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## Crowdsource Approach for Mapping of Illegal Dumps in the Czech Republic\*

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### Abstract

This paper describes the environmental project called [www.ZmapujTo.cz](http://www.ZmapujTo.cz) which is intended to fight against illegal waste dumps in the Czech Republic with the use of geographic information systems (GIS). A smartphone/tablet GIS reporting application ZmapujTo has been developed. This freely available mobile application makes it possible to report illegal dumps and also overloaded containers of municipal waste. The project ZmapujTo is intended for public institutions, municipalities, all people who do not like illegal dumping in their cities, villages, countryside and forests, especially if they want to do something against people's bad environmental behaviour. Users of this mobile GIS application can report an illegal dump quickly and easily thanks to the use of their smartphones/tablets. Therefore, anybody can use the interactive public website form to report an illegal dump in the Czech Republic. The objective of this project is to contribute to the solution of the problem of environmental pollution by illegal dumps in the Czech Republic by making available a modern, effective and widespread GIS platform for their monitoring.

**Keywords:** illegal dump sites, mapping, GPS, GIS, crowdsource applications

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## **1. INTRODUCTION**

Illegal dumping of waste has been a serious environmental concern of most countries in the world. They decrease the quality of life and liveability of the surrounding area. Illegal dumping of garbage, discarded appliances, old barrels, used tyres, furniture, yard debris, oil, antifreeze and pesticides can threaten human health, wildlife and the environment. Illegal dumps can pollute local waterways and groundwater, or cause injury to children playing at or around the dumps. Tyres retaining water become breeding grounds for mosquitoes and other noxious insects. Some dumps become home to rodents. Illegal dumps lower the value of surrounding land and neighbourhoods.

It is estimated that currently there is approximately 100 million tons of illegally dumped waste worldwide (Hanfman, 2009). Therefore, people should not be indifferent to them, and if they find an illegal dump site, for example when walking in the fields or in the forest, they should immediately inform competent authorities to take appropriate measures. Illegal trafficking and dumping of waste affects the environmental, human and financial health of every country. The cost of clean-up of illegal dump sites is high, especially if this involves multiple countries. For example, approximately 134,000 tons of waste was illegally dumped in a large gravel pit in North East Europe, and the extraction and transport of this waste cost 160 euros per ton which added up to over 21 million euros each year. It is even more costly when the waste is considered to be hazardous. The costs then rise to about 300 euros per ton (Europol, 2011).

For example, the situation in the United Kingdom is surveyed by councils across England in order to reveal illegal dumping statistics, to compare relative performance, and to identify opportunities for improvement. The AnyJunk Fly Tipping Report 2012 (Anyjunk Limited, 2012) revealed a total of 732,052 illegal dumps on public land in year 2012, which was a 9.1% decrease when compared to the previous year (805,320). 39 million euros were spent by councils on illegal dumping clearance, while only 0.6% of illegal dumping incidents were successfully prosecuted.

### **1.1. Illegal Dumps Monitoring in the World**

A responsible approach to environmental protection by regional authorities is to promote the enforcement of municipal policies assuming the residents' improved awareness and deliberate participation. In order to understand visible changes to the environment in the Czech Republic, such as illegal dumping in particular, there is an urgent need to create monitoring mechanisms based on a close collaboration between residents and local authorities.

The progress in information and communication technology (ICT) in recent years has extended the environment linked to geographic information systems (GISs) from professional spatial analysis tools (conventionally used by research institutes and technical consultants) to familiar information utilization tools, used on general PCs in the US (Brown et al, 2002; Hanfman, 2009; USEPA,1998), Japan (Morita and Takagishi, 2002; Tasaki et al, 2007; Ichinose and Yamamoto, 2011) and Australia, where a Regional Illegal Dumping Database in the Illegal Dumping project (HCCREMS, 2013) has been managed by Hunter and Central Coast region in New South Wales to collate and to analyse data from dumping sites, as collected by councils. All incidents are entered into a database which is linked to GIS and is able to draw maps of the locations in each council area (HCCREMS, 2013).

