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A CASE STUDY USING WEB TOOLS TO IMPROVE ENVIRONMENTAL MANAGEMENT INITIATIVES FOR MEDICAL WASTE

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Abstract: *Currently, in most developing countries, the visionary environmental initiative on waste management attracts the need to integrate social responsibilities. These environmental actions are recognized by the local administration, as they have well-defined strategic directions regarding the implementation of waste legislation, which include not only the monitoring of the recycling operator or the refurbished materials of producers and consumers but also changing the attitude of citizens and encouraging community in active participation to protect the environment. This research advances a prototype app to increase awareness regarding the importance of medical waste sorting, for a sustainable environment. Thus, it is necessary to integrate an intelligent management system for monitoring hazardous waste from medical centers. The aim of this paper is, therefore, to communicate in a modern way, using web tools, waste prevention actions to educate the community and involve key decision-makers.*
Key words: *mobile apps, medical waste, environmental management, human behavior*

1. INTRODUCTION

New information published by the World Meteorological Organization (WMO), global temperatures will reach new records in the next years, fueled by heat-trapping greenhouse gases and the emergence of the El Niño phenomenon. In 2022, CO2 emissions rose by 0.9% or 321 Mt, reporting a new high of over 36.8 Gt. The recycling rate has dropped from 34.7% in 2015 to 32.1% in 2022, not to mention the 10 billion tons of freshwater waste every day worldwide. Climate change is an imminent threat to the world we live in; therefore, it is imperative to use technology that brings real-time interconnectivity of smart devices to increase awareness of environmental problems caused by global warming. [26] Technology momentum is a key driver in providing access to initiatives and processes focused on environmental sustainability, ecological innovation and green technology. By touching a connect button, people and businesses can make changes that have a significant impact in the fight against the environmental challenges facing our planet [7]. Also, governments and entrepreneurs around the world are combining technologies and adopting persuasive strategies to guide citizens and educate responsible waste disposal behaviors [9].

United Nations (UN) Sustainable Development Goals (SDGs) facilitates and supports the realization of the global action plans for climate change through positive individual and community actions, as well as the promotion of people's health and well-being by using mobile sustainability apps for energy conservation, water preservation, biomedical waste management, green medical waste management. On the one hand, biomedical waste management (BMWM) represents a sensitive subject that creates controversy in providing strategic public health actions in the community. Due to The World Health Organization (WHO) considerations, BMWM is a principal measure for standard infection control practices, so strategies to improve BMWM standardized practices must receive urgent global attention [2]. On the other hand,

green medical waste management, provides solutions that can be implemented through the development and adoption of technologies, products and treatment concepts that will help the healthcare system move towards a circular economy concept [18]. The continuous advance of medical technologies and the need for modern equipment in hospitals to provide better medical care have significantly increased the amount of waste generated by health facilities [8]. From an economic and ecological point of view, harmless disposal through sustainable waste management together with greater energy recovery is urgent, and the key issues of energy recovery are the efficiency of recovery technologies and the reduction of environmental impact [20]. The Basel Convention argue that it is a fundamental obligation for all parties included to manage hazardous waste or other waste in an environmentally friendly manner. A series of technical guidelines developed under the Basel Convention at the recommendation of the OECD were elaborated for certain waste streams, including used tires, plastic waste, lead-acid batteries, ships, biomedical and healthcare waste.[25] For developing countries, good guidance is needed, as the development of their waste management processes is in the beginning phase and they have a gap in environmental knowledge and technologies necessary to ensure the Environmentally Sound Management (ESM) of Waste. If developed countries are systematically involved in the waste management activities since the ’80, developing countries such as Eastern European countries started to address environmental issues in the context of their accession to the European Union (EU). For Romania, a significant change in waste management from the healthcare system, took place after the Revolution of 1989 and involved the improvement of the medical act and the tendency to use disposable medical supplies - for example, the replacement of the traditional reusable syringe (metal and glass) with a disposable syringe with needle. Considering the need to fulfil the commitments undertaken by our country in the process of European integration and the need to create a unitary framework that contains the fundamental principles that protect the environment and the health of the population, a basis was established that leads to sustainable development. The legislative framework applicable to waste consists of numerous laws, government decisions, emergency ordinances, ministerial orders and regulations, of which we list three main normative acts:

1. The Law no. 211/2011 on the waste measures, republished,
2. H.G. no. 856/2002 for monitoring waste management and approving the list of hazardous waste
3. Government Decision no. 1061/2008 for hazardous and non-hazardous waste transport on the Romania territory.

Based on the Guide regarding the implementation of non-incineration technologies for the inactivation of medical waste in Romania, hazardous medical waste is waste that puts in jeopardy the human health and the environment, being generated in the hospitalization process, in diagnostic, treatment, surveillance, prevention and medical recovery activities. Non-hazardous medical waste is household waste, resulting from the activity of medical, technical-medical, administrative, accommodation services, food blocks and food distribution offices [19]. A significant amount of waste produced by dental centers falls into the category of hazardous waste, which can affect human health or the environment. Eliminating human and environmental risks from hazardous waste implies strict compliance with medical waste management regulations.

The pandemic with the Covid 19 virus demanded the resources of medical units and was an incentive that impacted the increase of medical waste. In so, the health crisis has emphasized the need to stabilize guidelines for compliance with medical waste management regulations. It remains a challenge for the authorities to manage medical waste safely, despite going through the pandemic context with all the regulations for the efficient handling of hazardous waste.

A solution to high-performance monitoring in waste management is given by the advance of technology for the use of digitized processes in waste management. This solution supports health institutions and contributes to the planning of an adequate infrastructure and capacity for a sustainable environment.

In this context, considering the situation of transition economies like Romania, the purpose of the paper is to advance a mobile app for the medical waste management. The paper first systematizes the literature on mobile sustainability apps and provides current information on the necessity of health centers' proper waste disposal and documents the configuration of the new mobile app to facilitate collaboration actions for medical waste sorting in dental praxis. The first part describes the theoretical foundation used in the configuration of the ECODENTAL WASTE application, namely My SQL, Tomcat (Apache Jakarta Project). The main attractivity of the Apache HTTP Server is that represents a open-source web server that delivers web content over the Internet. In the environment of application developers, it is commonly called Apache, which makes it popular, being the most well-known HTTP client on the web [5][6]. Node JS (Express Server) was used for App Backend. Nodejs has a particular characteristic to build up-to-date solutions based on microservices, WebSockets and event queues. React (Boostrap CSS) was used for App Frontend. React has a disadvantage when building a web application because it addresses explicit controversies such as slow user interactions and poor performance.

