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# OPTIMISATION OF SELECTIVE WASTE COLLECTION ROUTES ON THE BASIS OF GEOGRAPHICAL INFORMATION SYSTEM (GIS)

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**ABSTRACT:** The advantages of GIS systems are extended from determining positions into complex route optimisation software. A specialized type of these solutions are applied for elaborating the functions of advanced selective waste collection systems to handle the effects of variable – in some cases non-deterministic – boundary conditions. The aim of this paper is to represent the research activities according to the development of methods towards on one hand the above mentioned application and on the other hand to harmonize them for the sake of economic operation of the collection systems.
**KEYWORDS:** optimisation software, waste collection systems, GIS systems

## ❖ INTRODUCTION

Countrywide spreading of selective waste collection systems extends the demand for services which enable the cost -effective operation of these systems. These services are important as the marketing activities regarding the positive environmental effects of the selective collection enhance the amount of waste fractions which became secondary raw material in this way. Accordingly the time period between the unloading procedures of the collection islands have to be shortened to avoid the consumers facing overloaded and contaminated containers. There are several other factors which have influence on the waste amount which is carried to the selective islands (during the periods between the unloading service days) besides this emerging trend. One of these factors is the emerged amount of PET bottles in summer time or another one is the less amount of paper in case of the school organized paper collection actions.

## ❖ THE STUDY

Keeping the regular service level while emerging waste amounts means the continuous revision of the collecting vehicle routes and continuous monitoring of the waste amounts gathered in the collection islands. Collection Service Operators (CSOs) are interested in economic operation accordingly they seek combined collection possibilities of the different waste fractions which ensure the maximal utilization of the collection capacities. My research deals with the effects of various collection conditions and seasonal differences of the waste generation on the vehicle routes. It is possible to answer the following practical questions regarding the operation of collection systems in the base of the research activities:

- ❖ What effects the varying gathered waste amount has
  - on the route of the collection vehicles and on the collection time, and
  - on the number of collecting vehicles and other resources?
- ❖ What influence the varying velocities of the collection vehicles have on the collection time and length of the routes?
- ❖ What kinds of savings are realized (if any) by combined collection?
- ❖ Which recycling facilities have to be chosen in a specific situation?
- ❖ How collection parameters are influenced by relocating the collection islands or by modifying the configuration of the waste fraction containers on the islands?

The only way of answering these questions is to carry out simulation examinations regarding on one hand the different alternatives of measure of the waste generation and on the other hand the alternatives of collection system operation. The broader aims of the examinations are to determine the optimal service method which is in strict correlation with the decision about the mutual or separated collection of the waste fractions, after these the necessary number of routes has to be determined. Spatial modelling the road network of the service area with the island locations and receivable types and container number of waste fractions in each collection islands are preconditions for accomplishing the examinations.

A sample examination on a route optimization for an urban area selective waste collection system will be presented in the followings. The examined system contains 130 collection islands and covers 3 types of waste fractions: paper, plastic (mainly PET) and glass bottles.

The examinations are carried out by simulation activities on the ground of the following thoughts:

- adequately parameterized (regarding e.g. the fraction types, service locations, vehicle container capacities, vehicle speed, fuel) collection vehicle goes from island to island
- shifts the waste fractions from the waste bins of the collection islands to the vehicle container (The amounts of the waste quantities are taken into account by average load volumes of the waste bins in the case of every fraction. These averages are applied on every island)
- searching the treatment facility in case of reaching the vehicle container capacity
- continuing collection route after bulk unloading at the facility

## ANALYSES, DISCUSSIONS, APPROACHES AND INTERPRETATIONS

These simulation steps in iteration cycles are continuing until all island containers serviced and minimal collection route length found. The primary topic of this paper is not the calculation of the minimal route length but the interpretation of the effects of the above listed condition changes (e.g. the quantitative change of the waste on the islands between the unloading services) on the routes.