The "e-japan" Strategy formulated by the Japanese Government already in 2001 advocates the introduction of ICT to the administration, aiming at the establishment of an infrastructure for the world's most advanced communications environment by 2005. "GIS Action Program 2002-2005" based on the e-japan Strategy includes the plan for effectively using GISs in various governmental fields to streamline administration and to provide higher-quality administrative services (Tasaki et al, 2007).

The European Commission has supported the EuropeAid Project "Waste Governance – European Neighbourhood and Partnership Instrument (ENPI) East" (Azerbaijan, Armenia, Belarus, Georgia, Moldova, Russia, and Ukraine) with the "Completed Pilot Region Inventories of Existing Illegal/Non-Compliant Disposal Sites", (more information about this project is available at [http://www.wastegovernance.org/index\\_eng.html](http://www.wastegovernance.org/index_eng.html)). One partial result of key importance, whose achievement will ultimately lead to the achievement of the main result, is the development of an existing registry of illegal waste disposal sites through, firstly, a desk-based review of the existing inventory and then its updating through a series of field visits and stakeholder consultation throughout the pilot region.

"Let's do it 2008" project was a campaign that began in Estonia and was led by one of the inventors of Skype - Ahti Heinla and the founder of Microlink and Delfi-Rainer Nolvak. They put cutting-edge IT technology and 40,000 volunteers to work on Saturdays to clean up Estonia, a tiny Baltic country. Heinla and Nolvak used special software based on Google Earth, positioning software for mobile phones, as well as mobile phones with GPS to map and take images of illegal garbage dumps across the country. According to the organisers, the innovative software has also brought the massive garbage collection campaign virtually into living rooms where Estonians can follow its real-time progress. The project aims to recycle 80 percent of the estimated 10,000 tonnes of garbage in illegal dumps.

The biggest volunteer-based project "Očistimo Slovenijo" in the history of Slovenia was inspired by the above-mentioned clean-up action. A group of Slovenian volunteers called "Ecologists without borders" decided to follow the Estonian example in April 2010 and repeatedly in March 2012. The project was a huge success; more details about this event can be found in the final report (<http://ebm.si/r/OSVED-zakljucno.en.pdf>).

Project "Očistimo Slovenijo" was a very successful event, but it needs to be mentioned that crowdsourcing-based mapping of illegal dumps was only one part of this project. Mapping of illegal dumps was performed by volunteers and only in a specific time range (before the cleaning event). But we think that a regular mapping and cleaning process is needed, and that only this approach of regular mapping and cleaning is sustainable in the long term. Nevertheless we appreciate several interesting ideas in this project, which we will utilize in the future development of our ZmapujTo.cz project.

In the worldwide crowdsourcing projects as "Let's do it", there is the disadvantage that they cannot cover national specifics (e.g. fulfil the local waste legislation, enable the integration of cadastral map, etc.). These global approaches also cannot offer access intended to local municipalities, to enable the management of reported illegal dumps. Moreover, the structure of reported illegal dumps is strictly defined and is very difficult to observe the structure which is required by local municipalities. In the ZmapujTo.cz project, we also aim to inform the Czech population about the dangers related to illegal dump sites, to motivate the public to report them, and to offer municipalities and other organizations a tool for the administration of these reports.

In the following paragraphs, we will discuss the approach of ZmapujTo.cz in contrast with latest developments in the field of crowdsourcing mapping of illegal dumps. We will also point out disadvantages of the existing solutions.

## **1.2. Monitoring of Illegal Dumps in Czech Republic**

For over a decade, several thousand cases of illegal dumping have been reported in the Czech Republic. For example, the average volume of accumulated waste in the years 2007 to 2009 that was stored at illegal dumps in the forests was estimated to amount to approximately 8,000 m<sup>3</sup>. The average area of waste at illegal dumps that are annually removed in the forests is 3.4 hectares and 250 tons. The average annual cost of disposal of the waste from illegal dumps in the forests is about 40 thousand euros. In 2010, a total of 830 illegal dumps were registered in the forests of the Czech Republic, their total area reaching to almost 5.4 hectares with 280 tons of waste. Disposal costs exceeded 40 thousand euros (Fechtnerová, 2011).

