IMPLEMENTATION OF RFID TECHNOLOGY FOR WASTE DISPOSAL VEHICLES

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Abstract

RFID technologies are important in the collection of separate waste. The approach to waste management should be changed for the better by using RFID from landfill to recycling. This paper presents the use of RFID in waste management, theoretical background, design and application creation. The theoretical background deals with waste management, waste collection and RFID technology. The proposal addresses the issue of waste management and placing RFID chips in individual collection containers. The main criteria of the proposed application are the type of waste and weight. The application of RFID chips to collection containers should not only increase the interest in recycling, but also the percentage of recycling households in Slovakia, which is in 2019 in critical values.

Keywords: RFID technology, recycling, waste management

1.   INTRODUCTION

Landfilling is the most common way of disposing waste in Slovakia. Since Slovak legislation is also obliged to comply with European Union legislation, separate collection of waste and its subsequent recovery is increasingly promoted in Slovakia. An important factor is the composition of mixed municipal waste, such as the proportion of individual components in unseparated mixed municipal waste. Based on the research, the yield of separate collection of individual types of waste in the given municipality can be estimated. It is also important to define the composition of other flows of municipal waste, in addition to the separately collected fractions, also large-scale waste, garden waste and the like. On this basis, the first material analyses of municipal waste or mixed municipal waste began to appear in Slovakia at the end of the 1990s. By comparing and analysing the results obtained in terms of both time and area, it is possible to show that the results achieved have little informative value and are of little use. The reasons for this are:

- inconsistent methodology of analysis,
- inconsistent sampling and preparation system;
- different social structure of analysed population,
- different quantities and types of containers for collection points,
- very rapid development of production and consequently the supply of products on the market, which has a qualitative and quantitative impact on municipal waste [1].

2.   POSSIBILITIES OF USING RFID TECHNOLOGY IN WASTE MANAGEMENT

The use of recycling is expected as a result of the use of RFID technology. The approach to waste management should change positively depending on the use of RFID technology. The current situation of waste management is characterized by landfilling, as evidenced by a survey of the Slovak Environmental Agency, which has been carried out since 2010 and is presented in **Figure 1**. New technologies offer broad opportunities for streamlining recycling processes and monitoring product life cycles. One of the new technologies is Radio Frequency Identification (RFID), which currently extensively interferes with modern manufacturing and retail chains worldwide [2]. RFID technology can also be effectively used in waste management. The widespread use of this technology has been largely contributed to by the so-called EPC

coding. The EPC has been designed to use an unlicensed wireless protocol, allowing essential parts of the system to be constructed without the need for licensing or renting third party intellectual property. It is able to respond flexibly to changes in demand, which is its main advantage over traditional identification technologies. RFID technology consists of an evaluation unit and a wide range of tag tags that include an electronic circuit and an antenna [3].
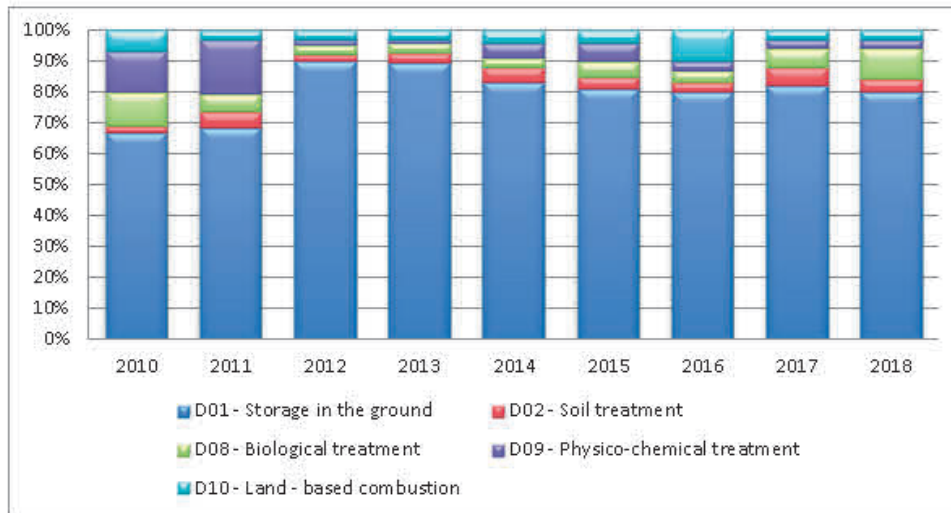