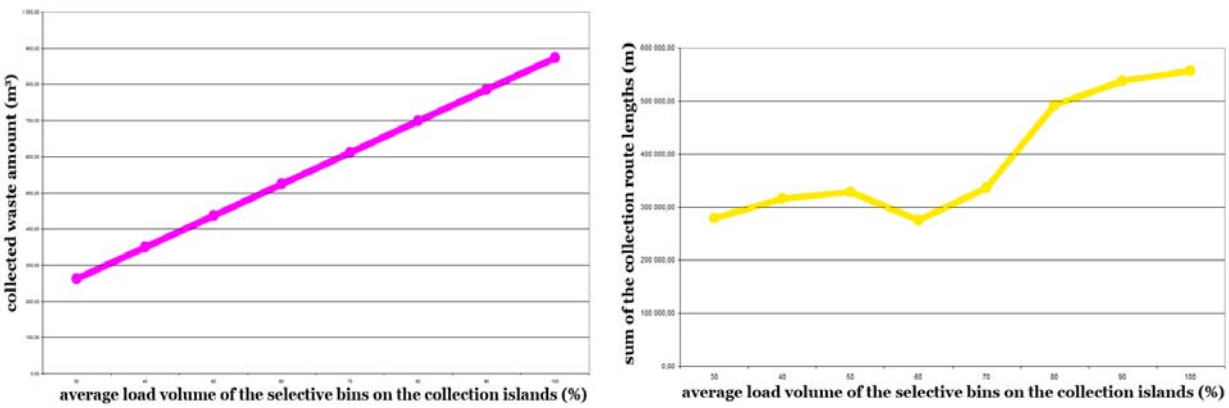


Fig.1.: Collected waste amount and sum of the collection route lengths against the average load volume of the selective bins on the collection islands

Left side of the 1st figure presents the achievement of the examination which regards to the collected waste amount against the average load volume of the selective bins on the collection islands. It shows that the collected waste amount is emerging proportionally with emerging of the average load volumes.

Right side of the 1st figure presents the achievement of the examination which regards to the sum of the collection route lengths against the average load volume of the selective bins on the collection islands. The result shows that the change of the summarized collection length is not proportional with the change of the average load volume. Accordingly higher load volumes of the selective bins will not mean longer collection routes in every case.

This graph shows that higher loads mean shorter routes in some cases. The potential causes to be taken into account for accepting this result are the following:

- the utilization of the vehicle container capacity (tons/km) is better if the load volumes of the selective bins are higher,
- the rate of the filling of the vehicle container is different in the cases of the different average load volumes of the selective bins. It means that treatment facility is visited from the different collection islands in these cases.

Since these visits mean different itineraries and in some cases the shorter route lengths for the collection of higher waste amounts are documented in the course of the route optimization processes.

It is necessary to answer the questions regarding the required number of collection vehicles. On one hand this number is an output parameter of the route optimization process and on the other hand this number has similar correlation to the load volumes of the selective bins such as the previous presented parameter (the sum length of collection routes) had. By the side of the collection service providers it is important to determine the increment of the load volumes of the selective bins which requires involvement a new vehicle to the collection fleet.

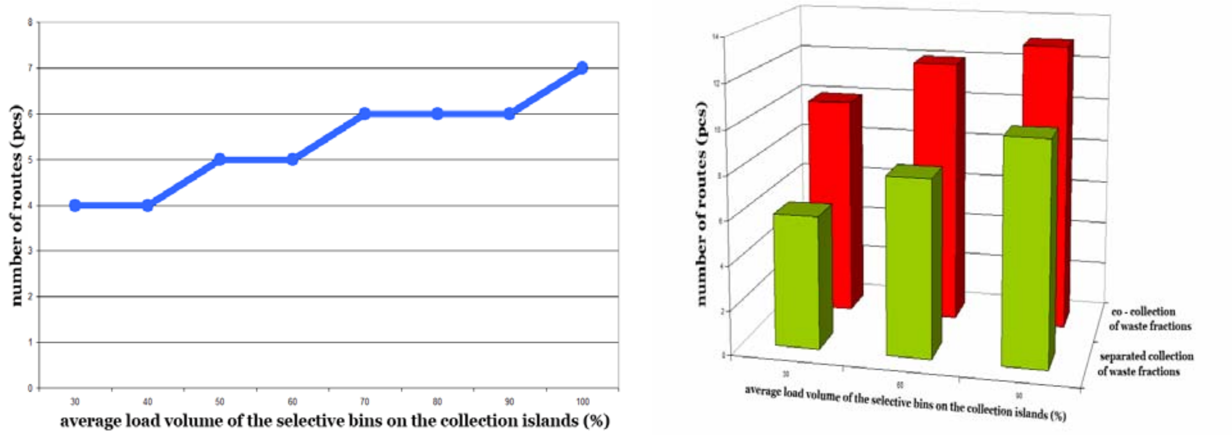


Fig.2.: The number of collection routes against the average load volume of the selective bins on the collection islands and the effects of the different collection methods on the collection routes

Left side of the 2nd figure presents the achievement of the examination which regards the number of collection routes against the average load volume of the selective bins on the collection islands. An important achievement of the examination is that the rising rate of the route numbers is lower than the rising rate of the average load volumes. By means of the previous achievement the reserves of the applied collection fleet are quantifiable by the service providers. E.g. the number of routes which set up for service of waste bins with 70 percent average load volume is able to service waste bins with 90 percent average load volume too.