In the second part of the paper, we present the ECODENTAL WASTE application' specifications and the way of implementation/use, namely the application description, the application functions, the user interface, the client interface and the database. This part of the paper explains how to implement such as login/authentication, creating new account, admin interface (order management and statistics) and customer interface (order creation/payment and statistics).

In the third part of the research, we present the details of the graphic package for ECODENTAL WASTE. The primary phase of the graphic design use was applied to the layout and formatting to obtain an educational material for the community. The second phase of the graphic design was to present a simple information more accessible and easier to understand. Different methods are used to create and combine words, symbols and images visually represent ideas and messages to change the community's perception of how waste is managed.

The last part of the paper, the conclusion points out an example to both the content and format of web application applied for recycling and waste prevention. The adoption of modern technology for waste management in Timisoara, facilitated through mobile applications, has a serious impact on the community offering an easy way to be informed and manage waste by downloading the app on their smartphones. There is a tremendous untapped opportunity to upgrade the systemic behavior of waste management systems using appropriate mobile applications.

2. DEVELOPMENT OF MOBILE APPLICATIONS FOR SUSTAINABLE WASTE MANAGEMENT

Although the historical data are different related to the appearance of the first mobile phone (in 1983 the first portable phone appeared, Motorola DynaTAC 8000X) one thing is certain that mobile technology has evolved to become a mainstream technology being indispensable in the development of societies in developing countries. The emergence of 3G and 4G networks and the advance of new, last-generation mobile technologies or "smartphones" have created multiple possibilities in the development of mobile applications through creative tools. The spread of mobile internet has given the opportunity to mobile application developers to incorporate new innovative features in the real-time use of different services. The accessibility given by the decrease in the prices of mobile devices and products made the mobile phone an accessible tool, this fact leading to the reduction of the digital distance between evolved and evolving countries.

The multitude of mobile applications have helped create multiple opportunities for phone owners by using applications in day-to-day activities [3]. Due to the progress offered by the capacity of mobile phones, being almost the

widely distributed communication devices worldwide, the emergence and use of mobile technologies have covered a series of activities through which advantages have been created in the use of specific services, respectively the participation of citizens in debates, public awareness, emergency and crisis management, public service provision, health information.

As mobile services have become cheaper and more accessible in recent years, local authorities have seized this opportunity and created the necessary infrastructure, especially in developing countries. Currently, most of the countries that have integrated new technologies enjoy the advantages they offer, implement and develop intelligent solutions to provide better services to the community. Most community services shared through these mobile apps can educate consumers in a conscious manner and be socially involved in every facet of their life.

This framework also includes applications for sustainable waste management, which offer smart and fast solutions to make the waste collection service provider's time and costs more efficient. The main facility when using a waste app all information are stored and accessible in real time, reminds users in advance when waste is collected, educates people about proper waste sorting and helps collection companies identify problems with the help of citizens who can report various situations (Figure 1).

Although there was a limitation regarding the activities related to storage, collection, transfer, treatment and proper disposal, it was not until recently that efforts to minimize the impact on the environment and health as well as discussions related to waste management began to be considered.

Following these discussions in the planning and implementation of waste management systems, it was considered necessary to use engineering and logistics tools as well as resource management. Another important component is given by social behavior being considered an integral part of any waste management system. All these elements as well as the participation of interested parties in the industry are essential to combat the increased recycling rates by ensuring much more efficient processes regarding better quality of recyclable materials, green design initiatives and closed product and material loops. Considering the increase in population and demand for solid materials, the time has come to integrate waste management applications with efficient automated tracking and sorting of recyclables.

Applications in waste management can establish the relevant tasks avoiding the traditional option of using manual spreadsheets or completing calendar charts on paper to verify the fulfilment of assigned tasks. Using a mobile application revolutionizes waste management and recycling by reducing paper requests.

Fig. 1. Statistics regarding the use of a smartphone in daily life

Through a cost-effective and efficient methodology, waste management tasks can be mechanized. Emphasis on mobile applications in various services has provided unparalleled

benefits for the healthcare system as well [17][16][1]. More precisely, with the help of a digital tracking system, it allows medical waste generators and authorities to identify current flows, determine the total amount of waste generated, thus reducing the carbon footprint over time.

2.1 Collection of clinical waste in healthcare system

To manage waste from the medical environment, hygiene and maintenance activities of the medical space are planned. In a medical space, it is necessary to manage a wide range of sanitary activities, but it also involves contacting an operator to ensure the collection, transport, operation/treatment of processing systems and waste disposal. The initial segregation and storage activities are the direct responsibility of the nursing staff who are employed in the medical facility [11].

The term "clinical waste" is associated with waste from medical, dental and veterinary sources and has been defined as "waste contaminated with blood, saliva or any other fluids dangerous to the body and which may prove dangerous to any person who comes into contact with them". The World Health Organization (WHO) has defined healthcare waste as "all waste produced by health facilities, research facilities and laboratories, including waste from 'minor' or 'scattered' sources such as those produced during care medical procedures performed at home (such as dialysis and insulin injections). Healthcare facilities (including dental clinics) are primarily concerned with providing high-standard services to the community; this cannot be fully achieved unless a proper waste handling policy is strictly implemented and this is consistent with international regulations. Considering the recent events regarding the health crisis caused by the COVID-19 virus, an important concern during the restrictions imposed by the pandemic was finding an optimal way of collaboration between the hazardous waste collection operator and health institutions. To obtain an effective collaboration, the developed application assumed a systematic analysis regarding its necessity among the community. Thus, the development of the application was born considering two important elements:

The first “Hardware” manifests itself in the three elementary pillars that are claimed in waste management systems to operate constantly in a sustainable manner. (Figure 2)

1. Public health: it is an impediment that every educated citizen must be aware to maintain healthy environment in cities, especially by contacting a waste collection service;
2. Environmental protection: the operator must ensure environmental protection through all activities carried out along the waste chain, especially during treatment and disposal;
3. Resource management: "closing the loop" by returning both materials and nutrients to beneficial use, waste prevention and efforts to achieve high rates of organics, recovery, reuse and recycling.

The second "Software" involves good waste governance (strategies, policies and regulations) to provide a functioning system. This means that the system needs to contribute to:

4. Development of public institutions: identification of proactive policies;
5. Financial viability: the system designed to be financially sustainable, which means cost-effective and affordable;
6. Support Community: providing possible scenarios for stakeholders to contribute as users, providers and facilitators.