Even worse situation with illegal dumping has been reported in various municipal areas in the Czech Republic, where local authorities are responsible. In 2011, for example, 130 thousand tons of waste were dumped illegally. These statistics have been reported by the Czech Environmental Agency (CENIA) to the Waste Management Information System of the Czech Republic (2013). The Ministry of Environment of the Czech Republic estimates that the costs of disposal of illegal dumps exceed 20 million of euros per year (i.e., disposal of one ton of waste from illegal dump costs approximately 160 euros). In addition, it is supposed that many other cases of domestic illegal dumping have been left unreported because of insufficient inspection. Local municipal governments confronting such illegal dumping issues have been making efforts to take countermeasures.

## **2. PROJECT ZMAPUJTO.CZ**

The project ZmapujTo.cz of mapping illegal dump sites was launched in mid-2011, and its website (<http://www.ZmapujTo.cz>) was put in operation in summer 2012. The initial aim of the project was to motivate citizens to start creating the map of illegal dump sites in their surroundings. That is why we concentrated on the promotion of the project among potential users (Kubásek, 2013).

Thanks to the linkage of the project ZmapujTo.cz with local authorities, forest owners, Protected Landscape Area administrators, etc., the persons who manage the specific site can quickly learn about an illegal dump site and take a prompt action.

At the end of 2012, we put the administration in operation for municipalities and we tested its functionality in several pilot territories. The administration function has been fully operational in May 2013; currently, we are trying to involve as many municipalities, town districts and other organizations responsible for disposal of illegal dump sites as possible.

The main contribution of this GIS application is the potential awareness of the broad public of the issue and economic drawbacks of illegal dump sites. The project also contributes to a more efficient use of municipality finance resources used for the disposal of dump sites; it can also contribute to catching the founder of illegal dumping sites; and finally, it contributes to their prevention.

An active involvement of local authorities in the project has many advantages. The municipality makes the citizens aware that it takes the issue of illegal dump sites seriously, and it also saves its expenses on looking for new dump sites in its territory. Moreover, a timely discovery of a new illegal dump site reduces the subsequent costs of its disposal. The GIS application allows an easy surveillance of dump sites even in difficult terrains, including the territory's plot number and its

owner. An appropriate municipal authority can thus gain maximum information about the illegal dump site without having to see the site personally.

Timely disposed illegal dump sites can also prevent a more serious environmental impact and damage (soil and water contamination, hazard of fire, etc.); it also improves the safety of human health, provides prevention of possible injuries (children, animals etc.), and prevents further uncontrollable extension of illegal dump sites (see Figure 1).

In order to enable detailed viewing of reported illegal dumps and their surrounding areas we, have included several advanced GIS technologies into our interactive map. The first one is the Google Street View, which enables users to get a very detail overview of situation around the illegal dump. Google Street View is a feature of Google Maps that provides 360° panoramic street-level views and allows users to view parts of selected cities and their surrounding metropolitan areas at ground level (source: en.wikipedia.org). The disadvantage of Street View is that they use photos which are quite out of date (approximately 3 years in the Czech Republic territory), so this can be only used to get a brief overview of situation at a specific site.

Panoramio is the second feature which enables geolocation-oriented photo sharing. The goal is to allow users to learn more about a given area by viewing the photos that other users have taken at that place. Panoramio is available at [www.panoramio.com](http://www.panoramio.com). The next feature enables the integration of cadastral map of the Czech Republic (see <http://nahliznidokn.cuzk.cz/>). This feature can simply identify the owner of a specific plot, and the municipal clerk can then directly contact the owner.

This interactive map is also enhanced by a set of layers of National INSPIRE Geoportal of the Czech Republic (Prášek et al, 2013), enabling the user to adjust the map as needed. Users can select from ortophoto layer (which displays satellite images), hybrid layer (displaying a mixture of normal and satellite views), and terrain layer (displays a physical map based on terrain information). The map can also integrate third-party map layers, such as Bing maps, Yahoo maps or Open Street maps. The interactive map also integrates the heat map - a graphical representation of data where the individual values contained in a matrix are represented as colours. This heat map enables to visualize the frequency of illegal dumping.

In order to comply with clean-up actions planned under the "Let's Do It" initiative, we plan to integrate additional environmental layers into our interactive map (e.g. protected areas, water streams, NATURA 2000 areas, etc.). These additional information will allow to event organizers to give priority order to clean up illegal dumps that are located in these important areas.

