VACUUM WASTE COLLECTION SYSTEM FOR AN HISTORICAL CITY CENTRE

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Waste management in historical city centres may be challengeable for waste handling operatives. In this paper a developed plan is presented for vacuum waste collection system for the historical city centre of Sibiu, Romania, together with its feasibility and opportunities. The main goal is to improve the urban environment, maintain the historic appeal, and stimulate local economic activity. This optimal solution is following the models of other European cities. The system is designed for the main streets and the total waste amount is calculated; moreover the number of population served is correlated with seasonal tourist flow. The following research is provided as an example to be followed by other cities facing the same challenges.

Keywords: waste management, vacuum waste system, historical city centres.

1. Introduction

Municipal Solid Waste (MSW) management is a topic that was deeply studied in the last decade and many solutions at national and international level were proposed [1,2,3,4,5]. The MSW management in historical areas create many "problems" when a suitable management plan must be made. In order of not to damage buildings or surroundings of historical value the vacuum system for waste management seems to be an optimal solution for such areas, followed by the kerb-side collection as it was demonstrated in many European cities [6, 7]. The vacuum system contributes also to the decrease of the air pollution, often critical in urban areas [8,9,10,11], thanks to the reduction of the collection tracks.

The challenges that should be faced in the case of Sibiu historical city centre are narrow streets, small areas for waste sorting, crowded places and high requirements for hygiene in the places of tourist attractions. Some studies analysed the tourist influence on MSW production and management in different cities in Europe but only few data are reported for the hystorical ones [12-14]. Underground vacuum system eliminates the need for heavy waste collection

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trucks, and the problem with ever-full containers, at the same time facilitate sorting at source, in order to leave in the residual MSW (RMSW) only not recyclable materials potentially suitable for Solid Recovered Fuel (SRF) generation [15-18]. Also underground containers can be easily fit in the environment taking into account buildings and historical heritage; hygiene improves considerably, as the system is hermetically sealed; in such a way insects and pests will not be attracted anymore.

Nowadays, many cities all over the world are adopting underground vacuum waste systems to transport and collect garbage without any surface activity, and this is considered a big advantage especially for historical centres of older urban zones. Vacuum system network takes away foul-smelling, dirty refuse collection rooms and containers in the streets. A number of studies present a variety of environmental, public-health, and quality-of-life arguments in favour of vacuum versus conventional collection systems using Life Cycle Assessment (LCA) to compare total greenhouse emissions and other environmental impacts [19]. Studies that compare the relative GHG emissions and other environmental impacts of hypothetical vacuum collection systems with those of conventional collection are showing several advantages of vacuum collection systems [20,21].

2. Current situation

The historical centre of Sibiu (Hermannstadt), Romania is dated back to the 15th century and is part of national and European heritage, hosting many tourist attractions, and also, seasonal cultural or social events. The old historical buildings are now hotels, shops, restaurants, etc. but also there are lot of householders. In order to propose an underground waste collection system first an evaluation of a number of population that will benefit from the system is presented, and also tourists flow and the most busy months from the point of view of cultural events.

Challenges of historical city centre of Sibiu are: lack of space and a lot of tourists; at the same time the need is to ensure a clean city environment. By the time of seasonal events the volume of waste increases considerably and the normal containers are overlapped. In order to propose a solution to eliminate unpleasant odour, pests and noisy waste collection tracks a plan for an underground vacuum waste collection is discussed farther. The underground pipe system can collect waste from shops, restaurants, boutiques, offices and householders.

Vacuum collection system reduces manual handling and traditional storage bins. Waste is transported from buildings through an underground pipe network, to a central collection station. Several researchers focused their studies on reductions in traffic congestion, worker accidents and exposure to pathogens and

other sanitary hazard, noise (a one - quarter reduction in levels, a two-thirds reduction in duration), animal and insect pests and odour [22].

At this stage the collection of waste in this particular area is carried out through door-to-door; the collection frequency is twice per week. Although the separate collection of household waste is a legislative obligation, it is no properly undergoing.

Currently solid waste management in Sibiu County is environmentally unsustainable and not entirely comply with the requirements of European Union directives and regulations [23, 24]. Garbage is dumped in containers placed along public right-of-ways; besides of bad aspect, these containers are quickly fooled up especially during the seasonal events; at the same time waste collection tracks heavily deteriorate the city by roaming old medieval roads and hence, badly damaging the local environment. Another reason for adopting this system is that in the historical quarter there are small courtyards and very little space to place waste bins.

3. Advantages/disadvantages of a vacuum waste collection system for historical city centre

The services of garbage trucks will no longer be required; in such a way several environmental issues are solved, if thinking about traffic congestions, especially in narrow old streets, less noise, pollution and greenhouse gas emissions; at the same time traditional containers will disappear together with unpleasant aspect, odours and insects in such a way largely improving health, sanitation and overall environmental conditions.

The terms of safety are improved, the risk of fire is reduced also [25], as the pipe network acts as a self-cleaning mechanism, in such a way vacuum waste collection is more sanitary [26], while refuse waste is no longer impacted by weather conditions like rain, snow or wind. This system will make street cleaning considerably easier.