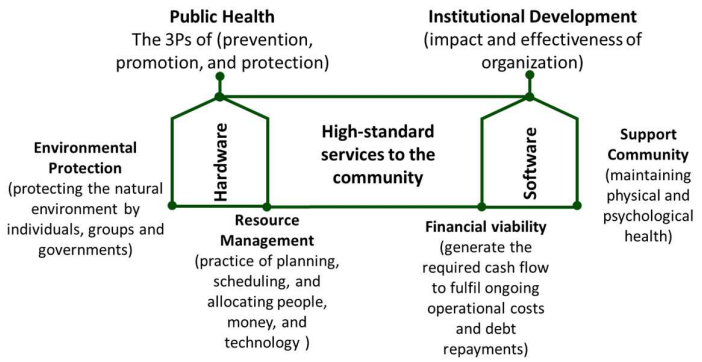

Fig. 2. The simplified concept of integrated and sustainable waste management [14]

In waste management activity, mobile devices offer citizens direct communication with the authorities mandated to collect the waste, establishing a real-time connection between these two entities through which certain problems are solved. Today, mobile practical education through relevant information, directly from the source, is essential because citizens / service users need an education in creating opinions and action regarding aspects such as active participation in recycling, cleaning or collection activities. Through the advantages brought by mobile technology, municipalities and citizens will jointly contribute to the creation of new opportunities for waste reduction and recycling through user-driven innovation.

According to the opinion of mobile technology users, three types of applications can be identified, informational - educational, interactive - participative and functional. [15]

Informational / educational: They are applications that offer technical elements or calculation tools through which the guidelines of the stated service are presented. The purpose of these applications is to display information for a wide category of users who access the application via the mobile Internet.

Within these applications, independent information is presented that provides

management by Mavropoulos (2011), the application developed in this research falls into the category of functional applications. The caused by the overcrowding of waste at the collection points of the local waste operator in Timisoara. Currently, Timisoara does not benefit from a modern waste collection system, there is no mobile application at the local level interaction between the user and the waste management operator.

Interactive / participatory: Through the interactive applications, citizens can send in real time the problems encountered, objections and solutions or service requests to the waste management authorities. In addition, citizens have the possibility to access forms, statistics or databases.

Functional: They are designed to solve specific waste management problems; they offer direct practical solutions or estimates and are configured especially for those who have experience and are active in the field and decision makers.

Innovation brought through the user interface for applications in waste management minimizes waiting times between the actions and interactions of several interested parties in waste reduction and recycling. Regardless of the type of recycling, it must become a consistent educational activity through practical actions, requiring the involvement of citizens, practitioners and scientists. In this field, communication and interactions through mobile technologies can provide an education in recycling activities and can influence human behavioral patterns.

Starting from the simplified concept of triangles of integrated and sustainable waste application developed as part of this research is a prototype that was configured during the Covid 19 pandemic, because of the impact to ensure direct communication with the operator for waste collection, especially medical waste. The developed web application is based on a client-server architecture through which the entire functionality of a software application is

segmented into smaller functions. These functions are data storage, data processing and data presentation. The client-server architecture assigns these functions to separate components of the software application. Once assigned a function, the component performs only the assigned function. In a complex architecture, these functions can be assigned to dedicated computers. Depending on which part of the application is installed, the computer is known as the server computer, intermediary computer, and client computer [10].

3. METHODOLOGY. THEORETICAL FOUNDATION OF THE WEB APPLICATION ECO DENTAL WASTE

Timisoara, being a city in full development, enjoys the initiatives of technological and automated projects that bring improvements to the community. The use of technology to create a healthier environment has become an inevitable condition. It is essential that this opening for modernization includes the implementation of a centralized mechanism for waste management.

The implementation of a mobile application only required a period to allow the municipality to manage waste processing and recycling on a large scale. Following all the actions preceding the development of the community, the research team brings into discussion a proposal through the ECO Dental WASTE web application, an application whose main subject is the collection of medical waste from health facilities.

The theoretical foundation used in the configuration of the ECODENTAL WASTE web application implies My SQL, Tomcat (Apache Jakarta Project). Visual Studio Code is a source code editor made by Microsoft for Windows (Bisson 2018). Apache HTTP Server is a free and open-source web server that delivers web content over the Internet. It is commonly referred to as Apache, and after its development, it quickly became the most popular HTTP client on the web. Node JS (Express Server) was used for App Backend. Nodejs is an ideal choice for building modern solutions based on microservices, WebSockets and event queues. React (Boostrap CSS) was used for App Frontend. With React, it is possible to build a web application that addresses explicitly challenges such as slow user interactions and poor performance due to Document Object Model (DOM) manipulations. (Moodie, 2007).

Table 1

Functional requirements

Feature	Description
Client data sheet	The system will allow to enter and edit user information through a web application
Create orders	The system will allow to enter and edit orders through a web/mobile application
Recommendation	The system will allow users to create waste disposal recommendations
Waste Alarms	The system will allow the creation of alarms to indicate the exceeding of certain quantities defined by the operator
Waste Reports	The system will allow to view the information stored in various forms and export them.

Table 2

Non-functional requirements

Feature	Description
Usability	The system will have a clearly structured graphic interface and a uniform structure.
Feedback	The system will display informative dialogs for important user actions and for errors.
Maintenance	The system will be implemented so that subsequent maintenance is as easy as possible (including properly commented source code and clear code structure).
Reliability	The system will be tested according to the test plan.
Performance and efficiency	System response time and system resource requirements (memory, CPU, etc.) must be efficient. User requests to the system must provide a result in a reasonable time corresponding to the action.

The designed system is addressed to users who own a mobile phone and have an Internet connection. The system will allow connecting to the application for entering/viewing the client's file and monitoring waste collection activities from sanitation institutions (collection schedule, list of containers for each collected waste). In this sense, the target segment for this product is people aged between 25-65 years. The system presents the necessary requirements that were the basis of the mobile application development (Table 1, Table 2)

After identifying the ideal architecture model for the intended application, process mapping followed. The purpose of process mapping was to identify the stages of the proposed project, followed by the creation of the process diagram for the designed application. This diagram provides a visual representation of the steps in a process.

Advantages of a process diagram (Figure 3):

• Empower entire teams to collaborate as they create, edit, and analyses organizational charts;
• Improved communication;
• Visual clarity;
• Effective analysis;
• Solving problems;
• Preparation of documentation.