In cooperation with the collective take-back systems in the Czech Republic ([http://www.mzp.cz/cz/zpetny\\_odber\\_vyrobnku](http://www.mzp.cz/cz/zpetny_odber_vyrobnku)), we also plan to supply our interactive map with a layer of places where citizens can legally dispose of their waste (the so-called Waste Collection Points).

**Figure 1: ZmapujTo.cz approach**



## 2.1. Reporting Tools

The primary way of sending reports about illegal dump sites is using the mobile phone application ZmapujTo. Currently, this application is available for mobile operational systems Android and iPhone, and anyone can download it from our website (<http://www.ZmapujTo.cz>).

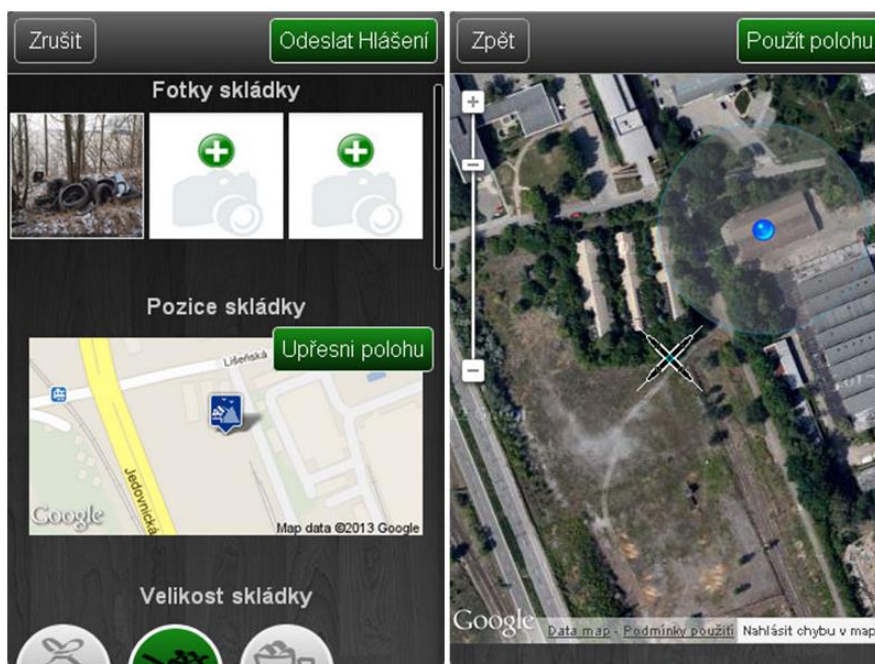
The user can take a photo of an illegal dump site by his/her mobile phone and mark its exact location into the map. The GPS in the mobile phone determines the position approximately, and the user can subsequently modify it so that it fits

the reality. Then the user selects the size of the illegal dump site, specifies what type of waste is included and sends the report (Figure 2).

The reports are anonymous, but the user can also insert an optional commentary or contact data. After checking if the report is genuine (elimination of spam or experimental/erroneous reports), all reports are displayed in the interactive map on the website, and local authorities can use the information in order to solve the problem.

Alternatively, the user can use the web-based interactive form to report an illegal dump site from the comforts of home. The interactive form can be opened in any computer with a commonly used web browser, or in a mobile device (smartphone, tablet). The form can be found at <http://new.zmapujto.cz>.

**Figure 2: Print Screen of the Mobile Phone Application**



The user which submitted his/her report about an illegal dump into the system is automatically notified by an e-mail when in case of any change in the future (e.g. when the municipality cleans up the dump). Any user interested in the situation at a specific illegal dump can simply add and confirm his/her e-mail and he/she will be also notified by e-mail in case of any change.