Figure 1 Waste disposal by code

2.1. Concept of using RFID technology in waste management

The proposed concept consists of 2 stages of application of RFID technology in waste management:

- RFID application for municipal waste collection;
- Labelling of specific RFID outputs.

2.1.1 RFID application for municipal waste collection

The use of RFID enables an improved support for recycling, while increasing the efficiency of waste management in cities and municipalities throughout the country. For better citizens' motivation, it is possible to use RFID features, which reliably identify containers and thus bring new possibilities for obtaining data regarding recycling. One way of remunerating these citizens may be to partially redu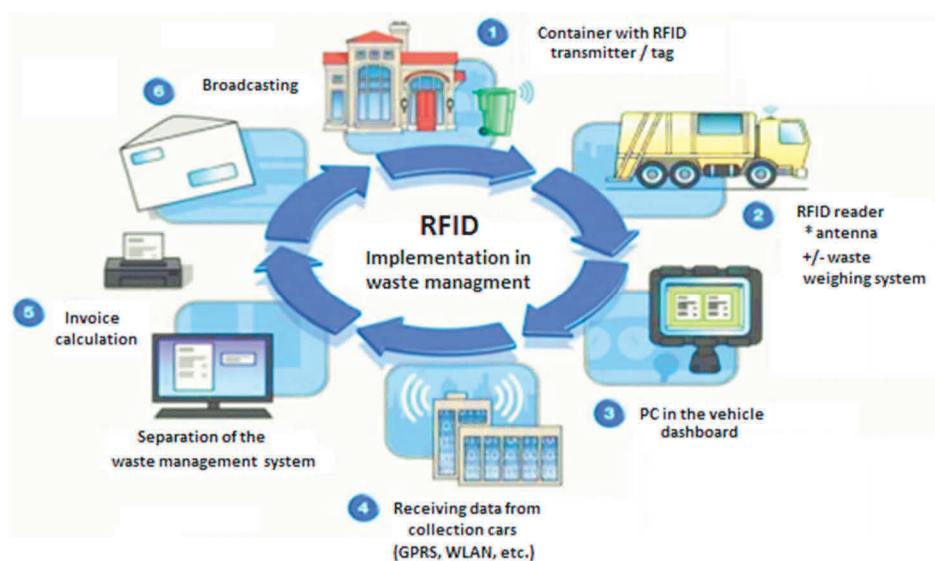ce the waste collection fees [4]. One of the applications of RFID technology is to enable the replacement of waste containers, which means the collection of full

Figure 2 Intelligent monitoring of waste exports

containers and the distribution of empty containers. Another possibility for an active use of RFID technology is an application of precise planning for the transport routes of waste disposal vehicles.

2.1.2 Labelling of specific RFID outputs

Each household will be assigned an ID number written on RFID tags attached to collection containers. These will work on the high frequency UHF tag. Subsequently, the waste collection vehicles with RFID readers pass through the city. The tag indicates that the municipal waste collection container is full and then the waste collection vehicle captures the tag. The tag determines the amount of waste as well as the residence based on the assigned ID. By determining the amount of recycled waste produced monthly in each household, individual households receive a discount on the collection fee. Waste collection vehicles should be considered. The described system is presented in **Figure 2**.