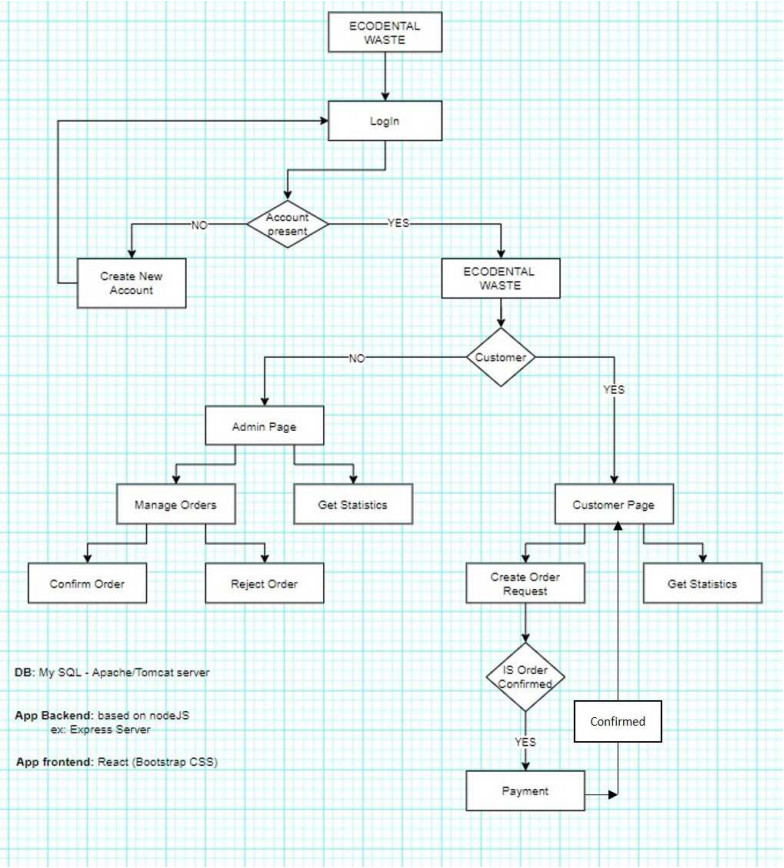

Fig. 3. Application process diagram

Designing the web application, the team researched the most downloaded applications that have incorporated waste management services. The team made a comparative analysis on several models of applications in waste management, creating a comparative table of the most appreciated applications in the field following certain selection criteria such as update, application type, size, installation, current version, content evaluation, interactive elements and reviews. Most of the apps have been selected from Google Play (Table 3).

Table 3

Comparative table of the most appreciated applications

Application criteria	IMAGE BMWMS	Biomedical Waste Management	Medical Waste	JK Medical WMS Driver App
Update	2023	2018	2019	2020
Application type	Educational	Educational	Functional	Functional
Dimension	32 MB	40 M	19 M	3,6 M
Installation	500+	10 000+	50+	100+
Current version	5.0.9	1.0	X	2.3
Requires Android	5.0	4.2	4.1	4.0.3
Content evaluation	PEGI 3	everybody	parental consent	PEGI 3
Interactive elements	X	X	X	X
Permission	X	X	X	X
Report	X	X	X	X
Reviews	-	76	-	-
Application provided by	EHI International	NK Creations	Developers Plus	e-Planet Infosystem India Pvt. Ltd.

4. PROPOSED APPLICATION. APPLICATION DESCRIPTION

Starting from the simplified concept of triangles of integrated and sustainable waste management by Mavropoulos (2011), the application developed in this research falls into the category of functional applications. The ECO Dental Waste application uses a client-server architecture based on a computing model where the server hosts, provides and manages most of the resources and services to be consumed by the client. (Figure 4). ECO Dental Waste (administrator) based on a contract made with medical staff (client) collects medical waste through the appointments made by the client (doctor) on the web platform. The notifications received indicate when the medical boxes at the dental clinics are full of medical waste, requiring transport to the recycling and incineration station according to international criteria. Each collection notice, depending on the selected waste, refers to the replacement of boxes for different types of medical waste (yellow-infectious waste, green-chemical waste, red-sharps waste, black-non-hazardous waste) (Figure 5). The purpose of the application is to facilitate the connection between the auxiliary health personnel who find the filled boxes and replace them with empty ones. Depending on the number of kilograms of waste collected from the customer, the invoice is issued.

4.1 Application Features

User role (Administrator or Client) - In this case, the user enters the account credentials according to the decision given by the login form. The login part provides a secure decision. The given login permission gives the user the possibility to access the application page.

Register / create a new account - If the user (Client) does not have an existing account, he can create a new account from the Registration form with a username and password.

Scheduled commands - The customer can schedule the waste collection in a customized way. In case of unforeseen situations regarding the client's schedule, he can cancel the scheduled order.

Online payment (future development) - A contract with an online payment provider (Netopia, Mobilepay) is required.

The collection of hazardous waste is a topic of interest for the community, so statistics can be made for each health institution. At the same time, the collection company can provide information on the degree of involvement of sanitary institutions in waste management.

Waste collection statistics – annually per company.

Admin interface - In the admin page you can access the statistics on waste collection and order management. Both statistics and orders are accessed from the database according to the established criteria.