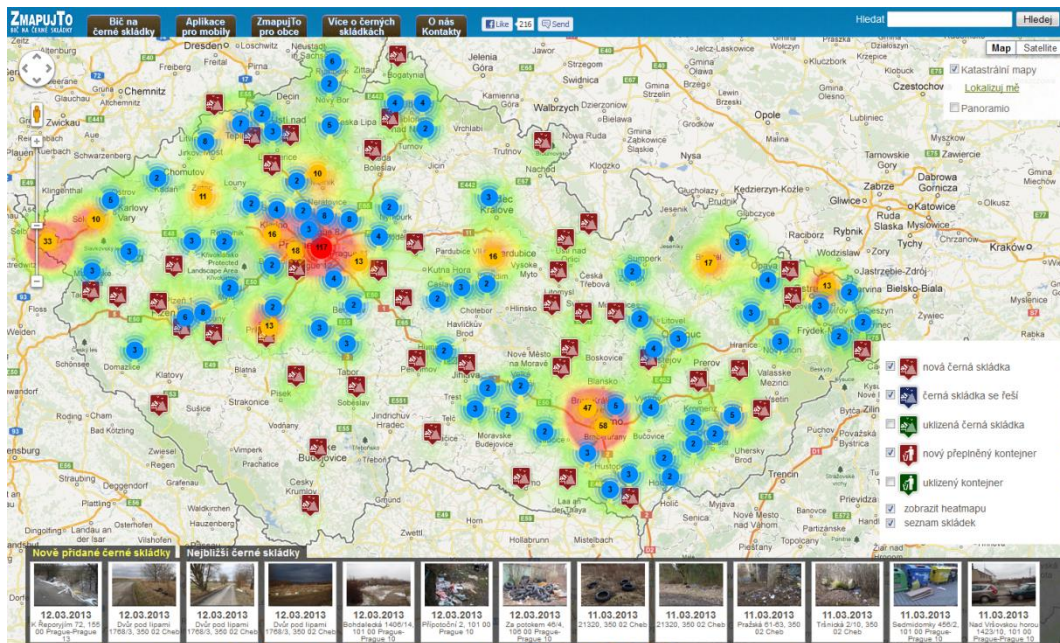


Currently, the incoming reports are checked manually by our colleagues. In forthcoming versions of project, we will invite local authorities or volunteers to check the incoming reports. We will also provide API for the involved institutions, so these institutions will be responsible for their sent reports.

## 2.2. Interactive Map

After the above-mentioned check of reports, the reported illegal dump sites appear in the interactive map of illegal dump sites, which is available at <http://skladky.zmapujto.cz> (Figure 3.). This map has filters of new reports, reports about to be removed, or already removed dump sites. At the bottom, the interactive map shows a list of the most recently reported illegal dump sites. The map can also show a list of dump sites nearest to a specific location, including information about the distance from the place.

Figure 3: Print Screen of the Interactive Map with Illegal Dump Sites



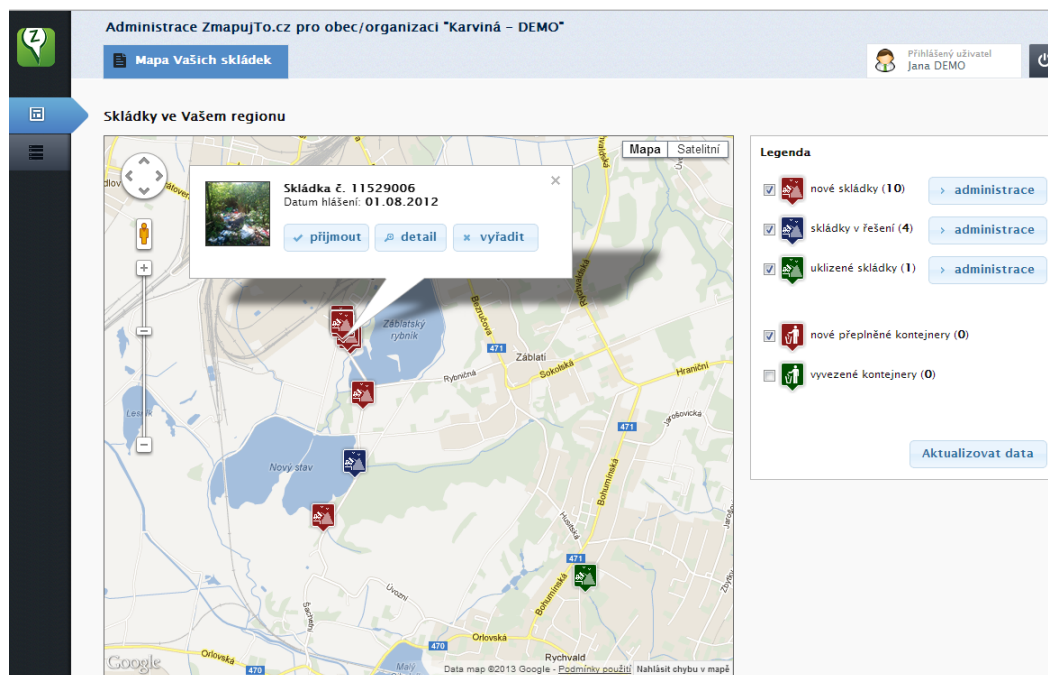
For the purpose of interactivity and integration of several map layers, the Google maps technology is used next to reverse geocoding services (converting geographic coordinates into a human-readable address in order to identify the responsibility for reported dumps). The cadastral map of Czech Republic is integrated through the WMS service. Due to a large number of illegal dumps displayed on the map, we used the MarkerClusterer library in order to manage large amounts of markers.