The only inconvenience is the construction of piping system; under the time of construction certainly inhabitants and businesses will suffer temporary inconveniences. The systems cannot collect large items such as white goods, bulky waste and there are difficulties with glass as well.

Nevertheless, residential and business area will benefit from pleasant environment and appeal both for trade and recreation.

4. Case study – historical city centre of Sibiu

The decision to evaluate the vacuum waste system for old city centre of Sibiu is based on several parameters: waste volume – which is wide variable because of seasonal events; composition of waste; source concentration; current

infrastructure; distance from sources and the level of public concern. The goal is to improve the urban environment, maintain the historic appeal and stimulate local economic activity. Table 1 provides data on pipe network for the main streets proposed to be equipped with the vacuum collection system.

Table 1

Waste collection vacuum system - pipe length

Street	Length (m)	Collection points	Nr. of waste collection points for householders	Nr. of collection boxes	Nr. of vacuum central systems
Balcescu	500	15	49 (medium length 7 m)	58	1
Odobescu	350	6			
Main square	150	7			
Mitropoliei	350	21			

The system was designed for a total area of 0.4 km^2, having 1000 inhabitants and around 32 bars and restaurants. The system consists of 58 collection boxes, and 1 central waste collection stations. The maximum transport distance is 1.3 km within the system and the total pipe network is of 1.35 km. Vacuum collection systems consist of a number of collection points which are linked together by piping to transport the waste to a central collection station.

In Figure 1, streets considered for vacuum waste collection system are presented; the criteria were tourist attractions and geographical location specifics.

Fig. 1. GIS map – proposed area: the historical centre of Sibiu

A second map is presented to show the area where the main vacuum unit will be placed, considering the easier accessibility for the waste trucks and topography (Figure 2).

Fig. 2. GIS map - vacuum chamber area

In order to calculate the population that will benefit from waste collection vacuum system, statistical data were used provided by the City Council of Sibiu, for the last 5 years. Coefficient of accommodation occupancy was considered 30%, and a total number of tourists was calculated according to an annual average.

Table 2

Number of population serviced from waste collection vacuum system

	Nr. of residential area	Nr. of restaurants and bars	Nr. of hotels, hostels and pensions	Nr. of shops and business area
	30	32	14	170
Inhabitants / tourists	1000	600	300	550
Seasonal tourists flow		1000		

Considering the total amount of population that benefits from this system, the average index of waste production and the waste weight, it is possible to develop some calculations.

Concerning the determination of the average daily amount of household waste ($\overline{Q}$):

$$\overline{Q} = N \cdot \overline{I} \cdot 0.001 \qquad [t/day] \tag{1}$$

where:

N – number of people that benefit from the system

$\overline{I}$ – average index of waste production [kg/day] = 0.5 – 0.8

Adopted $\overline{I} = 0.7$

$$\overline{Q} = 1000 \cdot \overline{I} \cdot 0.001 = 0.7 \ [t/day] \tag{2}$$

Determining the amount of daily urban assimilable waste (Q_a):

$$Q_a = \sum (I_{si} \cdot T_i) \ [t/day] \tag{3}$$

where:

T_i – capacity of buildings (administrative, shops, restaurants, hotels). According to the population serviced, it was taken into account:

$T_i = 1.2 \ [m^3]$, in the average.

I_{si} – index of household assimilable waste production, that was considered: $I_{si} = I_{si,min} = 1.25$

$$Q_a = 1.25 \cdot 1.2 = 1.5 \ [m^3/day] = 0.6 \ [t/day] \tag{4}$$

Quanfication of street waste (Q_s)

$$Q_s = S \cdot I_s \qquad [t/day] \tag{5}$$

where:

Q_s – daily amount of municipal waste collected from the streets of the proposed area, in t/day

S – area (streets and sidewalks) [km^2]

I_s – average index of municipal waste production from streets and sidewalks [t day^{-1} km^{-2}].

$$Q_s = S \cdot I_s = \ 0.03 \ [t/day] \tag{6}$$

Daily quantities of municipal waste (Q_{tot}) was calculated by considering the total amount of waste fractions produced daily in Sibiu city center

$$Q_{tot} = \sum Q_i \ [t/day] \tag{7}$$

where:

Q_{tot} – total amount of waste in t/day; Q_i – amount of waste fractions in t/day

$$Q_{tot} = \overline{Q} + Q_a + Q_s \ [t/day] \tag{8}$$

$$Q_{tot} = 1.33 \ [t/day] \tag{9}$$

Since glass and metals cannot be collected pneumatically, they will be disposed of in traditional recycle containers, while the collection boxes for vacuum systems will be green – for organic – and yellow, for paper and cardboard waste [3,12,13]. Several similar projects were done in Spain (city of Leon, Palma de Mallorca, Sevilla [27], and Roosevelt Island, New York [28], or Disney World Theme Park, Orlando, Florida [29].

5. Conclusions

The presented case study stressed out the positive and negative factors of waste management in Romanian historical city centres, and challenges what should be faced with, especially during seasonal events and months with the highest tourists flow.

Even if separate collection of household waste is a legislative obligation, people should receive an easy operated system and not just the awareness. By a vacuum collection system the terms of safety can be improved; traffic congestions, especially in narrow old streets, residential and business area will benefit from pleasant environment and appeal both for trade and recreation.

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