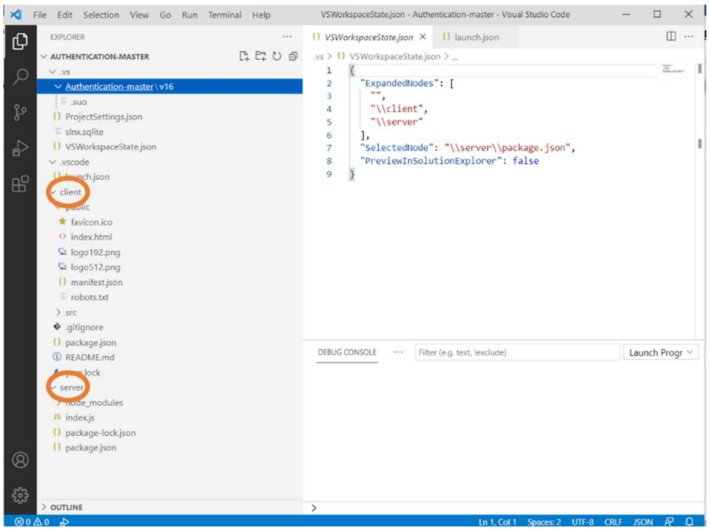

Fig. 4. Visual Studio Code

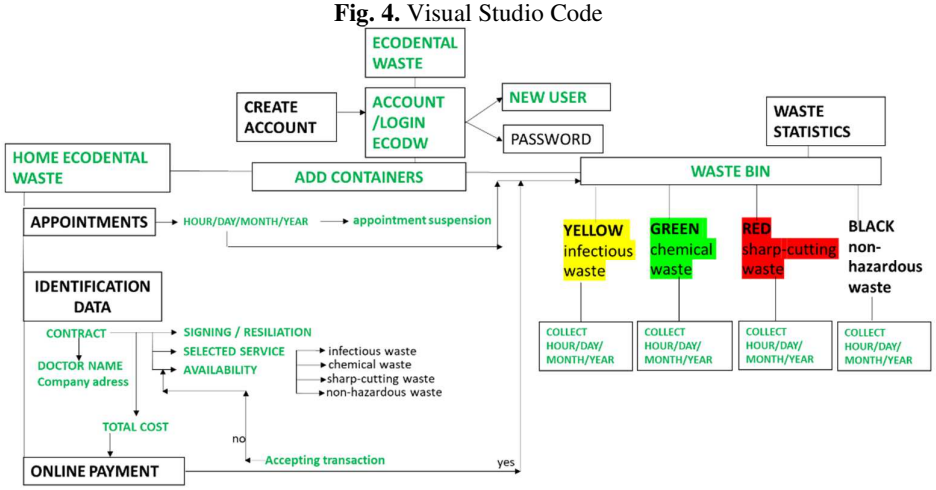

Fig. 5. Description of the ECODENTAL WASTE application

Customer interface - The customer places the order, checks the order status, order history.

Database - MySQL was used to create the database, which is populated as new users / new orders are registered. The advantage of using MySQL is that it provides data security, provides unmatched scalability, has a distinct storage engine framework, and comes with 24×7 availability assurance offering a wide range of high availability solutions. (Figure 6, Figure 7).

This part of the paper explains how to implement the application, namely the login/authentication interface, creating a new account, the administrator interface. Through the client interface, orders can be created, payments can be made and statistics can be obtained. Through the admin interface, orders can be managed and statistics can be obtained. For the ECO Dental Waste application, we used the My SQL Tomcat database (Apache Jakarta Project). Apache HTTP Server is a free and open-source web server that delivers web content over the Internet. Node JS (Express Server) was used for App Backend. Nodejs is an ideal choice for building modern solutions based on microservices, WebSockets and event queues. For App Frontend React (Boostrap CSS library) was used. (Figure 8).

	#	Nume	Tip	Colaționare	Atribute	Nul	Implicit	Comentarii
☐	1	id	int(11)			Nu	*Niciuna*	
☐	2	username	varchar(50)	utf8mb4_general_ci		Nu	*Niciuna*	
☐	3	password	varchar(500)	utf8mb4_general_ci		Nu	*Niciuna*	
☐	4	role	varchar(50)	utf8mb4_general_ci		Nu	*Niciuna*	

Fig. 6. Database client

#	Nume	Tip	Colaționare	Atribute	Nul	Implicit	Comentarii
1	id	int(11)			Nu	Niciuna	
2	ordername	varchar(50)	utf8mb4_general_ci		Nu	Niciuna	
3	datecreated	date			Nu	Niciuna	
4	yellow	tinyint(1)			Nu	Niciuna	
5	yellowqty	int(10)			Nu	Niciuna	
6	green	tinyint(1)			Nu	Niciuna	
7	greeqty	int(10)			Nu	Niciuna	
8	red	tinyint(1)			Nu	Niciuna	
9	redqty	int(10)			Nu	Niciuna	
10	black	tinyint(1)			Nu	Niciuna	
11	blackqty	int(10)			Nu	Niciuna	
12	status	varchar(20)	utf8mb4_general_ci		Nu	Niciuna	

Fig. 7. Database orders

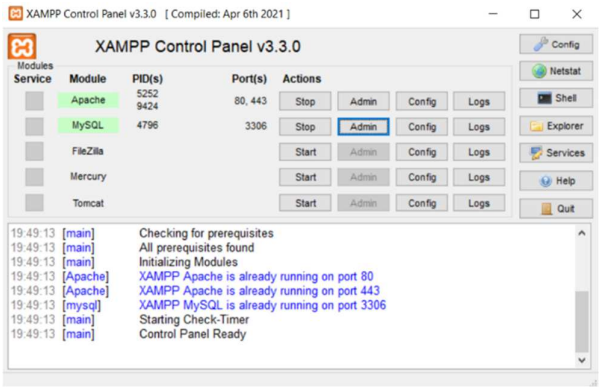

Fig. 8. XAMPP Control Panel

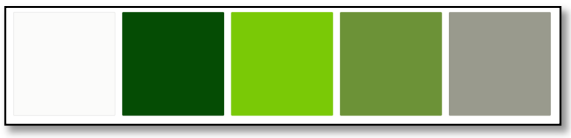

Fig. 9. The colour palette used for the logo design ECO Dental Waste

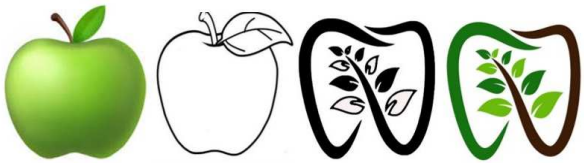

Fig. 10. Creating the logo design ECO Dental Waste

5. GRAPHIC DESIGN FOR THE ECO DENTAL WASTE

This is the presentation of the company in graphic formats with the use of typography, colors and photos. Identity usually refers to the rules explicitly intended to govern the visual description of an organization. A logo is an emblem or sign intended to identify a person or corporation. The logo does not act as a marketing tool but acts as an identifying mark. The logo is designed to remind customers of a company's operation, quality goods, and other virtues. The shape of the logo conveys information about the new business. The color of the logo determines how it is perceived and has the power to drive purchasing decisions. In choosing the colors for the logo, we analyzed the culture, trends and community context. The team chose a color palette for the logo design. Color triggers emotions and gives meaning. (Figure 9).

The green colour represents the colour of prosperity and luck. Green means the resurrection of nature, growth, and vitality. The warm and cold tones given by the combination of yellow and blue make green a neutral colour. Because green attracts the idea of nature, in targeting the market segment for the ECO Dental Waste logo, it started from the premise of an ecological marketing strategy. This type of marketing allows products or services to be promoted based on their environmental benefits.

