

# Client-Server System for Improving Ecological Conditions of the Environment

Dijana Jagodić<sup>1</sup>, Dejan Vujičić<sup>1</sup>, Siniša Randić<sup>1</sup>

**Abstract** – This paper describes the client-server system that was designed to improve ecological awareness of the society. Illegal landfills represent a big problem nowadays, and communal services cannot deal with them all, particularly because some of them are on unknown locations. The presented system can help communal services to better track illegal landfills and to react accordingly, but also any other communal problems can be reported. System is composed of Android client application, which is used to send information about ecological problems. These records are sent to the server, where the dispatchers review the issue and react accordingly to the problem. Users can send coordinates and description of the problem location, to facilitate problem solving process.

**Keywords** – Android, client-server, ecology, illegal landfills, waste management.

## I. INTRODUCTION

Natural resources are the key factor of the economic prosperity of a country. In order to be used at a maximum level, they need to be preserved and exploited in ecologically acceptable manner. However, with the technological development and increase in manufacturing production, the problem of waste management emerges as one of the major issues. The resolving of this problem not only involves the state legislations and regulations, but also the social responsibility of the companies and the whole society. While the companies' ecological responsibilities are primarily regulated by laws and inspections, the awareness of the society, particularly in developing countries, such as Serbia, is at low level. There have been numerous campaigns to increase ecological education in Serbia, but unfortunately, the reality is less than satisfactory.

Illegal landfills and undesirable disposal of communal waste are major factors in disturbing of natural balance. Large number of metal cans, plastic packaging, and even hazardous toxic materials are just dropped in nature and left to the mercy of ecologically responsible individuals. The degradation period of these materials can be longer than hundred years, some of them cannot be degradable at all. Their presence influences not only the soil, but also the watercourses and the ecological environment at a whole.

This paper describes the client-server system that is designed to help the community and state to overcome these ecological issues by suggesting larger involvement of the

society and individuals in this process. The people are given a chance to prove their ecological consciousness by reporting any illegal landfills or any sort of dump sites they stumble upon. In this way, the proper cooperation between the society and communal services can bring long expected balance to the environment.

The chapters in this paper are organized as follows. The second chapter brings the issues in waste management, particularly with the communal waste, packaging waste, and illegal landfills. In the third chapter the client-server system for reporting of ecological problems is described. The final chapter summarizes the whole matter.

## II. WASTE MANAGEMENT – MAJOR CHALLENGE OF THE MODERN SOCIETY

The waste management policy at European Union level is defined in Waste management strategy. It is based on hierarchy of principles, where the biggest priority is given to the prevention of waste formation, then to reusability and recycling, energy regeneration, and finally, to the waste disposal [1].

It is considered that Republic of Serbia belongs to the group of countries with low level of waste management. The following problems have been emphasized [1]:

- Omissions in applying the laws regarding waste management and ecological preservation;
- Lack of infrastructure;
- High costs and irrational organization of waste management;
- Low level of quality of service;
- Insufficient concern and enrollment of society and individuals into environmental problem solving.

Chapter 27 in the Serbia's application for membership of the European Union is regarding environmental conditions. In its document from 2011, it is said that Serbia has implemented crucial laws in line with the recommendations from EU, particularly in terms of waste prevention, reuse, recycling, and recovery. However, the major problems are emphasized as low waste collection rates in rural communities and vast number of illegal landfills [2]. In 2012, Serbia was successful in terms of registration and reporting on waste, but still, the waste collection rate in rural areas remains an issue [3]. By opening a regional waste management center in Pirot in 2013, Serbia moved on toward better waste management society. However, European Commission suggested that landfilling should be used only as a necessity, if there are no other waste management methods [4]. In 2014, a new waste management facility was opened and Serbia has had seven EU compliant regional landfills. European Commission emphasized the necessity of closing illegal landfills [5]. A regulation on the

<sup>1</sup>Dijana Jagodić, Dejan Vujičić, and Siniša Randić are with the Faculty of Technical Sciences in Čačak at University of Kragujevac, Sv. Save 65, Čačak 32000, Serbia, E-mails: [dijana7j@gmail.com](mailto:dijana7j@gmail.com), [dejan.vujicic@ftn.kg.ac.rs](mailto:dejan.vujicic@ftn.kg.ac.rs), [sinisa.randjic@ftn.kg.ac.rs](mailto:sinisa.randjic@ftn.kg.ac.rs)

plan for reducing packaging waste in period 2015 – 2019 was adopted by Serbia in 2015, but its implementation mainly depends on resolving “systematic weaknesses in the implementation of environmental projects” [6]. This paper addresses this problem, by suggesting larger enrolment of society and individuals in the preservation of ecological environment.