The interactive map has several layers (including satellite images), as well as the map layer of the cadastre of real estates, which allows for an easy identification of the owner of related lands. In the future development of this application, more layers can be integrated (e.g. points of waste collection, legal dump sites, contaminated places, etc.) from the Czech National Geoportal (<http://geoportal.gov.cz/web/>). The map is also equipped with the Google Street View technology which allows seeing the place using panoramic photos taken in the street. Thanks to this, a user can get a very detailed overview of illegal dump sites without even having to go there.

### 2.3. Illegal Dumps Management

Administration of illegal dump sites is an important part of our project. This feature allows municipalities or other interested organizations to get involved in the project. The aim of this part of application is to provide a simple tool determining which municipalities will have current information about illegal dump sites reported in its district (Figure 4).

Figure 4: Print Screen of Administration of Illegal Dump Sites



The administrator of the municipality allotted to a specific dump site can change its status – e.g. when they are preparing to dispose of it, it has been removed, comments can be added, or reports concerning the expenses of its disposal. If a new illegal dump site appears within the district, the administration system of our

application sends an e-mail to the administrator of the municipality. The administrator can also use the statistics of the district and a widget which can be placed on the municipality website and inform its visitors that the municipality is involved in the project, how many dump sites have been reported, removed or what expenses were related to their disposal.

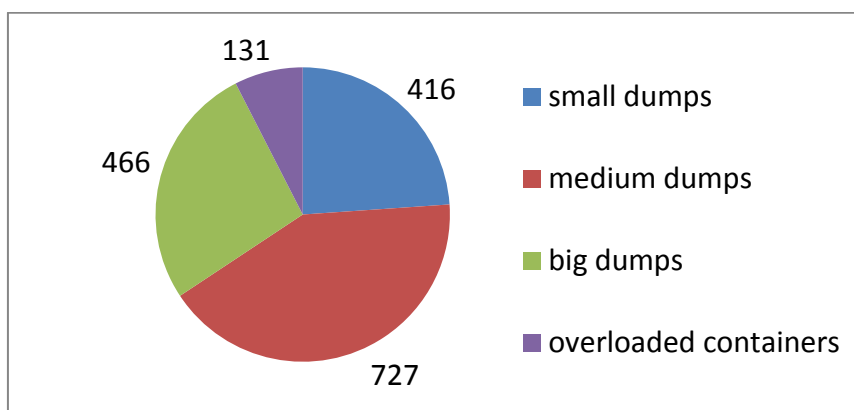
Currently, there are ten municipalities and institutions from the entire Czech Republic involved in ZmapujTo.cz project. We are collecting their experience with the employment of the information system, their comments concerning improvements, and we are expanding the service based on their experiences. There is also a DEMO version of the administration thanks to which any interested party can try out this system.

One of the most active system users are the officials of the city district Praha 10. These officials were even able to involve city policemen, who now report illegal dump sites and overfilled garbage bins as a part of their daily rounds. Within two months, 245 illegal dump sites have been reported and 146 of them were disposed.