The process of creating the logo started from a photo representing a green apple. (Figure 10) Colour psychology demonstrates that some colours attract different emotions in human life. It appears that green is the fifth colour used in the visual identity of products, respectively it reaches a percentage of 7% as used at the level of global brands. Considering the colour, the strategy chosen to promote the service is based on ecological marketing.

Obtaining a scalable logo to any size, the team has used Adobe Illustrator software. It was imported the image created in Adobe Photoshop in .jpg format and converted it to vector with the Object -> Image Trace option, saved the logo thus obtained with the ".ai" extension and exported it using the CYMK color code.

The next step was to create the logo for several presentation scenarios. The benefits of multi-product branding are return on brand equity, lower promotional costs, and increased brand awareness. These benefits arise from the widespread use of the brand name across a wide range of product offerings. We opted for a multi-branding strategy. This approach helps the firm to target all customer segments as it encompasses different services. Due to the

chosen colors, the direction given by the logo is clearly towards civic awareness respecting the "3 R" rules: Reduce, Reuse and Recycle (Figure 11).

5.1 The advertising poster

Currently, promotional actions in large companies adopt contemporary marketing channels, such as social networks, e-mail newsletters or service sales applications. Modern methods of promotion are necessary tools in the marketing activity, but when it comes to informing the community, the street becomes the main actor that allows the display of large-format billboards and highlights the most important of what brands must convey.

When it comes to posters the main advantage is their versatility. Knowing who the target audience is, printed advertising posters are present almost anywhere. For example, an environmental awareness poster could be strategically placed in a high traffic area to highlight the benefits of recycling and responsible waste sorting. In terms of affordability, unlike most modern advertising methods that require an ongoing payment, such as PPC advertising or social media, poster advertising simply requires a one-time payment from a dedicated printing company.

Due to the way printed posters can remain in a location indefinitely, it is likely that the audience will meet it on numerous occasions. The advertising board or poster generally has standard sizes: A4, A3, A2, A1, A0. Thus, we determined that the advertising poster is A3 size, whose dimensions without cropping edges are 297 x 420 mm with a resolution of 3508 x 4961 pixels for print and 842 x 1191 pixels for screen. (Figure 12).

The waste from medical institutions contains dangerous microorganisms, and toxic drugs and presents a radiological hazard so that the message transmitted ensures the presentation of environmental services that aim to protect and optimize water, land and air in the community, maintaining their quality functions.

To convey this message, the integrated elements are the product, the logo, the company name, the slogan and some contact details.

Fig. 11. Logo integration examples

Fig. 12. Poster processing in Adobe Photoshop

The poster was processed in Adobe Photoshop. In making the poster using the RGB color model and depending on the printing method, it can be converted to CMYK. For the background was respected the chromaticity which was started in building the graphic package. On the poster was inserted a layer that was obtained by processing a photo containing the company's logo. I positioned the layer so that it occupies the central part of the page. On the left side were inserted the text layers. The logo was positioned in the top left corner.

5.2 Cover photo for social network

A cover photo is that image that adorns the top of the business page and increases brand awareness on the world's most used social network. A cover photo is correlated with marketing and branding designed. A cover photo may seem like a small detail, but it can have a big impact on brand's presence on the world's most popular social network. The colors you choose play a vital role in cover photo design, as they help establish your brand identity for the more than one billion people on the platform. The standard dimensions for cover photo right now are 851 x 315 pixels. The photograph was processed in Adobe Photoshop and then uploaded in .jpg format. (Figure 13).

5.3 The ECODENTAL WASTE application

When accessing the page, the user is greeted by the-Homepage- page of the ECODENTAL WASTE website. When accessing the Registration/Login page, is necessary to press the "Login" button at the top right of the page. (Figure 14). From this page, one can register a new user or log in a registered user who is redirected to the user/admin page. (Figure 15).

The admin control page allows all administrator functions: Viewing users/confirming or rejecting orders/individual statistics per user. (Figure 16)

Fig. 13. Editing cover photo in Adobe Photoshop

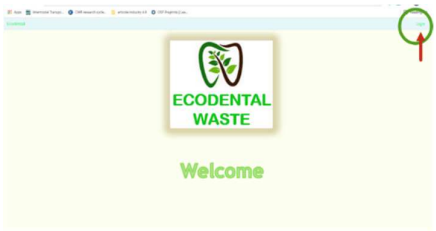

Fig. 14. Homepage

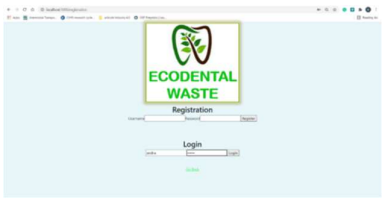

Fig. 15. Registration / Login

For each order made by the customer, Admin control can update its stock of boxes for waste storage. They are classified by color. The Customer page provides information on viewing the order history and has a configured table for creating a new order. For the new order, the customer must fill in each field (yellow/green/red and black) and select the number of boxes to be collected (Figure 17).

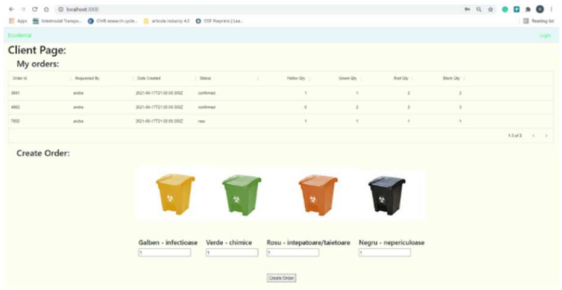

Fig. 16. Client page

5.4 Prototype mobile app

The research team designed the prototype of the mobile application using the Figma design tool. Figma is a tool for those who want to design interfaces. Consistent with the above, Figma is a must-have tool for user interface (UI) and user experience (UX) designers. The tool is incredibly useful for prototype apps or for multiple devices. Figma shows how the app interface will look on iPads and Android devices. Figma is one of the best interface design tools. It's handy for the early stages of planning and can be used in conjunction with numerous applications to facilitate collaboration with others (Figures 20 and 21).

6. CONCLUSIONS

Timisoara being a Romanian university center in medicine, has approximately 31 hospitals (public and private) and 260 dental offices (private), but the number is increasing for the private sector. For Timisoara, waste management using mobile applications represents a challenge waiting to be realized in the public sector. It is a matter of time before the municipalities will adopt a modern mechanism for waste disposal.