### A. Communal Waste

The data about communal waste are collected via reports from local communal services. Some indicators regarding communal waste for the period 2011 – 2014, are given in Table I [7].

TABLE I  
SOME INDICATORS REGARDING COMMUNAL WASTE FOR THE PERIOD  
2011 – 2014

Year	2011	2012	2013	2014
Amount of generated waste (millions of tons)	2.71	2.62	2.41	2.13
Amount of collected waste (millions of tons)	2.09	1.83	1.92	1.67
Amount of reused waste (tons)	N/A	N/A	24843	14521
Average percentage of waste collection (%)	77	~70	80	~80
Average daily amount of waste per capita (kg)	1.01	0.99	0.92	0.81
Average yearly amount of waste per capita (tons)	0.37	0.36	0.34	0.30

From Table I, it can be seen that the total amount of generated waste is decreasing, starting with the year 2011, which is in accordance with the data from the European Environment Agency, where many countries reported decreased amount of communal waste in 2014 [7].

### B. Packaging Waste

Packaging waste management is primarily related to preservation of natural resources. Some indicators regarding packaging waste for the period 2011 – 2014 are given in Table II [7-10].

TABLE II  
SOME INDICATORS REGARDING PACKAGING WASTE FOR THE PERIOD  
2011 – 2014

Year	2011	2012	2013	2014
Amount of market released packaging (thousands of tons)	343.66	344.25	321.58	327.71
Amount of reused waste (thousands of tons)	96.12	126.20	87.95	102.67
Percentage of collected paper and cardboard packaging (%)	79.51	72.35	63	62.8
Percentage of collected plastic packaging (%)	3.83	13.8	15	16.3
Percentage of collected wood packaging (%)	8.54	2.08	8	7.5
Percentage of collected metal packaging (%)	0.16	0.46	4	4.7
Percentage of collected glass packaging (%)	7.96	11.32	10	8.7

Packaging waste management has important ecological, social, and economic aspect. Packaging waste, depending on its category, has very long time of recycling. For example, it takes 500 years for degradation of one aluminum can. Degradation of PET packaging takes 100 years. Glass packaging will never degrade [11].

As can be seen from Table II, reusability of packaging waste has increased over years, but still it represents less than a third of an amount of market released packaging. Also, paper and cardboard packaging represent the major part of packaging waste. This issue can be resolved by building more recycling factories and waste management facilities, which is key principle in the Strategy of the waste management for the period 2010 – 2019 of the Republic of Serbia [12].

### C. Illegal Landfills

Data from 2014 show that there are total of seven sanitary landfills in the Republic of Serbia, and two are in the process of getting a working license. Communal services dispose communal waste to a total of 120 landfills. It has been located 3085 old and wild landfills. However, these data are collected from total of 142 municipalities. Landfills were not located in 15 municipalities, while 13 municipalities didn't send any data [7]. The location of illegal landfills in the Republic of Serbia, not including province of Kosovo and Metohija which is under temporary control of United Nations, is shown in Fig. 1 [13]. Yellow markers represent illegal landfills, and red markers represent communal services' landfills.

