government is responsible). Thus, there are specific laws (*leyes*), regulations (*reglamentos*) and standards (*normas*) for waste management in the states [4]. In the state of Quintana Roo, the Waste Act (*Ley para la prevención y la gestión integral de residuos*) regulates the prevention and treatment of waste.

About 100 metric tons of waste are produced daily by the total population of Cozumel [2]. This amount of waste is collected and disposed by the private waste management companies called Promotora Ambiental (PASA). Although a law for the prevention and treatment of household refuse has been in existence in Mexico since 2003, the waste of Cozumel was deposited on a wild dump until 2009. Only since 2010 has waste been deposited on a 25-hectare disposal site.

The statistics show that in Mexico only 10% of waste is collected separately [5]. The rest is placed on disposal sites. The recycling rate is about 5% [6] (in Germany it is 65%). The waste management company PASA is responsible for the collection and transportation of waste on the whole island. In Las Fincas the waste is collected three times a week. There are no data available concerning the amount of waste for Las Fincas.

3 Methods

3.1 Preparation

For the separation of waste according to the specifications of the waste sorting guidelines and household waste analysis data sheets of the Thuringian State Institute for Environment and Geology, two sieves with mesh sizes 50 mm and

10 mm were constructed. The leaflet has a mesh size (sieve cut) of 40 mm, but it was not possible to build the given mesh size in Mexico. Fractionation of waste was divided into three classes for a screening:

- Coarse waste Waste components > 50 mm
- Medium waste Waste components ≥ 10 mm ≤ 50 mm
- Fine waste Waste components < 10 mm

3.2 Sampling

As part of household waste analyses, it was necessary to consider the settlement structure circumstances of each study area [7]. For this the basic data of the previous survey of 2015 played a decisive role. Las Fincas was characterized by the following features [8]:

- Informal settlement without connection to public primary care;
- Thin housing development with high proportions of green space;
- Dry and rainy weather seasons;
- No systematic waste collection by municipal waste containers;
- No fees for waste by public institutions.

Las Fincas is divided into eight municipal districts (so-called manzanas). Figure 2 shows the location of the current waste collection places. Due to lack of infrastructure, the provisional collecting garbage cans were only positioned along the main road. A sampling of the waste of the public collection system was considered not to be effective in order to determine waste amounts because the inhabitants did not dispose their total amount of waste into the collecting garbage cans, but they burnt them or stored them in the vicinity of their homes.

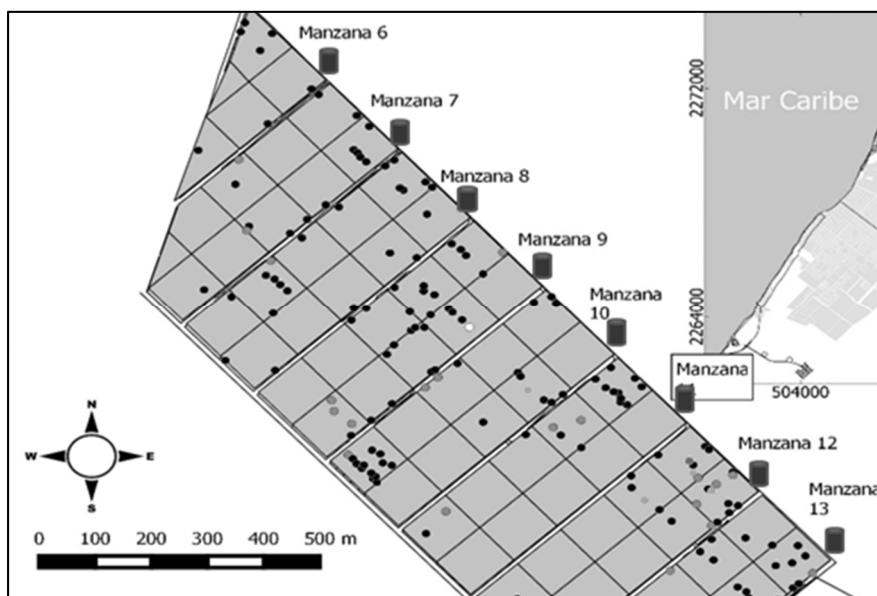


Figure 2: Current waste collection places in Las Fincas.

The actual amounts of waste could therefore only be ensured by direct detection. From eight manzanas, twenty families with a minimum capacity of three and a maximum of fourteen family members were selected. Another criterion was the permanent residence of the selected families. In these households, waste was collected as a sample for waste analysis. Garbage bags were distributed to the selected families to accommodate the total waste. Sampled households are shown in figure 3.

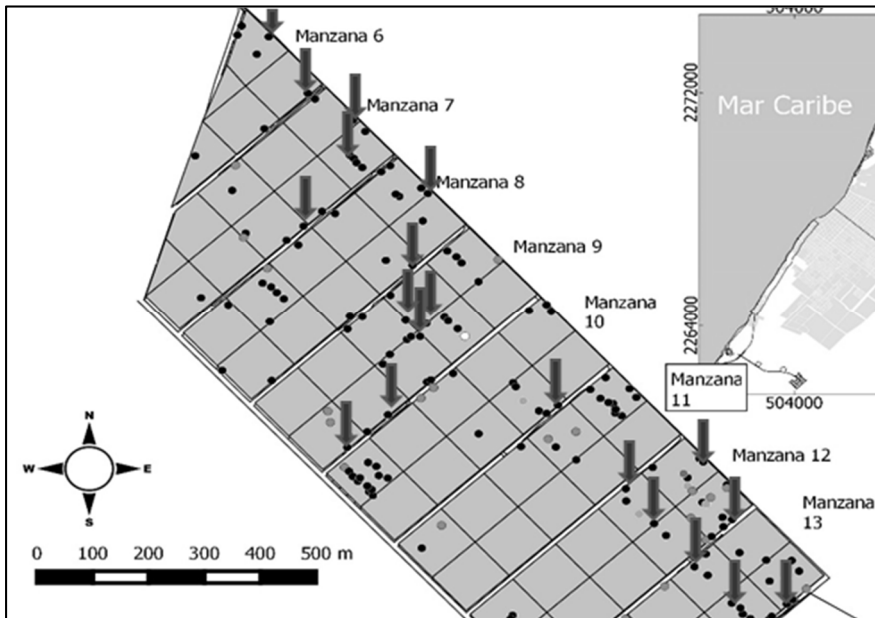


Figure 3: Location of the sampled households.