#### 2.4. Analysis of Illegal Dumps

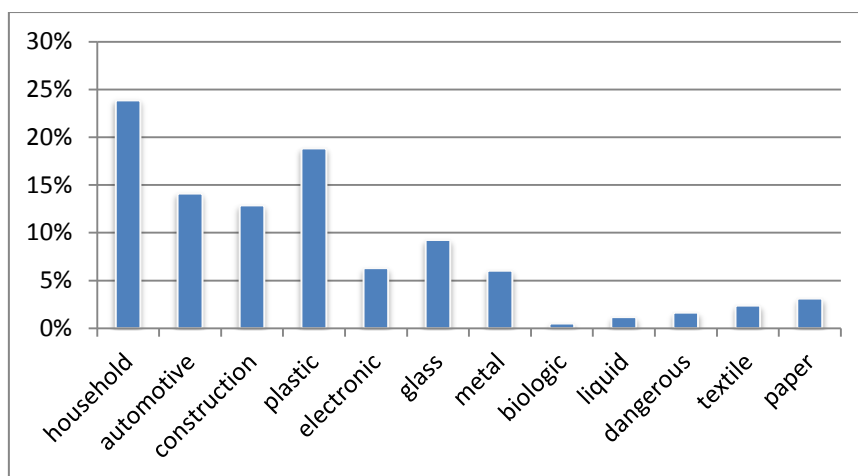
Since July 2012, a total of 1,740 illegal dumps were reported, and 641 dumps have been cleaned (as on 1st November 2013). Figure 5 shows the proportion of size of reported dumps. The majority of dumps are medium-sized (44%). A small-sized dump is an illegal dump which can be cleaned and transported by hand, while a medium-sized dump is a dump of up to 5m<sup>2</sup> of volume, and anything over this volume is a big dump. A small amount of reported overloaded containers is due to the fact that these reports were started later (since January 2013).

Figure 5: Representation of Size of Illegal Dumps



During the reporting process, the user has to specify in more detail the type of waste. The user can select from 12 categories of waste, which cover the whole range of possible wastes and, he/she can assign one or more categories in one report. As it can be seen on Figure 6, the most common type of illegal dump waste is one containing household waste and plastics. More than 10% of these dumps still contain construction and demolition waste, and also automotive waste (tyres, batteries, etc.).

**Figure 6: Distribution of Types of Waste**



### 3. CONCLUSION

The ZmapujTo.cz project was launched a year and a half ago, and over 1,740 illegal dump sites in the Czech Republic have been mapped during the project's existence thanks to the crowd source approach to the mapping of these dumps, and based on the usage of developed mobile GIS IT technology. 40 pilot municipalities of the Czech Republic are involved in this project, and over 641 illegal dump sites have been disposed of since the last year.

The project has been until now in the testing phase. The amount of reported dumps is sufficient to ensure that we could say that the system is usable and citizens are willing to report illegal dumping. Based on the experience from the providing of this system, we plan to create next version of the project, which will allow more interaction between users (government, activists and citizens). The up-coming system will enable also integration of services into information systems of governments and local police (public API). Up-coming system will be also be more flexible and will allow to report a greater variety of problems, not just illegal dumps.

The project ZmapujTo.cz is newly involved in the initiative "Let's do it" (<http://www.letsdoitworld.org/country/czech-republic>) and became the initiator of the forthcoming local clean-up activities in the Czech Republic. An interactive map of illegal dumps in the Czech Republic will become the basis for the coordination of these events and a mobile application will be used to update cleaned illegal dumps.

In partnership with Frank Bold company (<http://frankbold.org/>), the project will also provide free services of expert legal advice for municipalities as regards the issue of illegal landfilling.

We believe that the ZmapujTo.cz project is sensible and has a big potential based on the usage of related environmental maps of the Czech National Geoportal (e.g. points of waste collection, legal dump sites, contaminated places, etc.), and it can be also used in neighbouring countries, taking advantage of the INSPIRE GEOPORTAL (<http://inspire-geoportal.ec.europa.eu/>).

We are looking forward to other interested parties in getting involved, either local authorities or organizations responsible for the elimination of illegal dump sites.

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