The right side of the 2nd figure shows that the necessary number of routes in the case of combined collection (when waste collected into separated collection container sections of the same vehicle) is higher than this number of routes in case of separated collection of the waste fractions. The reason is the different loading rate of the vehicle container sections in correlation with the different rate of disposition of the waste fractions on the selective islands.

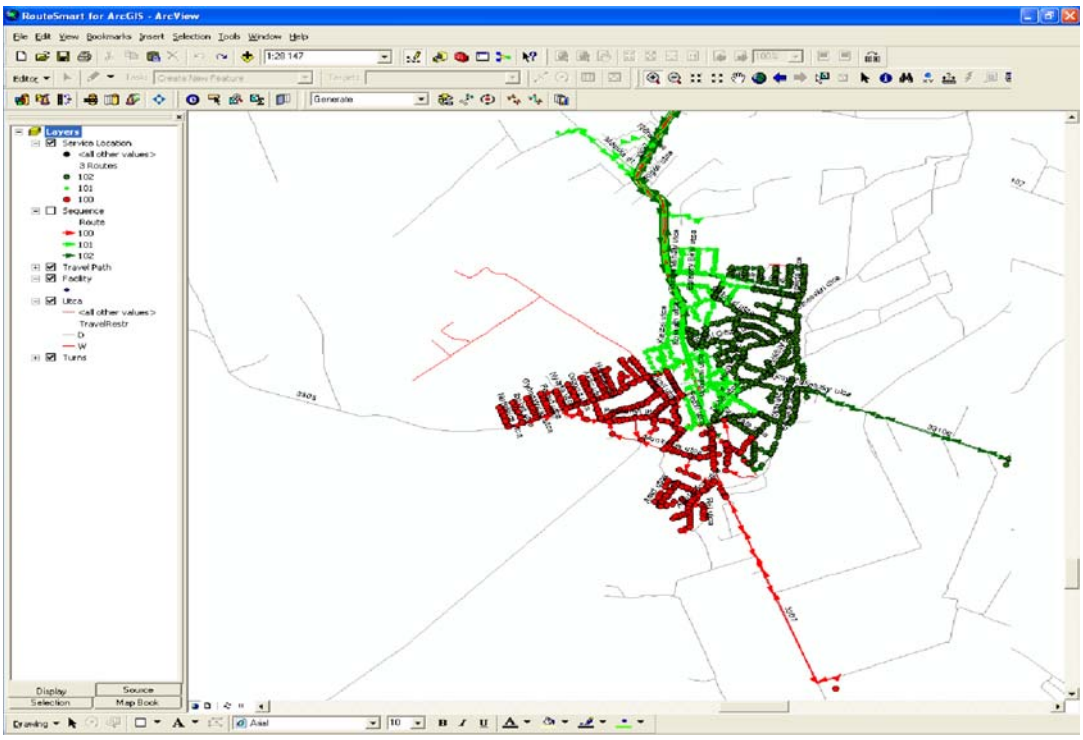


Fig.3.: Service area and collection routes (presented in different colours) in RouteSmart for ARCGIS

The volume of the separated sections are smaller than the volume of the whole vehicle container capacity therefore each of them are filled faster along the collection way. The section of the infrequent waste fraction is filled relatively slower than the section of the other fraction accordingly there will be unused capacity every time after the other section is filled. The collection vehicle visits the treatment facility more often because of this faster filling rate hence the collection route length is emerging.

## ❖ CONCLUSION

These statements depend on the examined area however, their application is generalized. Location of the selective collection islands correlated to each other and to the traffic infrastructures and the classification of the actual service area by settlement type (e.g. building estates or bungalow zone) have influence on the quantity of the selective waste fractions to be collected.

An important achievement of these examinations is that the interpretation of a routing system (even the evaluated one) as constantly valid set-up for collective vehicle operation is faulty.

Accordingly the routing system has to be revised and actualised periodically and during these revisions the boundary conditions, economic operation and keeping the desired service level have to be taken into account.

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