# Farm waste collection organizing based on information system

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**Abstract**. The article defines the relevance of the problem of utilisation of waste generated in the course of farms' activities, regardless of their size and type of activity. The possibility of using software tools to organise the processes of collection, storage, sorting, and transportation for the subsequent disposal of such waste is established. The use of methods of structural analysis, synthesis, statistical analysis, information modelling allowed to establish all key objects and processes with their characteristics for the design and development of an information system capable of digitalising the listed processes. As a result of using the methods of object-orientated programming, the corresponding system was developed, and fragments of the user interface with the description of functionalities for each category of users were presented.

## 1 Introduction

The problem of waste disposal is relevant in any country of the world, so every year programmes and rules of rubbish collection and sorting are developed, methods of its disposal are improved depending on a variety of factors [1]. As Zadaniuk notes in his study, "every year in the world there are about three billion tonnes of rubbish" [2]. The development of the waste utilisation sphere makes it possible to preserve the environment, ensure the safety of animals in wildlife, sustainable development of territories and its ecological well-being [3].

In Russia, as in other countries, there is a regulatory and legal framework for waste management [4]. In addition to federal laws regulating the processes of order and methods of storage, collection, use, neutralisation, transportation and disposal of waste, some provisions are prescribed in construction norms and rules, standards and technical specifications [1, 5]. According to the Russian legislation, rubbish is divided by the source of occurrence, aggregate state, recyclability and the level of danger they carry for the environment.

The most acute problem of waste utilisation is observed in the agricultural sector [6, 7]. It is connected with environmental pollution by hazardous components, out-of-service agricultural machinery and equipment, poultry and livestock waste, fertilisers, etc. [8]. All this occurs due to the imperfection of applied technologies and technical means in carrying out recycling, non-compliance with the established environmental requirements, high price for transportation due to the lack of waste reception points for subsequent sorting and

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recycling [6, 9]. The use of software tools capable of streamlining and unifying the processes of organising the collection, temporary storage, transportation and preparation for rubbish disposal is relevant and capable of keeping records and regulating the ecological state of the environment, improving the processes of agricultural organisations [10, 11].

Thus, the purpose of the study is to design and develop an information system capable of managing the waste disposal processes of agro-industrial companies. To do this, it is necessary to solve the problems of establishing all the objects and related processes that determine the stages of waste generation in the organisation, to produce the design of the user interface of the information system and algorithms of its operation.

Theoretical significance of the study lies in the systematisation and unification of waste by its types, the creation of a digital model of waste, allowing it to be used for research related to the digitalisation of agriculture and the development of appropriate software products. The practical significance of the study lies in the creation of an aggregator of services for the removal and disposal of different types of waste, control of organisations operating in the agricultural sector.

## 2 Materials and Methods

To implement the set tasks, the research used general scientific methods, which allowed us to define the boundaries of the problem area and formalise it. In studies related to obtaining a model of a complex object or system, the method of structural analysis is used to establish objects and processes, their quantitative and qualitative characteristics [12, 13]. With its help, significant elements at each level of decomposition are determined and through the integrated use of methods of synthesis, grouping, statistical analysis, observation and step-by-step refinement of their characteristics.

The results obtained became the basis for the design and development of the information system. Information modelling methods [14, 15] were used to transform the problem domain description data into the format required for information storage and digital processing. This allowed to form a dataset, on the basis of which the type of rubbish was automatically determined [16]. Object-oriented programming methods were used to create the software shell. With their help, the writing of program code was standardised, which was based on objects, their data and available set of actions [17].

## 3 Results

Analysing the problem domain allowed us to identify its key objects and the processes arising between them.

The main object of the problem area is rubbish and waste. The main difference between rubbish and waste is the impossibility of its use as secondary raw materials. The specificity of rubbish utilisation depends on its type. For farms or large agro-industrial complexes are characterised by household, construction and agricultural types of rubbish. Depending on the type of waste, the mechanisms of preparation for utilisation and utilisation or recycling are determined. This is due to the fact that waste has its own degree of hazard, aggregate states (solid, liquid, bulk, paste, gel and gaseous), nature of origin (chemical, mineral, organic, municipal) and source of origin (e.g., industrial waste).

Another key object of the process is the professional responsible for waste collection and utilisation on the farm. He or she decides on the appropriate status for the object to be disposed of in order to prepare the documentation on its decommissioning, timing and type of disposal. If necessary, the specialist selects a company to be involved in waste disposal.

Such companies are the third object involved in the disposal process. Depending on the type of waste, the company determines the terms of removal to the place of disposal and methods of transport.

Based on this, the categories of users of the developed system are defined. One of its elements is a mobile application, which allows to form and track the tasks of waste removal from the farm. The key function of the system is the automatic rubbish recognition function. Fig. 1 shows an image of the corresponding application screen.

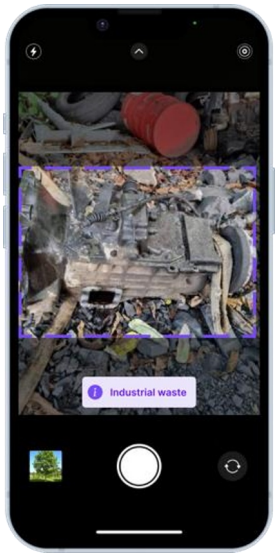


**Fig. 1.** Debris type recognition screen

The image is recognised using a neural network. For the function to work correctly, it is required to give the application access to the camera or image gallery. The recognition function works in such a way that all constituent elements of debris will be identified if they belong to different types (types, security classes, sources of origin, etc.). In addition, the application has the ability to establish the presence of the recognised object in the database containing information about the objects on the balance sheet of the organisation. The application informs the user about the accuracy of the established compliance and will require confirmation or manual binding. This will automatically generate documentation on the removal of the object from the organisation's balance sheet and its disposal.