3.   RFID SOLUTION FOR MUNICIPAL WASTE DISPOSAL

The automatic information collection regarding the municipal waste disposal container can be a very useful indication. The advantage for the customer is that he pays for genuine services as well as for service providers who have no problem of demonstrating performance. Ideally, the location and time of the discharge mechanism triggering is recorded along with the container identifier [5]. This makes it possible to record and clearly document the waste disposal vehicle movement, the number of waste disposals, the number and type of waste containers as well as other operating data.

Figure 3 Placing RFID chips on disposal containers

Barcodes or contactless RFID tags can be used to identify disposal containers. These allow readings without direct visibility over a relatively long distance, and are therefore suitable for fully automatic identification without any human intervention as shown in **Figure 3** [6].

4. DESIGN OF RFID TECHNOLOGY SOLUTIONSFID SOLUTION FOR MUNICIPAL WASTE DISPOSAL

Each waste disposal container is equipped with an RFID tag that has a unique number. This is assigned to a specific customer in the central database. The waste disposal vehicle is equipped with an RFID scanning system that is set up to read the RFID tag of the waste collection container or container when it is being emptied [7]. In combination with sensors that detect the physical movement of the mechanism, it is possible to compare the number of containers being emptied with the number of actually read codes and immediately identify the damaged / missing RFID tag or unauthorized dumping. The RFID reading itself is performed by an industrial reader with adjustable power and specially adapted antennas.

The data and software are located on an industrial PC with high durability since everything is located on the outside of the vehicle body with operating temperatures coincident with the external environment **Figure 4** [8]. Upon arrival at the base station, the data is automatically transferred via the WiFi network to the central server. The system is ready to record GPS coordinates of waste dipping and instantly transfers data over the GPRS network. The time of waste tipping and the unique EPC code from the RFID tag memory are transmitted. The data is transferred to the parent system used (usually the billing system) or to the database system. The system is used to view and calculate statistics. It is also possible to provide data to other applications. In normal operation, the vehicle operator may be provided with replacement RFID tags that may be used in the event of a damaged or missing tag. This will then be manually edited with the appropriate customer. By automatically identifying the waste containers, it is also possible to obtain information and evidence on the frequency of emptying the containers or on the efficiency of their deployment. Such information helps to optimize the number and location of collection points and also helps to draw out suitable routes for waste disposal vehicles [9,10].

This data can either be sent to the host computer in online mode or the data can be collected on-board and evaluated later. The offline option saves costs associated with mobile carrier data services that record track, consumption, and other traffic data.

Figure 4 RFID for waste disposal vehicle

Benefits of the solution for towns and villages [11]:

- Overview of exported waste volumes from individual payers.

- Possibility of charging waste payments according to actually disposed waste.

- Reducing the total amount of unseparated solid municipal waste for the whole municipality and thus reducing payments for its transport, disposal or landfill.

- A tool for targeted separation support.

- Tool for passportization, inspection and inventory of waste containers.

- A tool for the rapid identification of irregularities in the waste registration and export process, which enables their targeted and prompt correction.

Benefits of the solution for waste exporters [11]:

- Relevant basis for objective billing to the municipality - list of exported containers - documented volume of waste per billing period.

- Transparency of operations, which minimizes the need to resolve complaints from the municipality as well as complaints from the payers (citizens and organizations).

Benefits of the solution for payers (citizens and organizations) [11]:

- The solution provides an information portal on the status of container exports.

- Possibility of direct settlement of payments for municipal solid waste according to the actually exported volume from individual payers.

- Flexibility of waste disposal - the payer does not need to be bound exclusively by a flat-rate fees. Waste export and disposal services may be charged according to the amount of waste actually produced and exported [12].

5. CONCLUSION

The success of waste separation is currently variable and depends on the specified criteria for each individual location. Recycling capacities of secondary raw materials are sufficient in Slovakia, but the weak point is the optimum method of separate waste collection. Automation and technology are on the rise in all sectors, also in the waste collection and recycling [13]. RFID technologies are intended to increase the interest not only in the field of recycling, which is also related to the issue of concern for care and improvement of the environment.

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