The adoption of the mobile application allows portable devices to be facilitators of more sustainable waste management. For the private sector, the proposed web application was tested but much more work needs to be done for the mobile application. The first step for the proper disposal of biomedical waste is to know its classification, in this way the correct segregation can be done. Proper waste segregation is the fundamental step in handling biomedical waste.

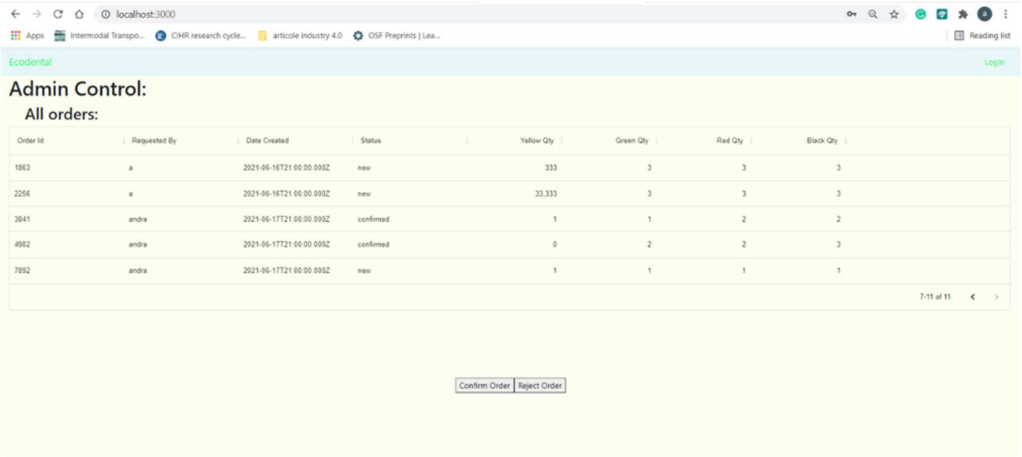

Fig. 17. Admin Control

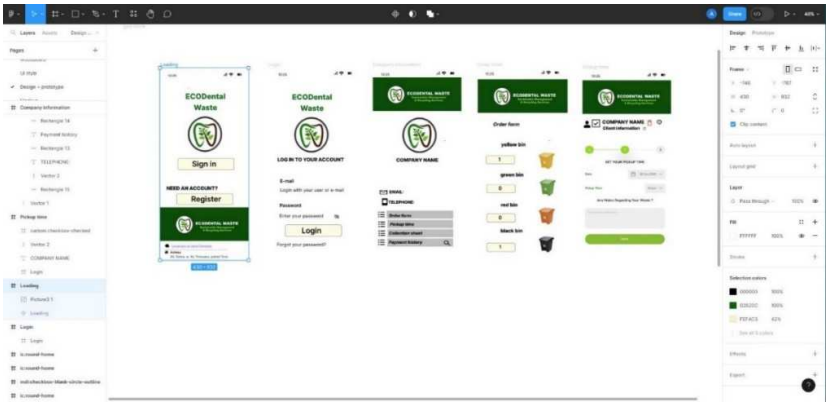

Fig. 18. Figma design web tool

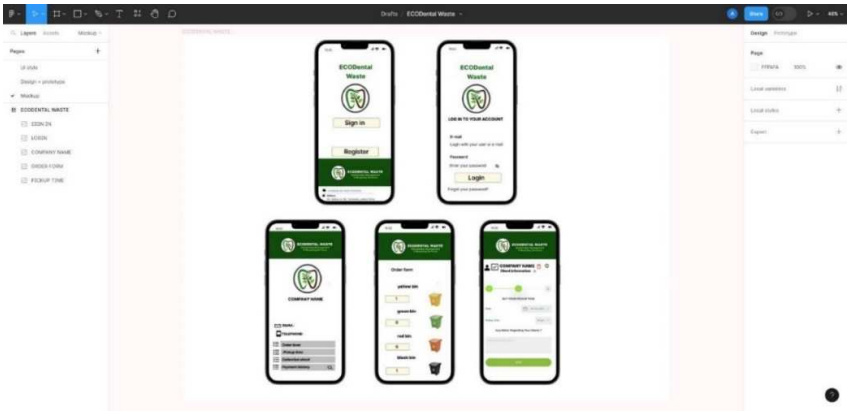

Fig. 19. Mock-up prototype

The informational content configured in the mobile application can contribute substantially to educating a responsible consumers behavior, to an appropriate sorting of ecological objects, or sharing information of interest for the well-being of the environment in which we live by creating an online interaction in the community. The developed application can identify, record and solve recycling problems in urban areas, either from a qualitative and quantitative point of view, or from the point of view of recycling attitudes in each sanitary unit. The benefits of the application provide some insight that are new opportunities to explore in the future:

- Consolidated and real-time information about the waste status of each dental praxis;
- Continuous monitoring and actions that can be taken in real time;
- Specialized recycling bin placement in each dental praxis;
- Higher versions of the system, improved after a certain period since the launch on the market;
- Increasing the number of customers
- The integration of several functions within the initial system;
- Missing competition in this market segment.

The application provides some disadvantages regarding the accuracy of certain information (misinterpretation of the waste law) or missing lessons on good practices in the management of biomedical waste.

Any medical care facility is responsible for the disposal of all waste resulting from its activity. The technical rules on the management of waste resulting from medical activities regulate how this is done: separate collection by category, packaging, temporary storage, recycling, recovery, transport, treatment and disposal of medical waste, paying particular attention to hazardous waste, to prevent environmental contamination. As the planet continues to warm, entrepreneurs are becoming increasingly interested in start-up concepts that address global warming. New potential services for the community are emerging, using innovative methods, and replacing approaches applied to waste management practices. Thus, solutions designed with the help of technology and mobile applications are necessary tools for authorities, communities and companies, and their integration is indispensable for environmental protection, waste prevention and recycling.

7. REFERENCES

[1] AlSlaity, A., Suruliraj, B., Oyebode, O., Fowles, J., steeves, D., & Orji, R., *Mobile applications for health and wellness: a systematic review*, Proceedings of the ACM on Human-Computer Interaction, 6(EICS), 1-29, 2022.

[2] Ara, L., Billah, W., Bashar, F., Mahmud, S., Amin, A., Iqbal, R., ... & Sarker, S. A., *Effectiveness of a multi-modal capacity-building initiative for upgrading biomedical waste management practices at healthcare facilities in Bangladesh: a 21st century challenge for developing countries*. Journal of Hospital Infection, 121, 49-56, 2022.

