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# A WIDER RANGE OF PUBLIC SERVICES AT THE EXPENSE OF OPTIMIZATION MODELS FOR WASTE MANAGEMENT AGRICULTURE

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**Abstract.** The concept of "zero waste" is one of the most modern in the field of waste management. It is based on the organization of closed cycles when one production waste used as raw materials for another. In this paper we discuss models of optimal allocation of agricultural waste by type of their processing and distribution. For investigation of the waste management system we use hybrid methods combining neural networks and deterministic algorithms. It is assumed that in the future this kind of models will be realized in the system of public service in electronic form.

**Key words:** waste management; optimization models; agricultural waste.

One of the most serious global environmental issues is the problem of waste production and consumption waste. In developed countries, these issues are resolved successfully. Russia lagged behind in this matter for several decades, not only in terms of technology, but also in understanding and comprehension of the seriousness of the problem at all levels. In particular it concerns housing and communal services and the agricultural sector. In the first case, the main problem is municipal solid waste (MSW), in the second case the problem is a waste of poultry and livestock, in particular, litter and manure, respectively. MSW are disposed of in landfills, which eventually turn into landfill gas, forming the combustion of toxic emissions into the atmosphere, toxic filtrate which pollutes ground water, etc. Litter and manure without any treatment are taken to the field, resulting in their biological and chemical contamination, and the birds and flies spread this malodorous environment for miles around. Meanwhile, MSW contains a whole range of potentially useful products for use as secondary raw materials. Bird droppings[1] are the basis for high-quality organic fertilizers, vermicompost, biogas and others are also known as secondary raw materials. It is known more than a dozen related technologies, including those which were developed by Russian scientists. They have long been tested and constantly improved, but remain unclaimed. Ignoring the role of modern management systems based on process and system approach is one of the main reasons for this situation. With regard to waste it concerns environmental management systems, industrial ecological systems, factors 4 and 10, Zero Waste. All this affects the negative impact on the environment and resource conservation, and focused on the fullest possible use of the basic principles of nature. Obviously, for agriculture, this approach is most natural if the processes poultry viewed together with the processes of crops (including forage production). In this case we obtain a closed cycle "Poultry–field–Poultry." Litter and other organic waste is processed into high-quality poultry farm fertilizers, which are taken to the field to improve soil fertility and crop yields. The products are then processed into a feed crop for birds and delivered to the farm. With this approach, simultaneously solve the problem of low fertility and soil pollution, their constant degradation, since these processes are largely due to the use of illegal methods of disposal of poultry and livestock (such as export of unprocessed waste directly on the field).

This approach involves the consideration of all the issues in the same complex. Importance of this approach is seen in the long term, when the automatic system of waste management is included in

[1] Later in the article the authors will refer to the poultry industry, but set out principles are applicable to livestock.

the list of public services provided in electronic form.

Currently, the legal system does not allow an extension of already approved by the government a list of public services. However it is clear that in the long term public and commercial structures will be responsible for such waste management procedures in agriculture.

**Mathematical Models.** In [1, 2] we considered problems of waste management with given mathematical models of some optimization problems and discussed approaches of solving such kind of problems in general. Waste management in specific types of industry, e. g. in agriculture, allows to test real models.

There are posed and solved a number of problems of type: "Farm-Field".

We will introduce some notations.

Let $m$ be a number of farms for waste processing, $i = 1, 2, \ldots, m$.

Let $n$ be a number of processing technologies (e. g., bioconversion, thermal desorption, etc.), $j = 1, 2, \ldots, n$.

As a result different technological processing methods give fertilizers of different composition.

Vector $\alpha_j = (a_{0j}, a_{1j}, \ldots a_{Lj})$ characterizes the composition of the components produced by the $j$-th technology of fertilizers.

$a_{0j}$ is the amount of contaminants remaining in the unit of fertilizer. Set of vectors form a matrix $A_{L+1,n}$.

$k = 1, 2, \ldots, K$, where $K$ is the number of fields.

Let $c_j$ be the unit cost of fertilizers obtained by the $j$-th technology (here we assume that it is the same for all farms).

$x_{ij}$ is the amount of waste in $i$-th farm and processed by the $j$-th technology. There is no processing if $j$=0.

$y_{ij}^k$ is the amount of fertilizer received on the $k$-th field from the $i$-th farm and processed by the $j$-th technology.

$B_{m,L}$ is the matrix of initial data (according to expert estimates) characterizing qualitative composition of fertilizers processed on $m$ farms of fertilizers.

$D_{K,L}$ is the matrix of initial data characterizing composition of fertilizers which are required on the $k$-th field and with $d_{kl}$ elements.

**Problem 1.** We will seek minimization of the function $F = F_1 + F_2$ where

$$F_1 = \sum_{i=1}^{m} x_{i0},$$

$$F_2 = \sum_{i=1}^{m}\sum_{j=1}^{n} a_{0j} * x_{ij}$$

appearing in the following set of constraints

$$x_{ij} \ge 0, \quad \sum_{j=0}^{n} x_{ij} = 1, \text{ for all } i = 1, \ldots, m,$$

$$X * A^T \ge B .$$

Here the function $F_1$ characterizes the amount of unprocessed waste, and $F_2$ characterizes the amount of pollutants that remain after processing in fertilizers.