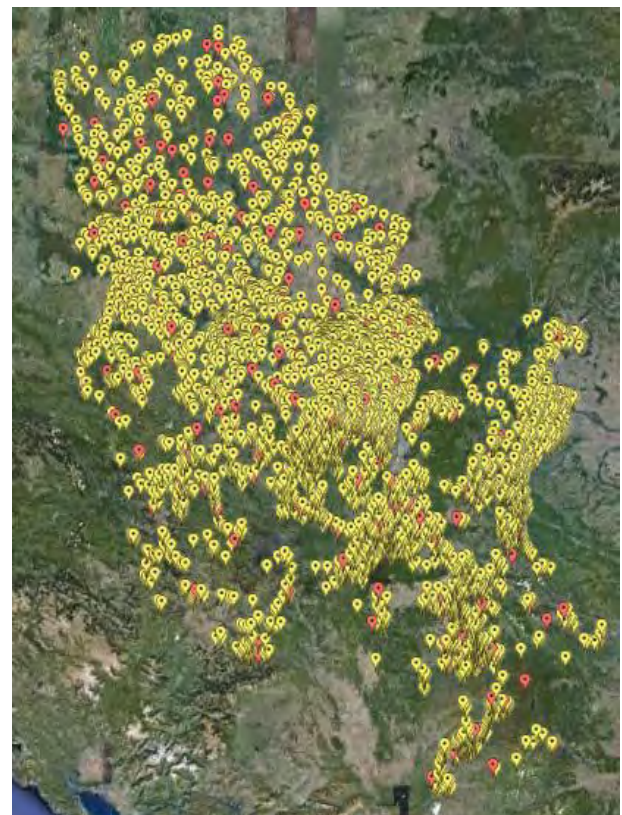


Fig. 1. Locations of illegal and communal landfills in the Republic of Serbia



### III. PRACTICAL REALIZATION OF THE SYSTEM

The system for reporting of ecological problems is comprised of client Android application and server for data acquisition and representation.

#### A. Client Android Application

The Android application layout is shown in Fig. 2.

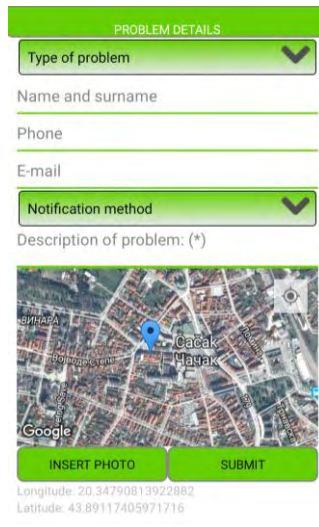


Fig. 2. The layout of Android client application

The field *Type of problem* is designed to select one of the three categories that the system is able to report:

1. Illegal landfill;
2. Other communal problems;
3. Inspection services.

The primarily target of reporting are illegal landfills, but some minor communal problems such as garbage on the public areas, can be reported as well. The third category is designed for reporting other communal problems not necessarily related to landfills.

The user may enter its name, phone, and e-mail address. If the user enters its phone or e-mail address, than by selecting the option from *Notification method* drop-down field, it can be notified about taken actions on the problem solving. The only obligatory field is *Description of problem*, in which user enters text describing the nature of the problem. The location of the troubleshooting place can be retrieved via GPS service inside the mobile phone, or by manual selection by placing the marker on the included map.

Another useful feature is the image of the problem, which user can take with camera on its mobile phone or select from device storage and send it together with other data. By clicking on the button *Submit*, the problem is sent to the server.

#### B. Server Side of the System

The data are sent to the server by using the SOAP – based Web service. Image is sent as an array of bytes. The Web

service is written in C# and it stores all the data in the database, together with the current date and time. The Web service acts as a mediator and represents more secure and reliable solution to accessing database.

Server – side application is written in PHP. It is intended for use in the dispatcher center of the communal services. Pictures are retrieved from the database by using *base64\_encode* PHP function, which encodes the byte representation of the stored image and displays it in PNG file format. For geolocation, the Google Maps API is used.

At first, users must enter their credentials to access the system. When accessed, they can view all the reported problems in two manners: as a list sorted by time of reporting, or on a map. The list view is shown in Fig. 3. (Please note that the images are taken from [14] and [15] and together with locations are used solely as a demonstration and may not represent the actual state on the field.)







Date	Type of problem	Description	Image	Location
2016-04-12 13:42:36	Other communal problems	Look at this! How embarrassing!		
2016-03-07 12:21:11	Illegal landfill	Near the local road, a huge amount of garbage has been dropped! Please do some surveillance because this is not the first time.		
2015-10-26 10:02:03	Illegal landfill	There is a massive junkyard not too far from the """" It is a great shame and something should be done immediately to resolve this embarrassment.		

Fig. 3. List of reported problems

The list shown in Fig. 3 consists of date and time of reporting, category (*Type of problem* field), problem description, its image if available, and location on the map.

The map view of reported problems is shown in Fig. 4. (Please note that locations and images are arbitrary and may not represent the actual state).