[3] Biduski, D., Bellei, E. A., Rodriguez, J. P. M., Zaina, L. A. M., & De Marchi, A. C. B., *Assessing long-term user experience on a mobile health application through an in-app embedded conversation-based questionnaire*, Computers in Human Behavior, 104, 106169, 2020.

[4] Bisson, S. *It's gotten a little easier to develop PWAs in Windows*. InfoWorld. Available at: https://www.infoworld.com/article/3304957/its-gotten-a-little-easier-to-develop-pwas-in-windows.html. 2018.

[5] Brittain, J., Darwin, I. Tomcat, *The Definitive Guide* (ed. 2nd), O'Reilly Media, p. 494, ISBN 978-0-596-10106-0., 2007.

[6] Chopra, V., Li, S., & Genender, J. *Professional Apache Tomcat 6* (ed. 1st), Wrox, p. 629, ISBN 978-0-471-75361-2. 2007.

[7] Chang, T. M., Kao, H. Y., Wu, J. H., Hsiao, K. W., & Chan, T. F. *Integrated ontology-based approach with navigation and content representation for health care website design*, Computers in Human Behavior, 128, 107119, 2022.

[8] Goswami, M., Goswami, P. J., Nautiyal, S., & Prakash, S. *Challenges and actions to the environmental management of Bio-Medical Waste during COVID-19 pandemic in India*. Heliyon, 7(3).,2021.

[9] Nkwo, M., Suruliraj, B., & Orji, R. *Persuasive apps for sustainable waste management: a comparative systematic evaluation of behavior change strategies and state-of-the-art*, Frontiers in artificial intelligence, 4, 748454, (2021)

[10] Hanson, M. D. *The client/server architecture*, Server Management, 3, 2000.

[11] Hassan, M. M., Ahmed, S. A., Rahman, K. A. & Biswas, T. K. *Pattern of Medical Waste Management: Existing Scenario in Dhaka City, Bangladesh,* BMC Public Health, Vol. 8, p. 36. doi:10.1186/1471-2458-8-36, 2008.

[12] Nautiyal, J., S., & Prakash, S. *Challenges and actions to the environmental management of Bio-Medical Waste during COVID-19 pandemic in India*. Heliyon, 7(3)., 2021.

[13] Moodie, M. *Pro Apache Tomcat 6* (ed. 1st), Apress, p. 325, 2007.

[14] Mavropoulos, A., *Globalization, Megacities*

and Waste Management, ISWA conference, Daegu, 2011.

[15] Mavropoulos, A., Tsakona, M., & Anthouli, A., *Urban waste management and the mobile challenge*, Waste Management & Research, 33(4), 381-387, 2015.

[16] Paiva, J. O., Andrade, R. M., de Oliveira, P. A. M., Duarte, P., Santos, I. S., Evangelista, A. L. D. P., ... & Barreto, I. C. D. H., *Mobile applications for elderly healthcare: Mobile applications for the health sector*, Washington: World Bank, 2. A systematic mapping. PloS one, 15(7), e0236091, 2020.

[17] Qiang, C. Z., Yamamichi, M., Hausman, V., Altman, D., & Unit, I. S, *Mobile applications for the health sector*. Washington: World Bank, 2, 2011.

[18] Singh, N., Ogunseitan, O. A., & Tang, Y., *Medical waste: Current challenges and future opportunities for sustainable management.* Critical Reviews in Environmental Science and Technology, 52(11), 2022.

[19] Shareefdeen Z., *Medical Waste Management and Control*, Journal of Environmental Protection 3:1625-1628, DOI: 10.4236/jep.2012.312179 (PDF) 2012.

[20] Zhao, H. L., Wang, L., Liu, F., Liu, H. Q., Zhang, N., & Zhu, Y. W. *Energy, environment and economy assessment of medical waste disposal technologies in China*. Science of The Total Environment, 796, 148964, 2021.

[21[GAMA, A., MARCOV, D., PAU, N., PIETRARU, A., VALEA, I., DIACONESCU, A. and ROZOVLEAN, D., *Study on Emotional Intelligence in The Workplace: Findings from A Case Study in Automotive Industry*. Review of Management & Economic Engineering, 22(3). 2023.

[22] https://www.statista.com/statistics/271644/worldwide-free-and-paid-mobile-app-store-downloads/[accessed Jun 03 2021].

[23] http://wastelessfuture.com/pdf/White_Paper_M-Apps__130513.pdf [accessed Jun 10 2021].

[24] https://cnmrmc.insp.gov.ro/cnmrmc/images/ghiduri/Ghid-Deseuri-Medicale.pdf [accessed Jun 15 2021].

[25] OECD, https://www.oecd.org/env/waste/39559085.pdf [accessed Jun 27 2021].

[26] Diaconescu, A., Pascu, D., Prostean, G., Tamasila, M., Ivascu, L., *Performance Evaluation to Improve Work Conditions and Maintain Waste Management Initiatives in Organizationn.* Acta Technica Napocensis - Series: Applied Mathematics, Mechanics, and Engineering, [S.l.], v. 64, n. 1-S1, feb. 2021. ISSN 2393–2988.

Un studiu de caz privind utilizarea instrumentelor web pentru îmbunătățirea inițiativelor de management de mediu pentru deșeuri medicale

În prezent, în majoritatea țărilor în curs de dezvoltare, inițiativa vizionară de mediu privind gestionarea deșeurilor atrage nevoia de a integra responsabilități sociale. Aceste acțiuni de mediu sunt recunoscute de către administrația locală, întrucât au direcții strategice bine definite în ceea ce privește implementarea legislației privind deșeurile, care includ nu doar monitorizarea operatorului de reciclare sau a materialelor recondiționate ale producătorilor și consumatorilor, ci și schimbarea atitudinii cetățenilor. și încurajarea comunității în participarea activă pentru protejarea mediului. Această cercetare promovează o aplicație prototip pentru a crește gradul de conștientizare cu privire la importanța sortării deșeurilor medicale, pentru un mediu durabil. Astfel, este necesar să se integreze un sistem inteligent de management pentru monitorizarea deșeurilor periculoase din centrele medicale. Scopul acestei lucrări este, așadar, de a comunica într-un mod modern, folosind instrumente web, acțiuni de prevenire a deșeurilor pentru a educa comunitatea și a implica factorii de decizie cheie.

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