Once the type of waste has been determined, the system will automatically generate recommendations for disposal. The recommendations are based on the ability of the farm to transport the rubbish to collection points independently. If there are collection points for the corresponding type of rubbish near the farm, a map with the corresponding collection points marked on it will be shown (Fig. 2).


**Fig. 2.** Screen with a map of collection points for waste sorting or recycling

When selecting a point, a description of the collection point will be shown. If it is necessary to transport waste to the collection point or there are no collection points for this type of waste, the system will recommend to fill in an application to call the appropriate waste removal service (Fig. 3).

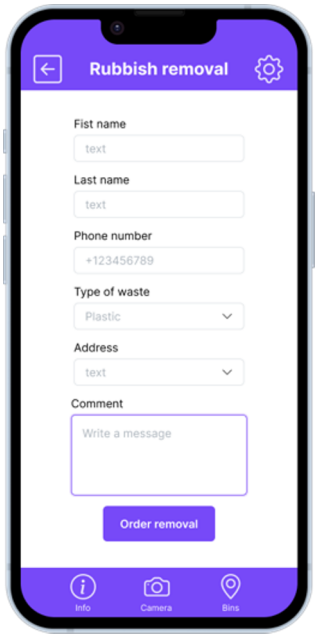


**Fig. 3.** Waste Disposal Application Screen

Based on this, the application generates a calendar of events, which serves as a basis for reminding the user about recycling deadlines, documentation or the arrival of a waste removal company.

The user can add waste to the list of tasks to be disposed of on their own, without using the recognition function. To do this, the user needs to specify the type of waste and the system will automatically provide recommendations for disposal and add a new task to the task list with a brief explanation (Fig. 4).

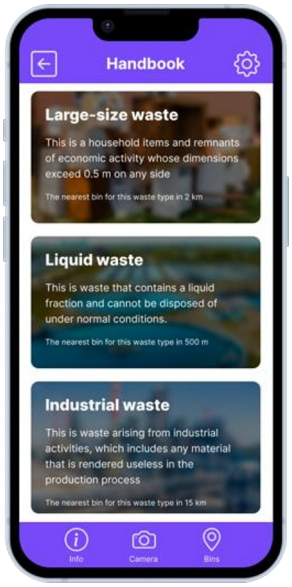


**Fig. 4.** Reference screen for tasks to be performed

Authorised and unauthorised users have access to the system. Unauthorised users have access to the functions of waste recognition, map of collection points and ordering of waste removal service. At the same time, there are no functions of forming a list of tasks, recommendations and other functions related to the management of waste management processes at the enterprise. Authorisation is available to corporate users representing an organisation. In this case the following profiles are possible:

*1.* *Supervisor* - a specialist engaged in personnel management within the framework of any production processes or inventory. By accessing the system, he/she can generate and receive documentation on the write-off of objects, disposal costs, control and define tasks related to disposal.

*2.* *Worker* - a specialist engaged in the performance or support of production processes that may generate waste. With the help of the system, the worker can record the presence of waste to form a list of tasks for its prompt disposal.

*3.* *Company* - representative of an organisation specialising in the removal, sorting, recycling or disposal of waste, depending on its type. It has an opportunity to add a description of its company, assign types of rubbish and waste with which the company works, receive and record the fulfilment of rubbish requests from customers.

To ensure the operation of the system, an administrator role is created, which confirms roles to corporate users, maintains an up-to-date status of all categories of rubbish and waste.

## 4 Discussion

The results obtained during the research correspond to the stated methods. The analysis of works related to rubbish disposal in different industries shows that all key objects and their characteristics that determine the processes of rubbish collection, accumulation, transportation, sorting and disposal have been established [1, 4, 6]. The use of methods that allow obtaining a digital model of the processes for their management is in line with the results obtained in studies on relevant topics [11, 12, 15, 16].

The developed information system provides access to digital resources and makes it possible to streamline the electronic document flow of organisations, to control the work of individual specialists, to establish the volume of necessary services for the removal of certain types of rubbish. When developing software products, researchers focus on the fact that the resulting information system should be a tool that complements the activities of relevant employees and relieves them of routine operations [8, 14, 17]. In addition, the developed information system is a tool that provides practice-oriented training of specialists in the field of organisation of agricultural processes and management of agro-industrial organisations or farms [18].

## 5 Conclusions

The main methods of waste disposal in Russia have been landfilling, composting, or incineration for a long time. In some cases, the lack of regulation of such processes resulted in uncontrolled waste dumps. This had a significant negative effect on the environment in addition to the proliferation of landfills. In recent years, many measures have been applied to improve the situation by promoting recycling culture and processes. To be effective, it requires the development of tools to make waste removal and recycling services available.

The developed software product allows on its platform to unite companies providing services in the sphere of disposal of different types of rubbish, to make them available to a large number of organisations that create rubbish as a result of their economic activities. When implementing the software product in such organisations, it becomes possible to systematise the production processes that result in waste, to form unified chains and algorithms for the collection, storage, and timely transportation of waste to the places of its processing. In addition, the documentation that accompany these processes is unified. All this allows one to reduce the unfavourable environmental impact of the activities of agroindustrial companies and farms, without excluding their technological and economic development.

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