3.3 Sample size

The sample included twenty out of 274 families. This presented about 7% of the families and enabled a serious assessment with respect to the waste analysis. From a statistical rule 5% would be sufficient, that means about 14 families. The investigation period was defined for a week, so it was long enough for the sample size [7]. The amount of the continuously accumulating bio-waste was taken down on a special form which made a subsequent assignment possible. In this way it was possible to detect the average mass of waste of the respective sorting action in the aftermath and thus it was possible to calculate the specific data (kilograms per inhabitant per year), which were indispensable for an accurate settlement structure-specific extrapolation of sorting results for the whole area of Las Fincas.

3.4 Sorting work implementation

The collected samples of the households were picked up by a pick-up truck and transported to the sorting station. Before the sorting work, the containers were

prepared with labels for the different waste fractions. There took place a manual sorting of the samples according to the waste garbage guidelines of the TLUG [9] into 24 fractions, which form 14 groups of substance (see Table 1). For separation of the waste the designed sieve that is described in section 3.1 was used. The amounts of waste were weighed by using a kitchen scale. The results were tabulated.

4 Results

In order to calculate the specific amount of household waste in kilograms per inhabitant per week or kilograms per inhabitant per year, it was necessary to determine the number of inhabitants who were considered in the sample. The total number of included residents was 120. The results could be used for an extrapolation. Waste amount were calculated for the whole settlement.

During the first sorting campaign (15–22 March 2016) was collected an amount of 169.50 kg). During the second sorting campaign (23–30 March 2016) was recorded an amount of 177.20 kg.

Looking at table 1 it is clearly to be seen which main substances characterize the domestic waste composition.

Table 1: Shares of household waste composition according to material groups.

Household waste composition Las Fincas		
Material group	Waste amount per inhabitant per year [kg]	Proportionally [%]
(1) Compostable materials	21.8	30
(2) Glass	13.04	18
(3) Plastics	10.02	14
(4) Paper/cardboard/carton (PCC)	7.26	10
(5) Hygiene products	3.48	5
(6) Composite packaging	2.82	4
(7) Inert material	2.61	4
(8) Other types of waste	12.63	15
(1-7) Total I	61.03	85
(1-8) Total II	73.66	100

Table 1 shows clearly that the municipal waste composition of Las Fincas is mainly dominated by a small group of substances. These are the groups of

substances organic, glass, plastics, paper-cardboard-carton packaging (PCC) and inert material, which accounted an amount 85% (see table 1).

The sorting work showed an average amount of waste of about 0.21 kg per inhabitant per day. There was an average drop mass of 75 kg per person per year. Table 2 shows the average results per inhabitant (daily, weekly and yearly) and the total annual mass for Las Fincas.

Table 2: Specific volume of household waste for Las Fincas.

Specific volume of household waste per person in Las Fincas			
	kg/d	kg/wk	kg/yr
1. Sorting campaign	0.20	1.41	74.00
2. Sorting campaign	0.21	1.48	77.00

Based on the sampling data, the waste production in Las Fincas of all residents was calculated, which mount up to about 76 metric tons per year.

5 Recommended action

Compared with the average waste balance (385 kilograms per person per year) of Cozumel, the results of the study (about 74 or 77 kilograms per person per year) are lower. The cause of the higher volume of waste in the balance sheet in Cozumel over Las Fincas is because of the fact that most of the waste are from hotels and retail stores. However, not environmentally storage and disposal of waste leads to significant and adverse impact on groundwater and the soil in Las Fincas. This demonstrates the groundwater investigation of Koch *et al.* [10] from the year 2016. The public waste management in San Miguel de Cozumel passes waste to the disposal site on the island. The small amounts of waste in Las Fincas, which are predominantly recyclable, could be eliminated without damage by an organized separation and disposal. Organic waste could be recycled through composting. As part of environmental education programs, the citizens of Las Fincas could be sensitized for waste separation, waste prevention and safe disposal. A financial incentive could also be created through the sale of recyclable waste to collection. In the study, as a practical model a composter was built, which can be reconstructed with little effort.

6 Summary

The waste balance in Las Fincas revealed that the local waste amounts to only 20% compared to the amount of waste the island's capital. However, there is no effective public waste management and the principle of circular economy is not applied. This lead to the problem that there is no proper waste disposal takes place



which has negative effects on groundwater and soil of the area. A perspective for the residents could be environmental education programs in order to increase and sensitize their awareness of environmentally sound and sustainable waste management. In addition, financial incentives such as the sale of recyclable waste, which presented approximately 36% of total waste generated, encourage people to separate the waste and the collection points. The composting of organic waste (30%) would reduce total waste generation considerably. Thus, only 34% would result by residual waste that must be disposed on disposal site. This corresponds to an amount of approximately 19 tons per year. As a result, the existing burden on water and soil would be significantly reduced.

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