Thus, Problem 1 is focused on the environmental aspects of recycling.

A solution of the problem will be obtained in the form

$$B^* = X^* * A^T ,$$

where $X^*$ is the matrix of optimal solutions and $B^*$ is the matrix characterizing quantitative composition of fertilizers obtained on each farm by each technology subject to a minimum of pollutants.

Next problem concerns minimization of costs for the purchase of a fertilizer.

Let

$$s_{lj} = \frac{c_j * a_{lj}}{\sum_{l=1}^{L} a_{lj}} , \text{ for all } l \text{ and } j$$

be the cost of a unit of $l$-th component of the fertilizer obtained by $j$-th technology. The matrix $S$ consists of these values. Let

$$C = B^* * S$$

be a matrix of costs of a unit of fertilizer processed on $i$-th farm by $j$-th technology.

Next set of problems is solved for each field separately. $k = 1, 2, \ldots, K$ are the field numbers.

**Problem 2.** Minimization

$$\sum_{j=1}^{n}\sum_{i=1}^{m} y_{ij}^k * c_{ij}$$

subject to

$$y_{ij}^k \ge 0, \quad \sum_{j=0}^{n} y_{ij}^k * a_{jl} \ge d_{kl},$$

for all $l = 1, \ldots, L$.

The heart of the problem is to determining the amount of fertilizer purchases for each field to be processed on each farm for each technology, while minimizing the costs of acquiring and serving the needs of specific substances.

The solution matrix is denoted by $Y^*$.

However, this approach does not take in consideration the financial interests of producers. They have the right to sell the goods to a particular user or not. In order to choose the best strategy for the fertilizer manufacturers the situation is considered as a matrix game.

Members of the game are poultry companies or a group of companies, (Player 1– farm), and crop companies (Player 2 – field).

Strategy for Player 1 is reduced to waste using different technologies and production of fertilizers with different properties with an increase in profits from fertilizer sold.

Strategy of player 1 is to increase the profits from fertilizer sold in waste treatment using various technologies fertilizers with different properties.

Strategy for Player 2 is to purchase fertilizers with the desired properties at the lowest price. Taking in account obtained results one can pose the following problem:

**Problem 3.** Find the optimal solution of the matrix game with the following payoff matrix

$$\begin{pmatrix} \sum_{j=1}^{n} y_{1j}^{1*} \cdot c_{1j} & \sum_{j=1}^{n} y_{1j}^{2*} \cdot c_{1j} & \ldots. & \sum_{j=1}^{n} y_{1j}^{k*} \cdot c_{1j} \\ \ldots. & \ldots. & \ldots. & \ldots. \\ \sum_{j=1}^{n} y_{mj}^{1*} \cdot c_{mj} & \sum_{j=1}^{n} y_{mj}^{2*} \cdot c_{mj} & \ldots. & \sum_{j=1}^{n} y_{mj}^{k*} \cdot c_{m1j} \end{pmatrix}.$$

Player 1 attempts to select a sales strategy that would maximize his income and player 2 tries to minimize costs.

Objective of problem 1 was to minimize the burden on the environment, and objective of Problem 2 was to minimize the expenditure of each customer individually. Thus we are obtaining mixed strategies of the players and the situation where the interests of both producers and consumers are taken into account.

A wider range of public services at the expense of optimization models for waste management agriculture

## CONCLUSION

Large farms may have their own or leased fields to be used to make fertilizer and subsequent production of feed, for example, in the form of specialized units, workshops. Another form of implementing a systematic approach may be holding, which includes separate companies for poultry, crop production, fertilizer and feed. For medium and small farms more acceptable form is the organization of cooperatives.

In general terms, a necessary condition for the implementation of a systematic approach is the formation of the closed cycle "Poultry / Farm–field–Poultry / Farm" in one of these forms, or in the form of a virtual enterprise, which is due to participate in the relevant agreements.

Currently the authors solved a number of models. The results show that the models are realistic and can be used to assist in making appropriate decisions concerning the management of waste within the agricultural public services or commercial enterprises.

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### МЕТАДАННЫЕ

**Название:** Расширение набора государственных услуг за счет оптимизационных моделей управления отходами сельскохозяйственного производства.

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**Аннотация**: В настоящее время наиболее современной в области обращения с отходами является концепция «Ноль отходов». В ее основе лежит организация замкнутых циклов, когда отходы одного производства служат сырьем для другого. В статье рассматриваются

модели процессов оптимального размещения сельскохозяйственных отходов по видам переработки и их распределения. Для исследования системы управления отходами используются гибридные методы, комбинирующие нейронные сети и детерминированные алгоритмы. Предполагается в дальнейшем встраивание нашей модели в сервисы государственных услуг, реализуемые в электронном виде.

**Ключевые слова:** оптимизационные модели; управление отходами; сельскохозяйственные отходы.

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