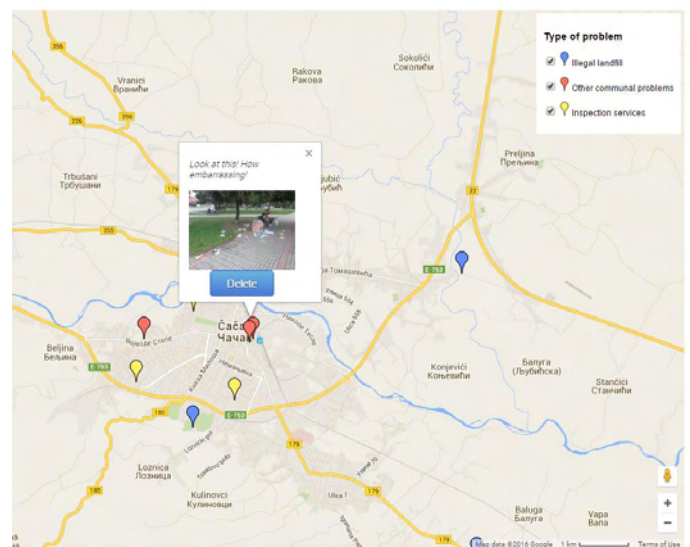


Fig. 4. Map view of reported problems

As can be seen from Fig. 4, different types of problems are represented with different colored markers. By checking the categories from top right corner, all corresponding markers are shown on the map. Clicking on the marker shows the info window in which the description and image of the problem is displayed. The user can click on the image and the bigger picture is displayed. Also, the user can delete the entry by clicking on the button *Delete*.

#### IV. CONCLUSION

Ecological environment preservation is one of the biggest challenges of the modern society. The enrollment of every part of the system is necessary in order to achieve this goal. Naturally, it all ends with the common citizens and their understanding of key principles of ecological balance. The education system needs to emphasize the major problems and to provide proper solutions and recommendations to solve this issue.

The amount of waste is constantly increasing and its management is of crucial importance. The planned construction of landfills and recycling facilities is of biggest importance. However, low ecological awareness of the society and lack of discipline and regulation enforcement leads to the formation of illegal landfills and dump sites that are not properly supervised. Furthermore, this brings misbalance to the ecological environment and can cause pollution of soil and watercourses.

In this paper, the client-server system for reporting ecological problems is presented. It consists of a client Android application that is intended for use among citizens, and server side, that is supposed to be used within communal services. Users can take a picture of a problem and send its coordinates to facilitate the issue solving process.

There are some indications that this system will be used by the communal service in the city of Čačak. If this becomes true, then the system can be slightly modified to adapt to the real situation on the field. Furthermore, by implementing this system, the citizens will have better insight in the work of communal service and entire municipality management.

#### ACKNOWLEDGEMENT

The work presented in this paper was funded by grant TR32043 for the period 2011-2016, by the Ministry of Education, Science, and Technological Development of the Republic of Serbia.

#### REFERENCES

- [1] Statistics Department of the Republic of Serbia, *Waste statistics and waste management in the Republic of Serbia for the period 2008 – 2010*, Belgrade, 2012, in Serbian
- [2] European Commission, *Commission staff working paper; Analytical report accompanying the document Communication from the commission to the European parliament and the council commission opinion on Serbia's application for membership of the European Union*, Brussels, 2011
- [3] European Commission, *Commission staff working document; Serbia 2012 progress report accompanying the document Communication from the commission to the European parliament and the council; Enlargement strategy and main challenges 2012-2013*, Brussels, 2012
- [4] European Commission, *Commission staff working document; Serbia 2013 progress report accompanying the document Communication from the commission to the European parliament and the council; Enlargement strategy and main challenges 2013-2014*, Brussels, 2013
- [5] European Commission, *Commission staff working document; Serbia 2014 progress report accompanying the document Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions; Enlargement strategy and main challenges 2014-2015*, Brussels, 2014
- [6] European Commission, *Commission staff working document; Serbia 2015 report accompanying the document communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions; EU enlargement strategy*, Brussels, 2015
- [7] Serbian Environmental Protection Agency, *The report on the conditions of the environment in the Republic of Serbia for the year 2014*, Belgrade, 2015, in Serbian
- [8] Serbian Environmental Protection Agency, *The report on the conditions of the environment in the Republic of Serbia for the year 2013*, Belgrade, 2014, in Serbian
- [9] Serbian Environmental Protection Agency, *The report on the conditions of the environment in the Republic of Serbia for the year 2012*, Belgrade, 2013, in Serbian
- [10] Serbian Environmental Protection Agency, *The report on the conditions of the environment in the Republic of Serbia for the year 2011*, Belgrade, 2012, in Serbian
- [11] Serbian Environmental Protection Agency, *The report on the packaging and packaging waste management in the year 2014*, Belgrade, 2015, in Serbian
- [12] Republic of Serbia, *The strategy of waste management for the period 2010 – 2019*, Službeni glasnik Republike Srbije, no. 29/10, 2010, in Serbian
- [13] [www.sepa.gov.rs](http://www.sepa.gov.rs)
- [14] [www.caglas.rs](http://www.caglas.rs)
- [15] [www.ozonpress.net](http://www.ozonpress.net)