Approaches to Integrated Waste Management System Modeling

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Abstract – The approaches to the integrated waste management system modeling, based on the Gaussian model, are presented. A mathematical model of the quality indicator of the environment and a hierarchical block diagram of the waste management system, which enables to obtain the matrix dependences of the environmental quality index are developed.

Keywords – mathematical modeling, integrated system, waste management, environmental quality indicator, Gaussian model.

Introduction

Currently, one of the most important and most urgent environmental pollution problems in Ukraine is the uncontrolled accumulation of industrial and domestic wastes, their burial at landfills.

Waste management is the collection, transportation, processing (including recovery and disposal), supervision of such operations and further control, care of waste facilities after their closure. Integration of waste management systems in developed countries has long been established. Integrated waste management systems need to be implemented for sustainable development of Ukraine [1].

The aim of the work is to formulate approaches to the integrated waste management system modeling.

Modeling of Integrated Waste Management Systems

Modeling of integrated waste management system covers the following issues:

– planning of options for implementation of the waste management system;

– analysis of processes of systems components;

– optimization of elementary processes of the waste management system (process management, task management);

– definition of correlation between the main elements and processes of the system;

– identification of data structures that describe system elements or processes;

– classification of data, processes, threats to the environment caused by the emission of chemical and biological substances;

– forecasting changes: process flow, process parameters, caused by waste stream;

– analysis of the migration of pollution from the technological processes of transformation and disposal of waste;

– modeling of elementary objects and processes;

– modeling of geo-natural data.

Based on the analysis of literary sources, the waste management model can be divided into [2]:

– models, which are based on the definition of economic efficiency CBA (Cost Benefit Analysis);

– models based on the ecological assessment of the life cycle LCA (Life Cycle Assesment);

–models based on multicriterial analysis of the decision cycle MCDA (Multicriteria Decision Analysis).

Taking into account the complexity of the processes of the components, waste management systems, these models consider the environmental, economic and social aspects in accordance with the idea of balanced development, where the proportions of components of dependence are $E : S : P$ (E – economic factor, S – social factor, P – a natural, environmental factor).

Mathematical model of environmental quality index

This model is a discrete, deterministic model that is based on the analysis of the distribution of concentrations of the pollutant c(x,y,z) in the components of the environment. The methodology for determining the values of pollutants is based on the Gaussian model, which has the form

$$c(x,y,z) = \frac{E}{2pd_y d_z \bar{u}} \exp\left[\frac{y^2}{2d_y^2}\right]\left\{\exp\left[-\frac{(z-H_e)^2}{2d_z^2}\right] + \exp\left[-\frac{z+H_e)^2}{2d_z^2}\right]\right\}, \quad (1)$$

where, E – intensity of pollution; δ_y, δ_z – RMS standard deviations of the distribution of the concentrations of contaminants, respectively, in the directions of the Y and Z axes; $\bar{u}$ – average wind speed; emission height H_e.

The structure of the data of the model of the quality index of the environment is based on the parameters describing the process of dispersion of pollution in the natural environment. The structure of data can be divided into the following block parameters: the range of modeling process; characteristics of sources of pollution; description of the topography of the territory; description of the components of the environment (landfills, surface and groundwater); description of roads, tracks, built-up areas; weather data; structure of chemical changes; parameters of time sampling and spatial model.

The model of distribution of pollution includes models of the atmosphere, transport of contaminated substances and the exchange of computational results, their visualization and interpretation. The block diagram of an integrated waste management system is developed. Matrix dependencies of the environment quality indicator for the integrated waste management system are obtained.

Conclusion

A mathematical model of the quality indicator of the environment, based on the Gaussian model, are presented. The hierarchical block diagram of the waste management system is presented, which allows to obtain the matrix dependencies of the environmental quality index for various variants of the integrated waste management system. The matrix equations of the model of the quality indices of the environment for the i-th pollutant for z-th object or group of objects, sources of pollution, are obtained.

References

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